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Effects of Preexposure to Shock on Autoshaping

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EFFECTS OF PREEXPOSURE TO SHOCK
ON AUTOSHAPING

by

Nancy L. Eldred

A dissertation submitted in partial fulfillment
of the requirements for the degree

of

DOCTOR OF PHILOSOPHY

in

Psychology

Approved:

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Nancy L. Eldred

DEDICATION

This dissertation is dedicated to the memory of
two of my earlier teachers:

M. Adolphus Cheeke and Hans Bierman.

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ABSTRACT

Effects of Preexposure to Shock on Autoshaping

by

Nancy L. Eldred, Doctor of Philosophy

Utah State University, 1981

Major Professor: Carl D. Cheney
Department: Psychology

The safety signal hypothesis suggests that during the absence of stimuli predicting impending shock, the organism is not fearful. The stimuli which predict the absence of shock are therefore called safety signals. The purpose of the present study was to investigate some critical properties of safety signals. Such stimuli in an avoidance or escape situation, according to the opponent process model, are expected to acquire hedonic value opposite to shock.

This study examined differences in conditioning variables between safety signals predicting different intensities of shock, and between safety signals present in procedures using predicted shock, and procedures using unpredicted shock. Additionally, the effects of inescapable unpredicted shock with no safety signals present were examined.

The general procedure involved exposing pigeons to aversive Pavlovian conditioning and subsequently autoshaping these birds to stimuli which had predicted safety in the aversive situation.

Dependent measures included trials to acquisition of the autoshaped response and subsequent rate of keypecking.

In the six experimental groups, pigeons were repeatedly and inescapably shocked at either 30 or 90 volts. Each individual 0.5 sec shock was (a) predicted by a specific stimulus or (b) not predicted. Additionally and explicitly unpaired with the shock, a safety signal was presented. For each voltage level, a control group was repeatedly shocked with no stimuli presented at any time.

Control groups were included which (a) received no aversive conditioning, (b) were autoshaped to a stimulus which had previously predicted shock, (c) received the aversive conditioning, and (4) were exposed to various stimuli but received no aversive reinforcement.

The principal finding was that preexposure to strong shock resulted in delays in response acquisition during subsequent autoshaping. This suggests that the learned helplessness hypothesis obtains with classically conditioned responding. Additionally, the importance of shock-alone control groups in the study of transfer effects is critical. Due to the lack of statistical power, the study was not definitive regarding the nature of safety signals or appetitive-to-appetitive transfers. Statistically significant differences were only found on acquisition measures, and no such differences were found on performance measures.

(96 pages)

CHAPTER I

INTRODUCTION

In a situation where aversive electric shock is delivered to an animal, it has been shown that the animal, if given a choice, will prefer shocks that are preceded by a signal as opposed to shocks without warning. In a typical experiment, a rat is allowed to move between sides of a shuttle box. Shocks on one side of the box are explicitly preceded by and paired with a specific stimulus (light or tone). On the other side, shocks are unsignaled. The rat spends more session time on the side where shocks are signaled, and this time asymmetry is called preference. Research concerning this preference for signaled shock has led to the development of three hypotheses (Seligman & Binik, 1977). The uncertainty reduction hypothesis suggests that organisms can be reinforced by a reduction in uncertainty, that is, by information about whether a shock is forthcoming or not. This hypothesis predicts that organisms will prefer signaled over unsignaled events regardless of the type of event (Berlyne, 1960). The preparatory response hypothesis (Perkins, 1955) indicates that organisms make an instrumental or physiological response during the signal which precedes shock because that response modifies the aversiveness of the shock. The exact nature of the response is not always known (Seligman & Binik, 1977) and may involve muscle relaxation, exaggerated posture, heart rate change, etc. The safety signal hypothesis states that during signaled shock, the animal is fearful[1] only during the signal which is explicitly paired with shock (conditioned aversive stimulus, CS). In the absence of this CS, the animal is not fearful since the absence of the CS is explicitly paired with the absence of shock. However, in an unsignaled shock procedure (no CS), the animal is fearful all of the time since there is no signal predicting either the occurrence or nonoccurrence of shock. Therefore, a signaled shock condition is preferred in comparison with an unsignaled shock condition because the animal spends less time in a state of fear (Seligman & Binik, 1977). Seligman and Binik (1977), in reviewing the literature pertaining to this area of research, concluded that the safety signal hypothesis is supported with more acceptable data than the other two hypotheses.

In view of both the relatively extensive support for the safety signal hypothesis and its frequent use in psychological theorizing, questions regarding the specific nature of the safety signal are important. It has been shown that animals will suppress making avoidance responses that were previously maintained by presentations of a stimulus explicitly paired with shock when a safety signal is introduced (Rescorla & LoLordo, 1965). It has also been shown that safety signals can serve as conditioned positive reinforcers

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[1] Fear is used by Seligman and Binik (1977) as a generic term describing various behaviors occurring in the presence of aversive stimuli, such as shock. These behaviors include, among others, increased attempts to escape the shock chamber, agitation (running and barking in dogs) (Rescorla & LoLordo, 1965), as well as various physiological changes such as heart rate and stomach ulceration (Weiss, 1970).

(Rescorla, 1969; Weisman & Litner, 1969). This means that safety signals (signals predictive of no shock) are conditionable and functional as response consequences. However, the differences, if any, between safety signals which indicate the absence of different intensities of shock have not previously been investigated. Additionally, there may very well be differences between safety signals present in a program of signaled shock versus those present in a program of unsignaled shock, particularly when one considers Seligman and Binik's (1977) concept of continuous fear in nonsignaled shock situations. That is, in a situation where a CS precedes shock, a safety signal may function differently than in a situation where no CS is present.

According to classical conditioning theory, a stimulus which predicts the absence of an unconditioned stimulus (US) acquires a hedonic value (subjective valence) opposite to that US (Gray, 1975). In the case of a stimulus predicting (perfectly correlated with) the absence of a shock US, its hedonic value would be that of an appetitive (positively reinforcing) event. Subsequent conditioning of a stimulus which had been explicitly paired with the absence of shock to another appetitive US (the process is called reconditioning) should be facilitated when compared to a neutral stimulus. In other words, when a CS which has acquired appetitive value is subsequently explicitly paired with a different although also appetitive US, the conditioned response to the CS should be more quickly acquired than if a neutral stimulus was used (Scavio & Gormezano, 1980). It follows that the greater the hedonic value of a particular conditioned stimulus, the greater will be the facilitation of reconditioning this CS to another US of similar hedonic value. Conditional stimuli may therefore be said to acquire different strengths, depending upon the valence of the event they predict. Differences between signals which predict the absence of various types of aversive shock (e.g., different intensities of shock, signaled or unsignaled shock) would appear as differences when reconditioning these same stimuli to a US of hedonic value opposite to shock.

CHAPTER II

REVIEW OF THE LITERATURE

Research has demonstrated repeatedly that animals given a choice will prefer shock which is predicted by a stimulus (signaled shock) to shock which is not predicted by a stimulus (unsignaled shock) (e.g., Badia, Culbertson, & Lewis, 1971; Perkins, 1955). For example, rats spend more time on (prefer) the side of a shuttle box where periodic inescapable shocks are preceded by a stimulus than on the side with no predictive stimulus. A variety of hypotheses have been suggested to explain this behavior. This chapter will briefly review these hypotheses, discuss previous research on safety signals, and propose a methodology to examine the attributes of safety signals.

The safety signal hypothesis suggests that with signaled shock, the organism is only fearful during the presentation of the signal for shock (a conditioned stimulus, CS+) since the absence of this stimulus is itself predictive of a shock-free period. In an unsignaled shock situation, the organism has no information and is, therefore, chronically fearful (Seligman & Binik, 1977) and, hence, supposedly much more uncomfortable. With signaled shock, the overall time that the animal is in fear is reduced compared with an unsignaled shock situation. The absence of the CS+ which is predictive of shock is a shock-free period, and a stimulus which is correlated with this shock-free period is (becomes) a safety signal (SS) by definition.

The uncertainty reduction hypothesis (Berlyne, 1960) is very similar to the safety signal hypothesis in terms of predictions which are possible. This hypothesis allows one to suggest that organisms are reinforced by a reduction in uncertainty about events, and further, that shock which is signaled has less uncertainty than has unsignaled shock. Unlike the safety signal hypothesis, however, this hypothesis leads one to predict preference for predictable events over unpredictable events regardless of the type of US (aversive or appetitive). Since an animal is not considered to be "fearful" during the absence of a CS+ for food, the safety signal hypothesis would not make a prediction regarding preference for such a signaled appetitive US. One might also consider that conditioning situations involving aversive electric shock are somehow very different from situations where food is delivered as a US. Therefore, it might be the case that entirely different principles are at work. The uncertainty reduction hypothesis also predicts preference for a situation in which the probability of the US occurring in the presence of the CS+ (p(US/CS+)) equals 1 as opposed to a (p(US/CS+)) equal to .5, where in both cases the probability of the US occurring in the absence of the CS+ (p(US/SS)) is 0 and where equal numbers of USs occur.

Finally, the preparatory response hypothesis (Perkins, 1955) assumes that the organism can make an instrumental or physiological response during the CS+ which modifies the intensity of the US. The exact nature of such a preparatory response is not always known. For an aversive stimulus, this hypothesized response supposedly makes the US less painful and, for an appetitive stimulus, supposedly more positively reinforcing. Therefore, preference for signaled shock occurs because the US becomes less painful than with unsignaled shock. This is a difficult position to refute.

Neither the uncertainty reduction hypothesis nor the preparatory response hypothesis ascribes conditioning to the stimulus which predicts the absence of an aversive US, whereas the safety signal hypothesis implies that this stimulus (SS) is very clearly conditioned. It is clear from the classical conditioning literature that organisms do, in fact, learn that a stimulus paired with the absence of a US predicts no US. Evidence from within the conditioned suppression paradigm (Seligman & Meyer, 1970) demonstrates that rats will bar press for food consequences in the presence of a SS but will suppress responding in the presence of a CS+ predictive of shock. Safety signals (SS) have also been shown to inhibit shock avoidance behavior (Rescorla & LoLordo, 1965). That is, when an already established SS is presented in conjunction with a nondiscriminative avoidance paradigm, the animal reduces its rate of responding.

Additional support for the safety signal hypothesis comes from literature wherein physiological variables are assessed. Weiss (1971a, b, c), using a 2 X 3 factorial design [2: signaled or unsignaled shock, 3: escapable/avoidable, inescapable, or no shock], investigated intestinal pathology in rats. A wheel was available to all subjects and wheel turning served as the instrumental response for the escape/avoid group. Rats in the unsignaled groups made more wheel turns than those in the signaled groups in both yoked and escape/avoid conditions. Rats in the escape/avoid groups made more wheel turns than yoked rats in both signaled and unsignaled groups. There were more ulcers produced in the unsignaled groups than in the signaled groups. Weiss proposed two factors to account for the results. First, as "relevant feedback" decreased, ulcerations increased. Second, the more "coping responses" (i.e., wheel turns) made, the greater the ulceration.

Seligman and Binik (1977) reexamined Weiss's propositions and suggested that "relevant feedback", i.e., the stimulus which follows the response but is not associated with the aversive stimulus, was a safety signal in that it predicted the absence of shock. An animal, therefore, which makes the successful escape or avoidance response is presented with this SS thereby reducing or eliminating fear and hence resulting in fewer ulcers. Second, Weiss maintained that the rats ulcerated more because they responded more. Seligman and Binik pointed out, however, that unsignaled groups should in fact wheel turn more because they have no CS+, whereas signaled groups only wheel turn during the CS+. The greater amount of fear produced by the lack of a SS produces more wheel turning and more ulceration. In a nondiscriminative avoidance situation (Sidman avoidance), the animal has no indication of response consequence except when no responding is followed by shock, in which case, it responds much more than in a discriminated (pre-aversive stimulus provided) situation.

Several investigators have attempted to separate the safety signal hypothesis from the preparatory response hypothesis. Arabian and Desiderato (1975) reported that organisms spend more time in situations where a safety signal is present compared to ones where only a preparatory signal is present. In their study, rats were exposed to different light-tone-shock contingencies on each of two sides of a shuttle box. One contingency (S/P) provided both a safety signal and a signal predicting shock, another contingency (NS/NP) provided neither, and a third (S/NP) provided a safety signal but no signal predicting shock. Rats spent more time on either the S/P or the S/NP side of the shuttle box. When allowed to choose between S/P and S/NP, rats spent 82% of the time on the S/NP side of the box, demonstrating a clear preference for a safety signal in contrast to a signal specifically predicting shock. An issue arises from this type of study having to do with the question of whether the absence of a CS+ is in itself an adequate SS. That is, when a CS+ for shock is present and there is no other stimulus, is the absence of the CS+ the same as a SS? This query is treated more later.

Several investigators have found that providing escape from the preparatory signal is a reinforcing event indicating that as a stimulus which is explicitly paired with shock, the preparatory signal becomes a conditioned aversive stimulus (Kalish, 1954; McAllister & McAllister, 1962). Organisms tend to avoid conditioned aversive stimuli (by definition). Such a tendency may explain why the rats in Arabian and Desiderato (1975) preferred the side of the shuttle box which did not present a stimulus predicting shock.

Badia and colleagues have also investigated the preference for signaled over unsignaled shock in terms of separation of the safety signal hypothesis from the preparatory response hypothesis. For example, they demonstrated that rats would select longer or more intense signaled shock in contrast to shorter or weaker but unsignaled shock (Badia, Coker, & Harsh, 1973; Badia, Culbertson, & Harsh, 1973).

In two experiments, Badia et al. (1973) presented unsignaled, inescapable shocks to rats. By pressing a lever, the rats could change the condition to signaled shock for 3 minutes. In the first study, the duration of the signaled shock was increased. All four subjects responded to receive signaled shock that was four (2.0 sec) to nine times (4.5 sec) longer than unsignaled shock (0.5 sec). In the second study, the intensity of the signaled shock was increased. All six subjects changed to signaled shock which was two (2.0 mA) to three times (3.0 mA) more intense than unsignaled shock (1.0 mA). Using similar methodology, Badia et al. (1973) increased the density of signaled shock. All four rats changed to signaled shock even when the signaled shock density was two times the density of the unsignaled shock, and three of the four subjects changed to signaled shock of four times the density of the unsignaled shock. Further study showed that the rats responded when the consequences were lower rather than higher shock density if both densities were unsignaled. Both of these studies stressed the reinforcing effects of safety signals.

Other work by the same group of investigators has demonstrated that a safety signal is necessary and sufficient in order for preferences to develop for signaled shock, whereas having the opportunity to make a preparatory response is neither necessary nor sufficient to produce such preference (Badia & Culbertson, 1972). Using the changeover procedure described above, Badia and Culbertson presented two stimuli during a 3-minute signaled shock period. One was correlated with safety in the signaled shock condition, while the other was the stimulus specifically correlated with shock. Following initial training, where the rats spent approximately 85% of the time in the signaled shock condition, the signaled shock condition was changed either to (1) unsignaled shock, (2) safety signal with no stimulus predicting shock, or (3) no safety signal with a stimulus predicting shock. When changeover produced unsignaled shock (Condition 1) or when it only produced a preshock stimulus (Condition 3), changeover responding decreased to near baseline levels. However, when changeover produced only the safety signal with no preshock stimulus, changeover responding only decreasesd slightly from when both stimuli were present. These results held for both escapable and inescapable shock conditions. Badia and Culbertson explained their results in terms of the safety signal hypothesis. They argued that shock-free periods were not clearly identifiable in either Conditions 1 or 3, so changeover responding was expected to decrease. In Condition 2, where shock free periods were identified, responding was maintained.

From the above, it can be seen that the safety signal hypothesis has considerable support. The uncertainty reduction hypothesis is identical to the safety signal hypothesis with regard to preference for signaled over unsignaled shock with two notable exceptions. The uncertainty reduction hypothesis predicts preference for a situation where p(US/CS+) = 1 over p(US/CS+) = .5, where p(US/SS) = 0 and where equal numbers of USs occur. To date, this aspect of the uncertainty reduction hypothesis has not been thoroughly examined. Second, the safety signal hypothesis predicts that the SS is in fact a conditioned stimulus (Seligman & Binik, 1977). This aspect has been shown to some extent in the work of Badia and colleagues. It should be noted that although the uncertainty reduction hypothesis does not preclude conditioning of the SS, it does not predict it.

Within the framework of the safety signal hypothesis, some discussion has been generated about the hedonic value of the safety signal (see discussion following Seligman & Binik, 1977). Until recently, research has considered the safety signal hypothesis in comparison to the two other hypotheses advanced to explain the preference on the part of a variety of organisms for signaled over unsignaled shock. Attributes of the safety signal have not been examined in detail. Are there differences between SSs depending on the intensity of the shock which they predict the absence of? Is a SS that is associated with the absence of a strong shock more strongly conditioned than a SS associated with weak shock, in that the former is associated with greater "relief" (Seligman & Binik, 1977)? Are there differences between conditioning to SSs within predicted and unpredicted shock situations, since a SS with predicted shock is somewhat redundant to the CS+ where p(US/CS+) = 1?

The remainder of this review will discuss a methodology for examining these questions and review literature surrounding such methodology.

The Opponent Process Model

According to classical conditioning theory, reconditioning an appetitive stimulus to a different appetitive US should result in more rapid conditioning compared to conditioning to a neutral stimulus. Retardation of conditioning, defined as a delay in the conditioning of the response, should only occur if an appetitive CS+ is reconditioned using an aversive US or an aversive CS+ is reconditioned with an appetitive US (Dickinson & Pearce, 1977; Konorski, 1967; Rescorla & Solomon, 1967; Scavio & Gormezano, 1980). The phenomenon of differential response conditioning rates (i.e., facilitation or retardation) when reconditioning a stimulus to a different US has led to the development of the opponent process model (Gray, 1975; Konorski, 1967; Rescorla & Solomon, 1967).

The model suggests that appetitive and aversive motivational states influence one another in an antagonistic fashion. Increased strength in one state produces decreased strength in the other state. This model indicates that the CS+ acquires the hedonic value of the US with which it is associated. For example, a CS+ which signals impending inescapable shock acquires an aversive hedonic value. Subsequent pairing of the CS+ to a US which is hedonically opposite to the original US would then retard acquisition of the conditioned response (CR). If, for example, a CS+ which has acquired aversive hedonic value is reconditioned to an appetitive US such as food, the acquisition of the CR will be delayed over the acquisition of the CR to a neutral stimulus. An extension of this model has been developed

(Gray, 1975; Rescorla & Solomon, 1967), and it predicts that a stimulus which is unpaired with a US acquires an hedonic value opposite to that US. Subsequent pairing of this stimulus with a second US, which is hedonically opposite to the original US, should, therefore, facilitate conditioning to the second US.

Most of the research on the opponent process model has concerned the problem of aversive to appetitive CS+ transfers. While there is good evidence for an established aversive CS+ retarding conditioning of responses to an appetitive US, the evidence for similar effects in appetitive to aversive transfer situations is equivocal. While some researchers have reported retardation as the model predicts (e.g., Goodkin, 1976), others have reported facilitation (e.g., Bacon & Bindra, 1967; Bromage & Scavio, 1978; Scavio & Gormezano, 1980). Because of this inconsistency of predictions and asymmetry, it has been recommended that a serious reexamination of the opponent process model be undertaken (Bromage & Scavio, 1978).

Other possible transfer situations, specifically aversive to aversive and appetitive to appetitive transfers, have not been well examined. Most research has concentrated instead on retardation in unlike, i.e., appetitive to aversive or aversive to appetitive, transfer situations. However, similar transfer situations (aversive to aversive or appetitive to appetitive) also need extensive examination in order to finally determine the status of this aspect of the model. With regard to the hedonic value of safety signals, reconditioning to an appetitive US should logically be facilitated if the safety signal has acquired an hedonic value opposite to that of shock. This is the direction of transfer attempted in the present study as described below.

Use of Preconditioning Stimuli in Classical-Classical Transfers

There are a variety of transfer methodologies which could be used in addressing questions regarding the hedonic value of various safety signals. Much of the safety signal research has been performed in the framework of conditioned suppression, i.e., the superimposing of classically conditioned aversive CSs and SSs on operantly maintained baselines to examine response suppression. For example, Rescorla and LoLordo (1965) trained dogs in a shuttle box to avoid shock on a Sidman avoidance schedule and were subsequently classically conditioned to various presentations of tones and shock. The tones were then presented while the subjects were performing the avoidance response. Tones which had predicted shock (CS+) increased the rate of responding, while tones which predicted the absence of shock (SS) suppressed responding.

Some researchers, notably Scavio (1974), have suggested that a conditioned suppression methodology, as well as other forms of classical to instrumental transfer learning methodology, are only indirect measures of classically conditioned aversiveness and that other methods are necessary to examine direct effects. He argued that the instrumental (operant) performance is under the control of many stimuli, and when the CS+ (or SS) is superimposed on the stimuli, the result is an interaction among all the stimuli present. This, for example, is seen when the operant reinforcement schedule is either a fixed ratio (FR) or variable ratio (VR). Rats on FR schedules of positive reinforcement are sensitive to conditioned suppression only at the beginning of each post-reinforcement run of responding (Lyon, 1964; Lyon & Felton, 1966a), and rats on VR schedules are insensitive to conditioned suppression (Lyon & Felton, 1966b). This criticism does not necessarily alter the value of conditioned suppression research, but it does suggest that other methodologies might be used effectively in examining the effects of conditioned stimuli on behavior. Scavio (1974) argued for the use of reconditioning in a classical-classical transfer methodology as opposed to classical-instrumental methodology.

Classical-classical transfers have been described above as reconditioning. To briefly reiterate, an organism is exposed to classical conditioning, i.e., the repeated pairing of a neutral stimulus with an unconditioned stimulus, and gradually develops a conditioned response (CR) to the neutral stimulus. The neutral stimulus is now a conditioned stimulus (CS+). The CS+ is then paired with a different unconditioned stimulus. As described by the opponent process model, facilitation or retardation of development of a CR to the new CS+, when compared to acquisition of a CR to a neutral stimulus, will occur depending upon whether the USs are similar or opposite in hedonic value. Specifically, facilitation is predicted when the USs are similar, for example, in an appetitive US-appetitive US transfer. Retardation is predicted when the USs are opposite, for example in an appetitive US-aversive US transfer.

Scavio (1974) has performed a number of experiments with rabbits to investigate aversive US to appetitive US transfer. The aversive US was a brief shock delivered near the eyelid resulting in an unconditioned response (UR) of nictitating membrane movement. The appetitive US was water delivered through a cannula into the oral cavity resulting in an UR of jaw movement. Scavio (1974) exposed rabbits to this classical aversive conditioning of the nictitating membrane response, then, using the same CS+ looked for transfer effects upon subsequent classical appetitive conditioning of the jaw movement response. Prior aversive conditioning to the CS+ clearly interfered with a transfer to appetitive conditioning. Rabbits which were exposed to unpaired CS-US or received no conditioning of the nictitating membrane response showed faster acquisition of the jaw movement CR in comparison to those exposed to paired CS-US conditioning of the nictitating membrane response. Since the two responses were shown to be independent of each other (performing one does not preclude performing the other), this interference with subsequent conditioning was considered to be a distinct measure of the hedonic value of the CS+ alone.

Using similar methodology, Bromage and Scavio (1978) further examined the prior conditioning of a CS unpaired with the aversive US for the nictitating membrane response on subsequent conditioning of the CS+ with the US for the jaw movement response. The opponent process model (Gray, 1975) predicted that the CS+ unpaired with the aversive US would acquire appetitive hedonic value, and subsequent pairing of this CS+ to an appetitive US should result in facilitation of the new CR. The results of this study supported the opponent process model. Acquisition of the jaw movement response was facilitated in comparison with no treatment controls.

Scavio and Gormezano (1980) reported an appetitive to aversive transfer wherein they exposed rabbits to classical appetitive conditioning of the jaw movement response, then using the same CS+, examined transfer effects upon subsequent classical aversive conditioning of the nictitating membrane response. Although the opponent process model predicts retardation in appetitive-aversive transfer, surprisingly they found facilitation. Additionally, a stimulus completely unpaired with the water US, when used as the CS+ in conditioning the nictitating membrane response, retarded acquisition of the response. According to the opponent process model, the stimulus unpaired with water should acquire hedonic value opposite to the hedonic value of water, specifically it should be aversive. Therefore, transferring this stimulus to an aversive US should have been facilitated, if the opponent process model held.

To briefly review the work of Scavio and his colleagues (Scavio, 1974; Bromage & Scavio, 1978; Scavio & Gormezano, 1980), the opponent process model was shown to obtain in aversive to appetitive (Scavio, 1974) and in appetitive to appetitive (Bromage & Scavio, 1978) transfers. However, an apparent appetitive to aversive transfer (Scavio & Gormezano, 1980) did not support the model.

This apparent asymmetry of predictability may force reconsideration of the model. Other researchers have also reported problems with the model. For example, Bacon and Bindra (1967) reported facilitation in an appetitive-aversive transfer (which should not have happened). Konorski (1967) noted the possibility that aversive CSs promote motivation, whereas appetitive CSs reduce motivation. While this interpretation allows for asymmetrical transfer effects, other explanations which do not rely upon hypothetical internal states should be developed.

Currently, most experimental events are characterized as being either aversive or appetitive. The absence of an aversive event is therefore considered to be appetitive (Gray, 1975). Moreover, in a transfer situation, there is assumed to be equivalence between a stimulus predicting the absence of an aversive event and a stimulus predicting the occurrence of an appetitive event, even though differences between the two events are apparent. Specifically, the absence of shock is not known to elicit a response on the part of the organism, whereas presentation of food does elicit a response, yet both would be considered appetitive. According to the safety signal hypothesis, in a situation where safety from shock is predicted by a safety signal, the presentation of the safety signal reduces fear (Seligman & Binik, 1977). This is seen, for example, in conditioned suppression research, where organisms suppress avoidance responding when a previously conditioned safety signal is presented (Rescorla & LoLordo, 1965). Further investigation into the hedonic value of a stimulus signaling the absence of an event may lead to a better understanding of the comparability of a stimulus paired with the absence of shock and a stimulus paired with the occurrence of food.

Apart from the opponent process model, literature from the area of classical appetitive conditioning of the keypeck response in pigeons has examined the effects of preconditioning on response acquisition of the keypeck. The keypeck response in this instance is produced when pigeons are exposed to repeated presentation of an illuminated response key immediately followed by access to food or water. This conditioning is called autoshaping (Brown & Jenkins, 1968). It is similar to the conditioning of the jaw movement response in rabbits in which rabbits are exposed to an auditory stimulus immediately followed by injections of water into the mouth. In this case, the conditioned response (CR) is movement of the jaw during presentation of the auditory stimulus, whereas in autoshaping the CR is pecking of the illuminated response key. In both cases, the topography of the response is similar to the unconditioned response to the US (Moore, 1973; Scavio, 1974). Specifically, the autoshaped response resembles either drinking or eating responses depending upon the US used (Moore, 1973). This finding is further support for the concept that the CS+ for a particular US does in fact take on properties of that US. Hence, one is clearly led to suggest that hedonic values are conditionable from US to CS+.

Three types of stimulus preexposure in autoshaping have been examined. The first type involves various preexposures to presentations of the US, such as extended magazine training (Downing & Neuringer, 1976; Steinhauer, Davol, & Lee, 1976). The second manipulation involves explicitly unpaired presentations of keylight (CS+) and food (US) (e.g., Tomie, 1976; Wasserman & Molina, 1975).

The third type of preexposure involves presentations of the CS+ prior to autoshaping, either alone (Tranberg & Rilling, 1978) or paired with an aversive US (Eldred & Cheney, Note 1).

Differences in the number of magazine training trials prior to the autoshaping procedure cause substantial differences in the number of trials to acquisition of the keypeck response. In general, the greater the number of magazine training trials, the fewer trials to acquisition (Steinhauer et al., 1976). However, a great number of magazine training trials, e.g., 1000, results in substantial delays in acquisition of the keypeck (Downing & Neuringer, 1976). Unfortunately, only two values above 25 trials have been examined, i.e., 100 and 1000, making it impossible to detail large portions of this apparently U-shaped function. However, this work does indicate that trials to acquisition can be a discriminating measure with regard to preexposure of stimuli prior to autoshaping.

Pigeons preexposed to seven sessions of 18 explicitly unpaired presentations of grain and keylight each did not develop a keypeck response to the keylight (Wasserman & Molina, 1975). Following such preexposure, the same CS+ was explicitly paired with food. Control groups included a no pretreatment group and a group which received explicitly unpaired pretraining to a stimulus which was not used during autoshaping. The acquisition of the keypeck response (median trials to first peck) was statistically significantly retarded, at the .01 level, with respect to the two control groups. In terms of the opponent process model, this was a demonstration of an aversive-appetitive transfer and the results supported the model.

Tomie (1976) investigated prior exposure to a tone stimulus uncorrelated with food, followed by autoshaping to a keylight. If birds received the preexposure in the same setting (i.e., the context was the same) as they were later autoshaped in, acquisition of the keypeck was delayed. However, birds preexposed in a different setting (i.e., the context was different) showed no delays in acquisition compared with control birds which had no preexposure or control birds which had preexposure to correlated presentations of food and tone. Tomie argued that a blocking interpretation (Kamin, 1969) accounts for these results as opposed to what Tomie considers a general transfer of learning interpretation. The latter interpretation states that animals exposed to an unpredictable US learn that it is unpredictable, and this knowledge proactively interferes with the acquisition of autoshaping. A blocking interpretation suggests that acquisition is retarded because the contextual, environmental stimuli become associated with the US during preexposure and subsequently prevent (block) the association of the US with the keylight CS+. Therefore, preexposure in a different context should not interfere with autoshaping as the previous contextual stimuli are absent. It should be emphasized that no stimuli, except the presentation of food, were the same in the two settings, so this was not a demonstration of a strict classical-classical transfer.

Others have investigated preexposure to CS-US correlations by allowing only observation of the stimuli. Browne (1976) extensively magazine trained pigeons (five sessions of 60 presentations each), then exposed them to explicitly paired keylight and visible but inaccessible grain presentations (three sessions, 60 trials each) prior to autoshaping. Three control groups were used. One was exposed to random presentations of the CS+ and US. The second control group was exposed to explicitly unpaired presentations of the CS+ and US. The third received presentations of only the US. Pigeons observing the explicitly paired presentations of CS+ and US pecked sooner, at higher rates, and on more trials than the first two control groups. However, the performance of the US only control group was similar to the experimental group exposed to explicitly paired CS-US presentations. Critically, a no treatment control group was not included, so no statements can be made regarding whether response acquisition of experimental and US-only groups was facilitated or whether response acquisition of the random and explicitly unpaired groups was retarded.

In response to this report, Oberdieck and Cheney (Note 2) performed similar work but without extensive magazine training. Four groups were used: explicitly paired presentations of CS-US, no treatment control, exposure to the chamber alone, and random presentations of CS+ and US. They found that such observation preexposure neither facilitated nor retarded subsequent autoshaping in that the mean trials to acquisition did not differ among groups. Additionally, it should be noted that in both Browne (1976) and Oberdieck and Cheney (Note 2), individual subject data within groups, while not specifically discussed in either study, was quite variable. The size of the groups (n = 8) and the use of medians as opposed to means in the Browne study produced a stronger argument than the Oberdieck and Cheney study. However, the Browne study certainly lacks several appropriate controls seen in the Oberdieck and Cheney study.

Tranberg and Rilling (1978) examined preexposure to the to-be-CS+ prior to autoshaping. Two groups of pigeons were preexposed to the chamber for 10 sessions, and one group was additionally exposed to the to-be-CS+ for 50 trials per session (500 CS+ only trials). Both groups were then autoshaped. Birds preexposed to the to-be-CS+ plus the chamber took longer to acquire the keypeck response and had fewer trials with a CS+ peck, as well as lower overall pecks per trial for the first 200 trials, than the birds which were preexposed to the chamber alone. CS+ preexposure was effective even though it was imbedded in the context.

Eldred and Cheney (Note 1) examined the use of a conditioned aversive stimulus as a CS+ in autoshaping. Pigeons which received 45 pairings of the to-be-CS+ with 90 volts of shock were delayed in subsequent acquisition of the autoshaped keypeck response over no-treatment controls. Time of preexposure (20 days or 2 days prior to autoshaping) had no differential effect. This retardation was expected in light of previous work by Scavio (1974) in which acquisition of the jaw movement response in rabbits was retarded when an aversive CS+ was used to predict water injections into the mouth.

The literature reviewed so far demonstrates the sensitivity of acquisition of the keypeck response to various stimulus preconditioning/preexposure treatments. If a stimulus has been previously explicitly paired with a US and is subsequently explicitly paired with food in an autoshaping procedure, the acquisition of the keypeck response should vary between groups depending on the hedonic value of the first US. The autoshaping procedure provides a framework with which to examine the hedonic value of safety signals. By preexposing birds to signals explicitly unpaired with shock, and varying both the intensity of shock and signals paired with shock, and then autoshaping to that same signal as a CS+ for food, questions regarding the nature of safety signals can be examined. Within the framework of the opponent process model, this procedure is an appetitive-appetitive transfer, so that acquisition of the autoshaped response should be facilitated when the CS+ explicitly paired with food has been previously explicitly unpaired with shock.

Additional questions regarding the effects of preexposure to aversive events prior to appetitive conditioning (autoshaping) can be addressed. For example, it has been shown that preexposure to inescapable/uncontrollable shock will cause delays in subsequent escape/avoidance learning (Seligman, Maier, & Solomon, 1971). This phenomenon has been termed the learned helplessness effect. This effect has traditionally been examined within an operant conditioning paradigm.

For example, Overmier and Seligman (1967) preexposed one group of dogs to unsignaled, inescapable shock. Subsequently, the dogs received signaled escape/avoidance training in a shuttle box. The dogs preexposed to unsignaled and inescapable shock demonstrated severely retarded acquisition of the escape response over dogs which were not preexposed to shock.

Learned helplessness has not been well researched in the area of classical conditioning. It is unknown whether preexposure to unsignaled, inescapable shock will effect classical appetitive conditioning. Since an enormous amount of research considered the pigeon keypeck response to be an operant, the question has been raised as to whether autoshaping as a classical conditioning procedure develops a classical response or an operant response (Brown & Jenkins, 1968). Learned helplessness research has clearly demonstrated that operant responding is effected by preexposure to unsignaled, inescapable shock. If such preexposure does not effect acquisition of the autoshaped response, further support would be given to the autoshaped response as a classically conditioned response argument.

CHAPTER III

STATEMENT OF PROBLEM

Previous research has attempted to determine which of three possible hypotheses best describe the data concerning organisms' preference for signaled shock. The most widely accepted of the three is the safety signal hypothesis which suggests that during the absence of a CS+ for shock, the organism is not fearful. Without such a CS+ signaling impending shock, the organism is presumably fearful all of the time throughout the procedure. However, little research has investigated the critical properties of stimuli signaling the absence of shock, i.e., safety signals.

According to the opponent process model (Gray, 1975), stimuli predicting the absence of a US acquire hedonic value opposite to that US. In the case of safety signals, this model would predict that safety signals are appetitive in value. In a situation where such a safety signal was subsequently used as a CS+ to predict an appetitive US, acquisition of a response to the CS+ should be facilitated. Various properties of safety signals could be examined using transfer (reconditioning) methodology, specifically developing the safety signal then using the safety signal as a CS+ for food.

The purpose of the present study was to investigate critical properties of safety signals by exposing pigeons to various types of signals and then using the signal to predict a food US in an autoshaping procedure. The following questions regarding the properties of safety signals (SS) were examined.

1. Are there differences in conditioning variables that occur when the SS is explicitly paired with the absence of different levels of shock intensity?

2. Are there differences in appetitive conditioning that occur to the SS between those SSs present in a procedure where shock is explicitly paired with a specific stimulus and those SSs present in a procedure where shock is not explicitly paired with a specific stimulus?

3. What are the effects on subsequent autoshaping of preexposing pigeons to inescapable shock with no stimuli either explicitly paired or unpaired with the shock?

In order to examine these questions, groups of pigeons were repeatedly and inescapably shocked at either 30 or 90 volts. Each individual 0.5 sec shock was (a) predicted by a specific CS+, or (b) not predicted by a CS+. Additionally and explicitly unpaired with the shock, a safety signal was presented. For each voltage level, a control group of pigeons was repeatedly shocked with no stimuli presented at any time. One additional group received no aversive treatment. Another group received stimulus presentations but were never exposed to shock. All birds were then autoshaped with a red key light CS+. For four groups of birds, this colored key had been the safety signal. In one group, it had been a stimulus explicitly paired with shock, and for another group, no consequences (i.e., shock or its absence) had been paired with the stimulus. For four more groups this was a novel stimulus. To summarize, the groups were:

A. CS for shock and SS both present:

Group 1 - 90 volts; autoshaped to the SS
Group 2 - 30 volts; autoshaped to the SS
Group 8 - 90 volts; autoshaped to the CS
Group 9 - 90 volts; autoshaped to a novel stimulus

B. SS presented, no CS explicitly paired with shock:

Group 3 - 90 volts; autoshaped to the SS
Group 4 - 30 volts; autoshaped to the SS

C. No stimuli (SS or CS) presented, only shock:

Group 5 - 90 volts; autoshaped to a novel stimulus
Group 6 - 30 volts; autoshaped to a novel stimulus

D. Stimuli presented (as Groups 1 and 2) but no shock:

Group 10 - autoshaped to the "SS" (as Groups 1 and 2)

E. No pretreatment:

Group 7 - autoshaped to a novel stimulus

CHAPTER IV

METHODS

Subjects

Subjects were selected from a population of 95 naive common pigeons and randomly assigned to groups. When attrition occurred, replacement birds were drawn from this population in order to attain 6 birds per group.

Subjects were maintained at 80% of their free-feeding weight. Water was available at all times in their home cages.

Apparatus

The shock chamber consisted of a cage (23 cm by 18.3 cm by 36.3 cm) with wire mesh (.63 cm by .63 cm) top, bottom, and sides, and solid metal or cardboard end panels which itself was housed in a 70 cm by 70 cm by 70 cm acoustically tiled wooden box. The stimulus display was centered on the cardboard end panel of the cage and consisted of a 2.5 cm circular hole through which the stimuli were displayed. The apparatus displaying the stimuli was identical to that in the autoshaping chamber.

Events were programmed using electromechanical equipment located in an adjacent room. Shock was delivered by a variable output shock generator, connected through a relay, to the electrodes placed in the subject's body. Resistance across the system was constant and equal to 13,500 ohms (± 1,500 ohms). Shock voltage levels of 90 and 30 were equivalent to 6.6 mA and 2.2 mA respectively. During conditioning, the room exhaust fan was on, and a small night light, placed in back of the subject's wire cage, provided diffuse light within the chamber.

The autoshaping chamber was a Coulbourn three-key operant chamber (with the two side keys covered) measuring 28.75 cm by 24.38 cm by 29.38 cm. This was housed inside a larger sound attenuating chamber. The center key (2.54 cm in diameter) was transilluminated by colored light produced by capping a 28v GE No. 1820 light bulb with an appropriate color cap. For stimulus display in the shock chamber, color caps were red and green, while in the autoshaping chamber, only red was necessary. Caps were identical and illuminated by the same type of bulb. To the human observer the appearance of keys in both chambers was identical. The US was Purina racing pigeon checkers provided in a hopper illuminated by a 28v GE No. 1820 bulb. The key operated with a pressure greater than .16 N. Events were programmed and responses recorded using electromechanical equipment located in an adjacent room.

Since the standard autoshaping procedure using an 8 sec CS, 3 sec US, and variable time (VT) 60 sec intertrial interval (ITI) produced rapid acquisition of the keypeck (Gibbon, Baldock, Locurto, Gold, & Terrace, 1977), this procedure was not used, as minute facilitation effects might have been difficult to detect. Instead, an 8 sec CS+, 3 sec US, and VT 24 sec ITI was used. The extensive work of Gibbon et al. (1977) and Muller and Cheney (1975) demonstrated that trials to first peck (using a VT 24 sec ITI) will be approximately two times as great as the standard procedure (using a VT 60 sec ITI). In this case, approximately 70 trials as opposed to 30 trials was expected to acquisition. This allowed for any facilitation effects to be seen as well as any retardation effects.

Procedure

Magazine Training

Subjects at 80% free feeding weight were magazine trained prior to any conditioning. On Day 1, each was individually placed in the autoshaping chamber with the white house light on and the filled food hopper raised and illuminated with white light. The hopper funnel contained approximately 8 grams of checkers. An observer watched each subject and after the subject ate the 8 grams of checkers in the hopper funnel, it was returned to its home cage. On Day 2, the subject was returned to the chamber, and the hopper was again raised and illuminated. Once the subject had eaten for 5 sec from the hopper, the hopper was lowered and raised on a fixed time 15 sec schedule with 4 sec access to checkers (programmed magazine training) until the subject reached criterion. Criterion was defined as eating from the hopper on 12 out of 15 consecutive trials. Each programmed magazine training session contained 30 trials and all trials were observed.

Aversive Conditioning

Within three days following magazine training, subjects were randomly assigned to groups and individually exposed to the aversive experience. Following subcutaneous implantation of wire loop electrodes into the lower back of the pigeon, the pigeon was restrained by wrapping its body in plastic netting and placing it into a solid plastic container. This restraint system prevented the subject from rolling during administration of shock and effectively kept the subject in the same place, relative to the CS+, throughout the procedure. The pigeon was then placed so that its beak was approximately 5 cm from the front panel. This placement ensured that the stimuli were displayed immediately in front of the subject and, because of the restraint system and proximity to the stimulus display, prevented the subject from turning away or otherwise not being exposed to the stimuli.

Six of the groups varied in terms of the types of signals provided and the intensity of shock delivered (30 or 90 volts). The types of signals provided were (a) shock predicted by a CS+ (green) and explicitly unpaired with a SS (red) (Groups 1 and 2); (b) shock with no predictive stimulus and explicitly unpaired with a SS (red) (Groups 3 and 4); and (c) shock delivered at the same times as (a) and (b) but no signals given (Groups 5 and 6). Finally, one group was never exposed to any of these preautoshaping conditions (Group 7). Group 8 received 90v shock predicted by a CS+ (red) and explicitly unpaired with a SS (green). Group 9 received 90v shock predicted by a CS+ (green) and explicitly unpaired with a SS (white). Group 10 received no shock (electrodes were not implanted) but was exposed to the same CS+ (green) and SS (red) presentations as Groups 1 and 2. Table 1 provides a summary of group treatments. Figure 1 diagrams presentations of CS+, SS and US for each group. Each bird was given one 70-minute session consisting of 80 trials each of CS+/US and/or SS. The stimulus display was not illuminated between trials. Following conditioning, the electrodes were removed,

Table 1

Summary of Stimulus Exposures for Each Group

GROUP	Signaled 90v 1	Signaled 30v 2	Unsignaled 90v 3	Unsignaled 30v 4	No Signals 90v 5	No Signals 30v 6	No Treatment 7	Signaled 90v 8	Signaled 90v 9	Signaled no shock 10
PRETREATMENT:										
8 sec Safety Signal (SS)	Red	Red	Red	Red	-	-	-	Green	White	Red
5 sec CS for Shock (CS+)	Green	Green						Red	Green	Green
5 sec Shock Intensity	90	30	90	30	90	30	-	90	90	-
AUTOSHAPING:										
8 sec CS for Food	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
CS previously conditioned	SS	SS	SS	SS				CS+		not predictive
CS new	-	-	-	-	X	X	X	-	X	-

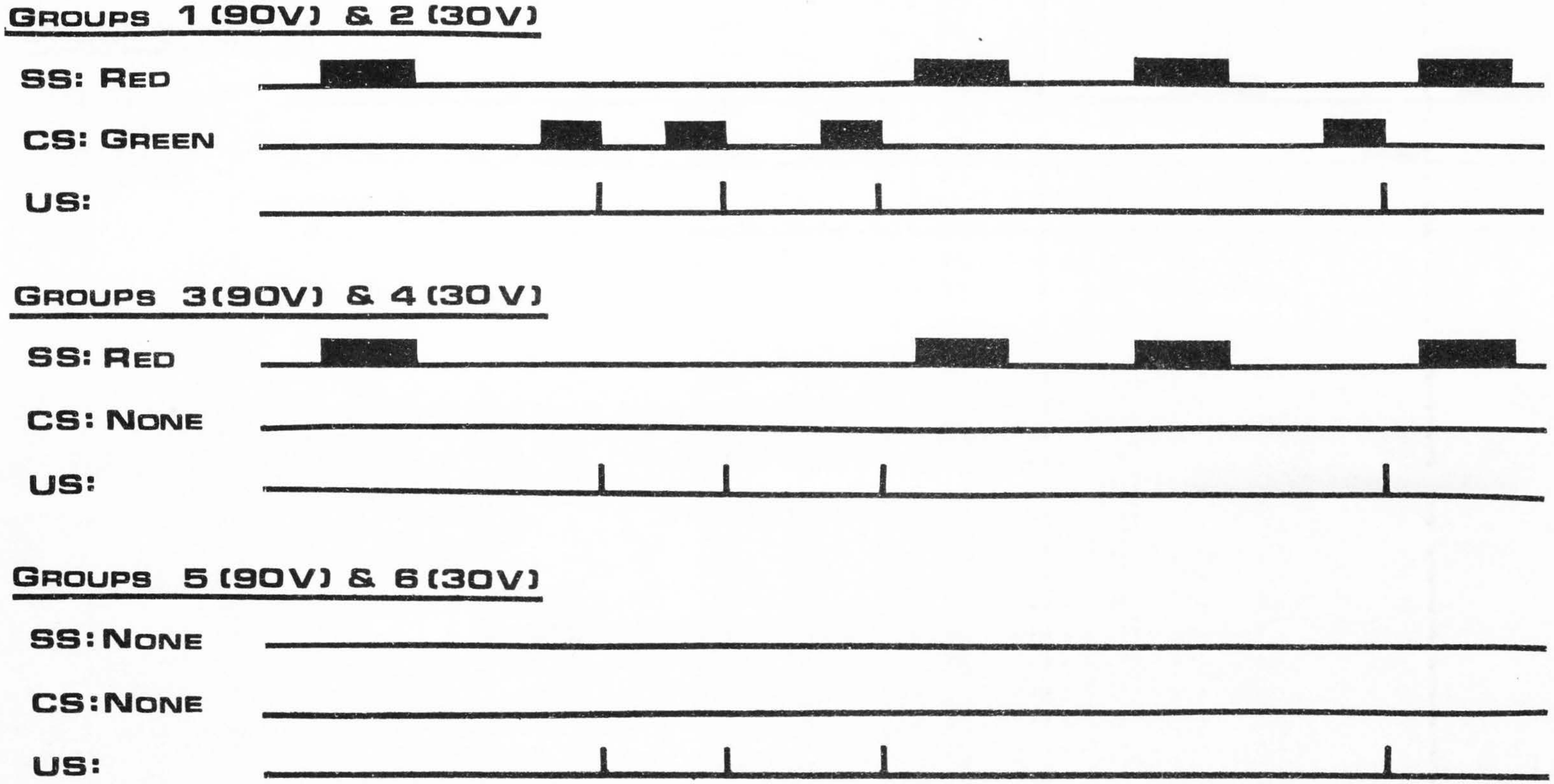
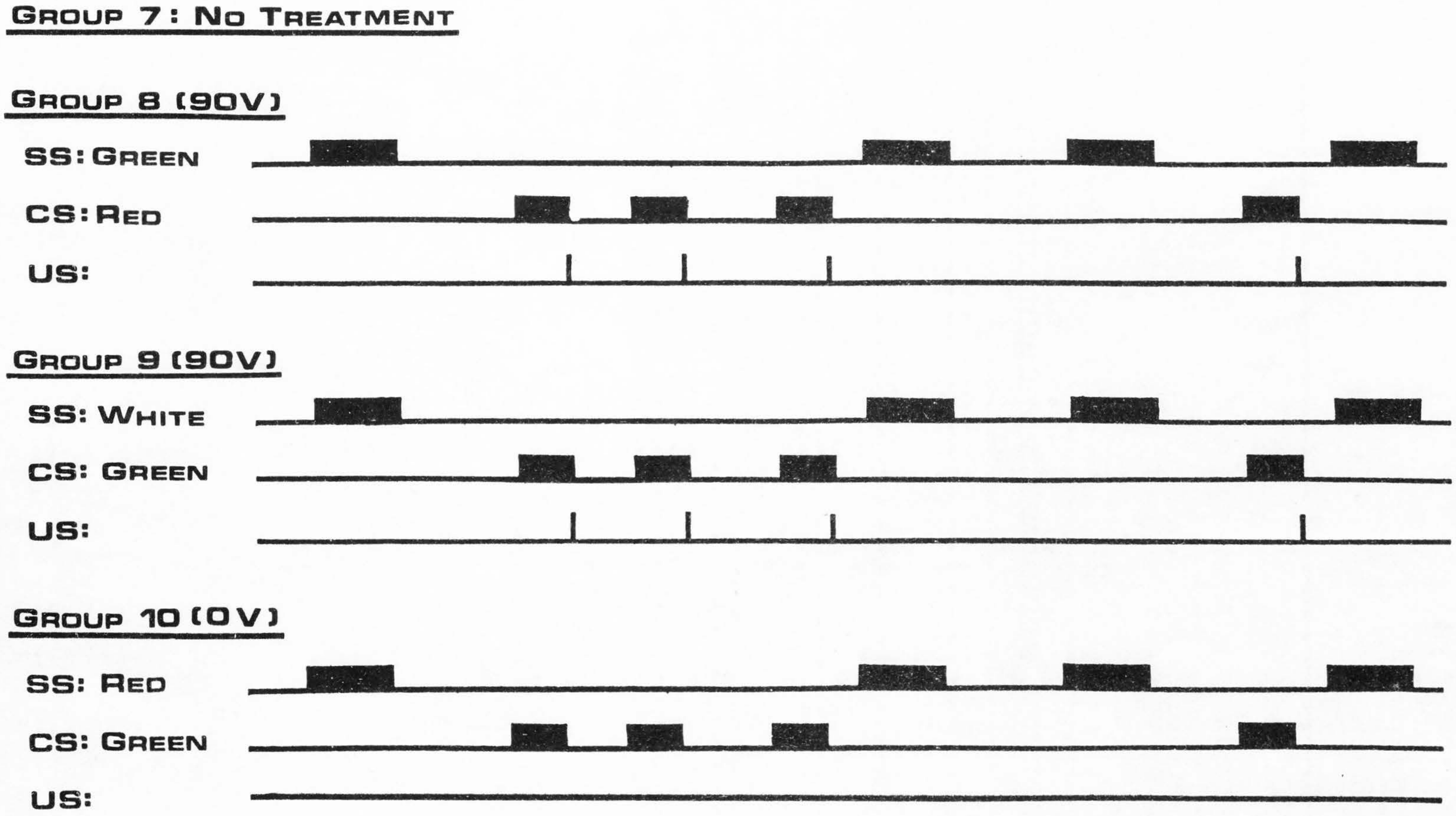


Figure 1. Preautoshaping stimulus presentations for each group (SS = 8 sec, CS = 5 sec, and US = 0.5 sec). A total of 80 trials of SS and/or CS-US presentations were delivered over a single 70-minute session. SSs were explicitly unpaired with presentation of shock. Each CS+ overlapped completely with the US, with both CS+ and US ending simultaneously.

Figure 1 (continued)



medication (Betadine) applied to the surgical area, and the subject returned to its home cage.

Autoshaping

On the fourth day following exposure to the aversive conditioning, subjects were exposed to the autoshaping procedure with a red keylight (CS+) predictive of food. For Groups 1-4 and 10, this keylight was identical to the SS. For Groups 5, 6, 7, and 9, this keylight was a novel stimulus. For Group 8, this keylight was identical to the previous CS+ for shock. There were 50 CS+/US trials per daily session following a schedule of 8 sec CS+, 3 sec US, and VT 24 sec ITI. During each session, each subject was systematically observed to ensure that it was eating consistently from the hopper. Those birds which did not eat consistently (at least 7 out of 10 trials) were eliminated from the study as were subjects which failed to acquire a keypeck response to the CS+ within 200 trials. There were 31 birds rejected for these reasons. Subjects were not run on days when they were not at 80% (±4%) of their free-feeding weight. Subjects were run four sessions (200 trials) following the session during which acquisition occurred. Trials to acquisition were defined as the first of five consecutive CS+ trials with at least one peck (Newlin & LoLordo, 1976).

CHAPTER V

RESULTS

The following data were collected during autoshaping: trials to acquisition, percent of trials with one or more CS+ pecks, percent of trials with one or more CS+ pecks for each of the four post-acquisition sessions, and pecks per CS+ for each of the four sessions following acquisition. The trials to acquisition were defined as the number of the first trial of five consecutive CS+ trials with at least one peck, followed by a peck on at least 50% of the trials during the subsequent sessions. Percent of trials with one or more CS+ pecks was calculated for the first five sessions for each bird. Only data from the first five were used, as five sessions were the maximum number of sessions for some birds (i.e., those birds which acquired in the first session). Additionally, percent of trials with one or more CS+ pecks was calculated for the four post-acquisition sessions for each bird. Mean pecks per CS+ trial were determined by dividing the total CS pecks during a session by the total number of CS+ trials (50). These dependent variables were chosen due to their traditional use in the autoshaping literature, with trials to acquisition being the most common measure seen in the literature. Percent of trials with one or more CS+ pecks was chosen as a secondary measure of acquisition (Leyland & Mackintosh, 1978). The two remaining measures of post-acquisition performance were also found in the literature (Poling & Thompson, 1977; Wesp, Lattal, & Poling, 1977; Woodard, Ballinger, & Bitterman, 1974). Schwartz and

Gamzu (1977) have suggested that acquisition of the autoshaped response is classically conditioned, but maintenance performance on an autoshaping schedule is of a more operant nature, therefore, measures of both acquisition and performance were used in this study. Appendix A lists individual subject data for each group. Descriptive statistics for these measures are listed in Tables 2a and 2b. Group means were used for three of the measures; due to non-normal distribution of the data for percent trials with one or more CS pecks over the first five sessions, medians were used as they are better measures of central tendency (Glass & Stanley, 1970).

A total of 38 birds were dropped from the study (see Appendix B): 5 due to mechanical failures, 2 died, 21 did not acquire the response within 200 trials, and 10 did not eat consistently from the hopper. Every group evidenced some attrition. Of the 21 subjects who failed to acquire the response, two types were evident. Thirteen birds failed to peck on five consecutive trials. In order to ascertain whether the 200 trial limit was appropriate, these 13 birds were run an additional 300 trials (for a total of 500 trials). None of the 13 birds acquired the response within the additional trials. The 8 remaining birds at some point met the criterion of pecking five consecutive trials, but subsequently (and possibly prior) to meeting this criterion, pecks were too weak to activate the key mechanism. This problem ("air pecks") has been noted by other researchers (LoLordo, McMillan, & Riley, 1974; Moore, 1973; Wasserman, 1973; Wasserman & Molina, 1975). Since these birds did not exhibit typical or acceptable behavior, they were dropped

Table 2a

Descriptive Statistics on Two Measures of Acquisition for All Groups: Mean Trials to Acquisition (± Standard Deviation) and Median % Trials with One or More CS Pecks

Group	n	Preexposure Experience SS	CS	Volts	Autoshaped to:	Mean Trials to Acquisition (± Standard Deviation)	Median % Trials with One or More CS+ Pecks. Session: 1	2	3	4	5
1	6	*	*	90	SS	94.0 (±42.1)	0	28	90	96	98
2	6	*	*	30	SS	75.5 (±28.8)	8	61	91	97	97
3	6	*	-	90	SS	126.0 (±42.9)	0	7	68	96	96
4	6	*	-	30	SS	71.7 (±44.8)	0	48	89	88	98
5	6	-	-	90	Novel	76.7 (±23.2)	2	61	91	89	95
6	6	-	-	30	Novel	57.5 (±39.2)	7	79	95	98	98
7	6	-	-	-	Novel	63.3 (±22.1)	4	70	92	100	100
8	5	*	*	90	CS	101.6 (±54.1)	0	48	78	94	92
9	4	*	*	90	Novel	93.3 (±40.3)	1	45	82	91	98
10	6	*	*	-	"SS"	74.5 (±31.4)	3	73	91	95	97
	N = 57										

(* indicates presence during preexposure experience.)

Table 2b

Descriptive Statistics on Two Measures on 4 Sessions of Post-Acquisition Performance: Mean Percent of Trials with at Least One CS Peck (± Standard Deviation) and Mean Pecks Per CS Trial (± Standard Deviation)

Group	n	Preexposure Experience SS	Preexposure Experience CS	Volts	Autoshaped to:	Mean Percent of Trials with at Least One CS Peck Over 4 Post-Acquisition Sessions Session: 1	2	3	4	Mean Pecks Per CS Trial Over 4 Post-Acquisition Sessions Session: 1	2	3	4
1	6	*	*	90	SS	85.3 (±13.5)	94.0 (±11.8)	94.3 (±8.3)	96.3 (±4.6)	7.2 (±3.9)	10.9 (±4.4)	12.9 (±3.8)	14.8 (±3.4)
2	6	*	*	30	SS	92.3 (±10.1)	95.3 (±4.5)	92.3 (±8.8)	96.0 (±4.6)	10.4 (±7.5)	12.1 (±6.9)	12.7 (±8.4)	14.2 (±8.2)
3	6	*	-	90	SS	90.0 (±14.1)	92.0 (±17.7)	91.7 (±10.8)	95.3 (±10.5)	6.8 (±4.1)	8.7 (±5.2)	9.1 (±4.9)	10.2 (±6.7)
4	6	*	-	30	SS	88.7 (±9.6)	89.3 (±10.5)	94.7 (±5.6)	94.3 (±9.8)	6.2 (±3.2)	7.3 (±3.8)	10.4 (±2.1)	9.6 (±3.1)
5	6	-	-	90	Novel	90.3 (±7.8)	91.7 (±5.0)	95.3 (±5.5)	95.0 (±4.3)	7.3 (±6.1)	8.7 (±6.3)	10.5 (±5.8)	12.3 (±5.7)
6	6	-	-	30	Novel	90.3 (±12.9)	94.0 (±11.0)	95.7 (±6.9)	98.0 (±4.9)	9.8 (±6.7)	11.0 (±7.4)	12.2 (±6.0)	14.0 (±5.5)
7	6	-	-		Novel	87.7 (±15.0)	90.7 (±15.3)	98.3 (±2.7)	97.3 (±5.6)	4.9 (±3.7)	6.6 (±4.6)	6.7 (±3.8)	7.0 (±2.5)
8	5	*	*	90	CS	78.8 (±14.2)	92.0 (±4.5)	92.8 (±5.8)	95.6 (±7.0	3.5 (±2.0)	4.3 (±2.0)	5.5 (±2.5)	4.3 (±3.5)
9	4	*	*	90	Novel	86.0 (±8.6)	92.0 (±12.1)	98.5 (±1.0)	93.5 (±13.0)	6.2 (±3.6)	8.8 (±5.3)	9.2 (±5.5)	9.4 (±6.4)
10	6	*	*		"SS"	93.3 (±5.3)	92.7 (±5.5)	97.0 (±2.1)	92.7 (±8.8)	7.3 (±3.6)	7.4 (±4.6)	9.1 (±5.0)	11.2 (±7.0)

(* indicates presence during preexposure experience.)

from the study, as inclusion of their data in the analysis would have been misleading.

Analysis of Acquisition Measures

A two-way analysis of variance (Table 3) on trials to acquisition by volts and signal for shock, for Groups 1-6 revealed that statistically significant differences existed between groups receiving 30 volts and those receiving 90 volts at the .05 level (p = .02). Differences among signaled, unsignaled, and no signal for shock groups were not statistically significant at the .05 level (p = .136).

Gibbon et al. (1977) noted that as mean trials to acquisition increased, as a function of intertrial interval and CS+ durations, the standard deviation also increased. Large variances in the present study were also found in trials to acquisition. Two attempts were made to locate possible sources of variance by performing analyses of covariance on trials to acquisition using bird weight, and number of sessions of programmed magazine training, as covariates in two separate analyses. On the basis of these analyses, neither factor was found to have contributed to the variance in terms of trials to acquisition.

Because of the statistically significant differences between voltage levels, a second one-way analysis of variance was performed to include comparison groups (Table 4). Acquisition data from voltage groups were combined so that Groups 1, 3, and 5 formed a 90-volt group; Groups 2, 4, and 6 formed a 30-volt group; and Groups 7 and 10 formed a 0-volt group (Table 5). Statistically significant

Table 3

Two-way Analysis of Variance: Trials to Acquisition by Signal, Volts for Groups 1-6

SV	df	Sums of Squares	Mean Square	F	Significance of F
Main Effects	3	14538.056	4846.019	3.410	.030
Volts	1	8464.0	8464.000	5.955	.021
Signal	2	6074.056	3037.028	2.137	.136
2-way Interactions					
Volts Signal	2	2521.167	1260.583	.887	.422
Explained	5	17059.22	3411.844	2.401	.060
Error	30	42637.667	1421.256	-	-
Total	35	59696.889	1705.625	-	-

Table 4

One-way Analysis of Variance: Trials to Acquisition by the Combined 90-Volt Groups (1, 3, 5), the Combined 30-Volt Groups (2, 4, 6), and the Combined 0-Volt Comparison Groups (7, 10)

SV	df	Sums of Squares	Mean Square	F	Significance of F
Main Effects	2	10392.674	5196.337	3.964	0.026
Group	2	10392.674	5196.337	3.964	0.026
Explained	2	10392.674	5196.337	3.964	0.026
Error	45	58995.806	1311.018	-	-
Total	47	69388.479	1476.351	-	-

Table 5

Mean Trials to Acquisition (± Standard Deviation) for Groups Combined by Voltage Level: Groups 1, 3, 5 (90-Volt Group), Groups 2, 4, 6 (30-Volt Group), and Groups 7, 10 (0-Volt Group)

Group	Mean Trials to Acquisition	Standard Deviation
90-volt	98.9	40.8
30-volt	68.2	36.8
0-volt	68.9	26.6

differences were found among these three groups at the .05 level (p = .026). Pairwise comparisons were performed between groups using the Newman-Keuls method of multiple comparisons. Statistically significant differences were found between the 90-volt group and the 30-volt and the 0-volt groups at the .05 level. No statistically significant differences were found between the 30-volt group and the 0-volt group. Mean trials to acquisition for all 10 groups are presented graphically for visual comparison in Figure 2.

Considering the differences found in the data regarding trials to acquisition, median percent trials with one or more CS pecks were combined into 90-volt groups (1, 3, and 5), 30-volt groups (2, 4, and 6) and comparison 0-volt groups (7 and 10). A chi square median analysis was performed (Ferguson, 1976) among these three groups for each of the first five sessions of autoshaping. Statistically significant differences were not found at the .05 level (critical value of chi square = 5.99, with 2 degrees of freedom; chi square for each session were 2.32, 5.00, 1.80, 3.18, and 2.28 respectively).

Analysis of Post-Acquisition Performance Measures

A two-way analysis of variance on mean percent of trials with one or more CS pecks by volts and signal for shock for Groups 1-6 revealed no statistically significant differences at the .05 level for any of the four post-acquisition sessions. Additionally, a two-way analysis of variance on total mean percent of trials with one or more CS pecks over four post-acquisition sessions by volts and signal

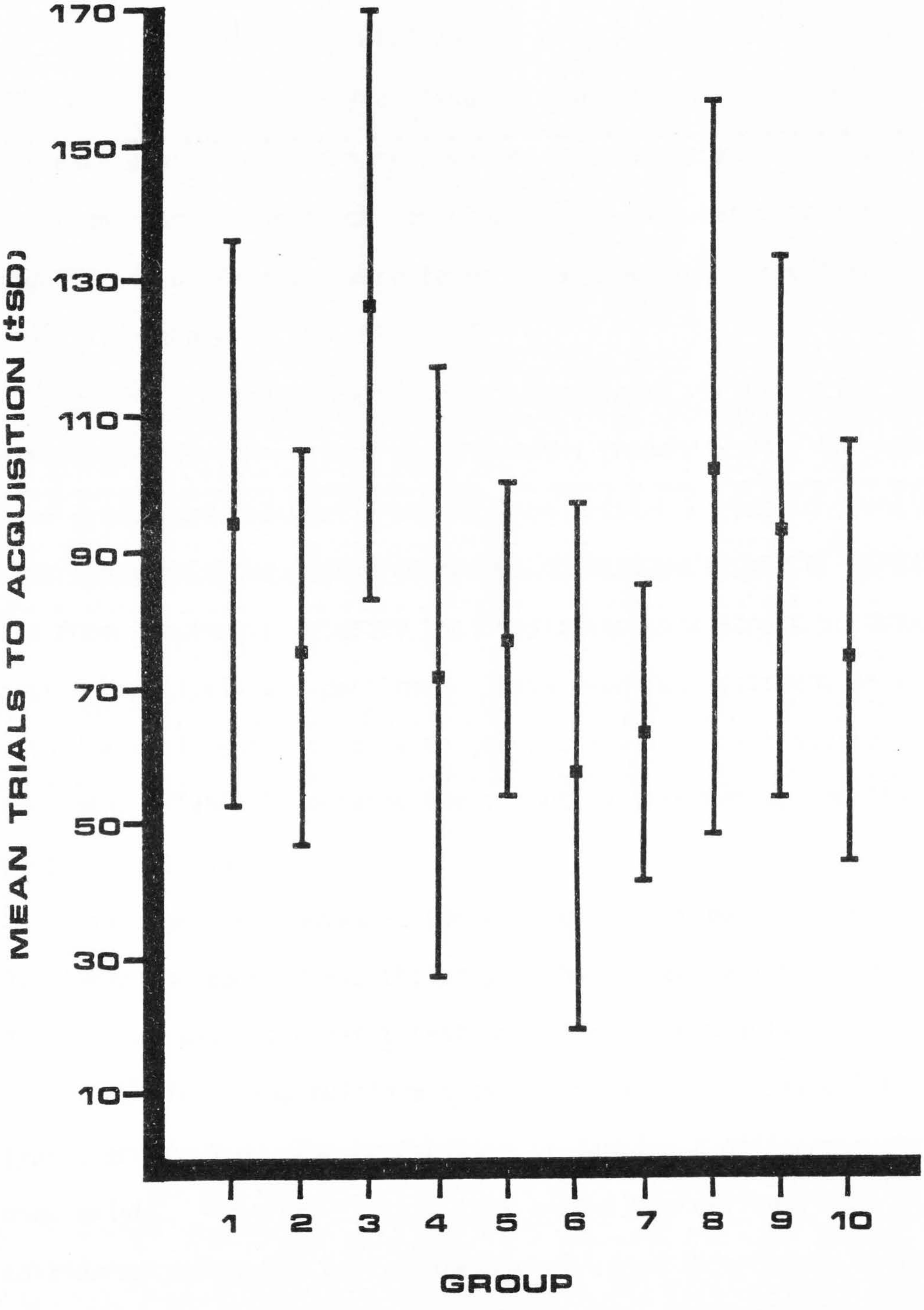


Figure 2. Mean trials to acquisition for each group. Center points are means; lines indicate one standard deviation from the mean. Group 3 required the most trials and Group 6 the least. Group 7 was a no pretreatment control group.

for shock for Groups 1-6 revealed no statistically significant differences at the .05 level.

Mean pecks per CS+ trial varied greatly among subjects within each group. Four two-way analyses of variance were performed (one for each post-acquisition session) on mean pecks per CS+ trial by volts and signal for shock for Groups 1-6. No statistically significant differences were found on any session for either volts or signal for shock at the .05 level.

However, visual examination of mean pecks per CS+ trial revealed differences in the pattern of responding (Appendix C). The means of some groups were basically stable from session to session, while others demonstrated steady increases in mean pecks per CS+ trial over the four sessions. In order to investigate this aspect in detail, a post hoc analysis was performed. Data over four sessions were fitted with lines of best fit for each group using the least squares technique. Table 6 contains the slopes, y intercepts, and standard error of the slopes.

Since only one datum (slope of the line of best fit) was available for each group, the only method of analyzing slope differences was a student _t_ test and pairwise comparisons. Unfortunately, using multiple _t_ tests inflates the possibility of a Type I error, i.e., the probability of finding a difference where none exists. However, in this type of exploratory analysis, it was considered acceptable to inflate Type I error in order to decrease the possibility of Type II error, i.e., the probability of overlooking important differences. In examining the data, it

Table 6

The Lines of Best Fit for Each Group: Slopes, y Intercept, and Standard Error of the Slope

Group	Slope	y Intercept	SE
1	2.48	5.26	.685
2	1.22	9.2	1.337
3	.972	6.22	.936
4	1.34	5.02	.567
5	1.67	5.52	1.042
6	1.38	8.30	1.534
7	.639	4.68	.658
8	.69	2.96	.464
9	.985	5.93	1.101
10	1.32	5.43	.904

appeared as though the slopes for Group 1 and possibly Group 5 differed from the other 90-volt groups. Since the slopes of the 30-volt groups (2, 4, and 6) did not appear to differ from each other and because previous analysis indicated that the 30-volt groups did not differ in other factors among themselves or among appropriate comparison groups, these slopes were not compared. Group 1 was then compared to Groups 3, 5, 7, 8, 9, and 10 using the following formula:

$$t = \frac{b_i - b_j}{\sqrt{\dfrac{(n_i-1)(SE_{bi})^2 + (n_j-1)(SE_{bj})^2}{n_i + n_j - 2} \quad \dfrac{1}{n_i} + \dfrac{1}{n_j}}}$$

where b is the slope for group i. SE_{bi} is the standard error of the slope for group i, n is the number of subjects in a group, and $(n_i + n_j - 2)$ the degrees of freedom.

Group 5 trend was then compared to the slope of Group 7. No statistically significant differences were found and no further comparisons made, as the difference between the slopes of these groups was the largest that would occur, smaller differences would also not have been significant. (This resulted in a total of seven *t*-tests. The Type I error increases by $1 - (\alpha)^k$, where α is the level of significance and k is the number of *t*-tests performed (Winer, 1971). Type I error will only be increased by this factor for *one* of the tests. For seven *t*-tests, using an α of .01, the Type I error increased to .068 for one of these tests.)

Statistically significant differences were found between Group 1 and Groups 3, 7, 8, 9, and 10 at the .05 level of significance. Table 7 lists *t* values, appropriate degrees of freedom, and unadjusted significance levels. It is stressed that this analysis was exploratory in nature, and possible interpretations of the meaning of this novel measure are discussed in the next chapter.

Table 7

The *t*-test Values for Group 1 and Groups 3, 5, 7, 8, 9, and 10

	Group 1	df	t>.05	t>.01	t>.001
Group 7	4.74	10	-	-	*
8	4.950	9	-	-	*
3	3.181	10	-	*	-
9	2.677	8	*	-	-
10	2.466	10	*	-	-
5	1.590	10	-	-	-

* = significance.

CHAPTER VI

DISCUSSION

This study exposed birds to a stimulus (called a safety signal) associated with the absence of shock. Subsequently, the same stimulus was used to predict food in an autoshaping paradigm. Trials to acquisition of the keypeck response to that stimulus varied depending upon the intensity of the shock. Preexposure to strong shock (90 volts) resulted in a greater number of trials to acquisition than weak (30 volts) and no shock controls. These differences were statistically significant at the .05 level. Statistically significant differences were not found on three other dependent measures: percent of trials with a CS+ peck, percent of trials with a CS+ peck across the four post-acquisition sessions, and mean pecks per CS+ trial over the four post-acquisition sessions. Post hoc examination of the mean trials with a CS+ peck revealed that preexposure to 90 volts of signaled shock with a SS resulted in positive acceleration in mean pecks per CS+ trial over the four post-acquisition sessions. This was statistically significantly different from most of the other 90-volt groups. Possible meanings of these findings are discussed below.

Attrition

Attrition appeared to be due to two factors. First, approximately 7 days elapsed between magazine training and autoshaping. Ten birds failed to eat consistently from the hopper during autoshaping, probably because of this delay, and were dropped from the study. Secondly, the length of the ITI during autoshaping was deliberately and specifically chosen so as to delay acquisition and thereby allow for the observation of group facilitation differences. However, as a result (most likely), 21 birds failed to meet the criterion for autoshaping acquisition. As mentioned above, 8 of these birds did meet the initial criterion of at least one peck on five consecutive trials, however, they did not maintain the response due to pecking too weakly (i.e., <.16N) to activate the key mechanism. Attrition due to failure to acquire any response (13 birds) included birds from nearly all groups. It is difficult to factor out specific causes other than the ITI length since most groups were affected by attrition, including the no treatment group. Attrition did not appear to be systematic or restricted to any particular group. Two changes in methodology are suggested as possible improvements of future research: a longer ITI during autoshaping and addition of a "refresher" session of magazine training.

Subject Variability

One problem in interpreting the current results was the amount of variance between birds in a given group. Gibbon et al. (1977) reported that as mean trials to acquisition increased, concomitant increases were seen in the standard deviation. While researchers have not directly addressed this issue, the method of analysis in most autoshaping studies leads to the suspicion of large amounts of between subject variability. For example, median trials to acquisition have been frequently reported (Browne, 1976; Engberg, Hansen, Welker, & Thomas, 1972; Sperling, Perkins, & Duncan, 1977; Zentall & Hogan, 1975). What this means is that there were probably used in the present study since a comparison of means and medians revealed little difference between the measures. This indicated that the samples were normally distributed within each group. In addition, very few statistical tests can be performed on median data.

Although medians are used as better measures of central tendency when a non-normal distribution is apparent, they can also be used to avoid large variances about the mean and resulting lack of statistically significant differences. For example, Engbert et al. (1972) reported a range in trials to acquisition of 30 to 762 for 8 birds in a control group. Gibbon et al. (1977), using ITI and CS durations identical to those in the present study, report a range of 29 to 268 trials to criterion for 8 birds. In order to adequately analyze their findings, log transformations were performed.

Therefore, the subject variability in this study was not unusual when compared to other autoshaping studies. When no pretreatment occurred (Group 7), the standard deviation of trials to acquisition was ±22.1 trials (Table 2). Increases in standard deviation were seen in all pretreated groups; however, there appeared to be no systematic increase that depended upon voltage or type of signals presented. Subject variability is one of the major reasons for using a group statistical design. Classical conditioning differs substantially from operant conditioning with regard to design. In operant conditioning, response-stimulus contingencies are established and response dependent. However, in classical conditioning, no such contingencies exist and procedures are response independent.

Response dependent measures tend to exhibit little subject variability, provided subjects are of the same type and history. Most researchers in the operant area specify, for example, subject age, breed, weight, etc. in order to better control for inter-subject variability. In classical conditioning, this is also done to some extent; however, it is often impossible to determine those factors which account for inter-subject variability and, therefore, a group statistical design is used.

In this study, I attempted to locate possible sources of variation (after the fact) by performing analyses of covariance on trials to acquisition with subject weight and programmed magazine training as possible covariates. These two factors were not found to contribute to the variability.

One possible factor may be the number of shock exposure conditioning trials. Eighty trials of SS, CS+/shock could be insufficient to equally condition all of the birds in a given group. Tranberg and Rilling (1978), in a latent inhibition of autoshaping study, used 500 trials of CS+ alone, since previous work showed that if only a few trials were used, no effects were seen. Group 10 of the present study was established to see if any latent inhibition occurred with 80 exposures to the SS. Eighty trials were not sufficient to consistently cause delays in trials to acquisition indicating that the 80 conditioning trials were not, in fact, sufficient to condition all birds.

Another possible example of the insufficiency of 80 conditioning trials is seen upon examination of individual subject data for Group

8. The 5 birds in the group took 43, 68, 79, 154, and 164 trials to acquire the keypeck response, where the CS had previously predicted shock. Two of these birds showed an apparent delay in acquisition while the remaining three did not. Other groups show similar patterns in trials to acquisition, e.g., Group 9 (65, 76, 79, and 153) and Group 1 (33, 64, 85, 104, 138, and 140). It may be that increasing the number of aversive conditioning trials could lead to substantial decreases in subject variation. However, Gibbon et al. (1977) reported that as mean trials to acquisition increased, subject variability also increased. Therefore, larger between subject variability would be expected when trials to acquisition were delayed due to treatment effects as found in this study.

Acquisition Measures

There were no statistically significant differences ($p<.05$) between the 30-volt group (Groups 2, 4, and 6 combined) and the 0-volt comparison groups (7 and 10). The 90-volt group (1, 3, and 5 combined) was statistically significantly different from the 30-volt group and the 0-volt group. Thirty volts appeared to be too weak to condition all birds during preexposure to the aversive treatment within 80 trials. Visual inspection of the data from the two remaining 90-volt groups (Groups 8 and 9), which were not included in the data analysis due to low n, showed mean trials to acquisition essentially equivalent to the other 90-volt groups. No statistically significant differences existed between type of preexposure (i.e., signaled, unsignaled, or no signaled shock). However, lack of statistical differences among signal types may have been due to the small n and resulting lack of power.

Power is the probability of rejecting a false null hypothesis, i.e., $1 - \beta$, where β is the probability of not rejecting a false null hypothesis (Type II error) (Glass & Stanley, 1970). Lower power results in a higher probability of a Type II error and reduces the probability of finding statistically significant differences. There are several methods of increasing power, including increasing sample size and relaxing the α level (Hopkins, 1973). If the probable treatment effect is known, estimates of power can be made prior to performing the experiment, and the researcher can adjust the experimental design accordingly in order to increase power. For the two-way analysis of variance on trials to acquisition by volts and signal type, the power was .32 for signal type and .42 for volts for an alpha level of .05, assuming a medium treatment effect. Power was .43 on the subsequent one-way analysis of variance on 90-volt groups (1, 3, and 5), 30-volt groups (2, 4, and 6), and 0-volt groups (7 and 10) using the average of the sample sizes (n = 16). This was still quite low, and reduced the probability of finding statistically significant differences where a true difference exists (Cohen, 1977). (Power was determined by using the power tables in Cohen, 1977).

In terms of the importance of power for the interpretation of these data, it should be realized that with low power, the probability of making a Type I error is lower than with high power. Therefore, finding statistically significant differences with low power is more difficult, and greater differences among group means is necessary. In spite of the small sample sizes, low power, and large variance, statistically significant differences were found in these data between voltage levels. However, if differences in signal type did exist, the low power may have resulted in the lack of statistical significance. Using the power tables in Cohen (1977), and assuming the use of the same two-way analysis of variance on trials to acquisition by volts and signal for Groups 1-6, it is evident that with α set at .05 to increase power to an appropriate level, for example .85, the sample size would have to be 28. (When the six groups are combined by signal type, three groups of 12 each result, so the sample size would have had to be substantially increased, to 14 birds per group as opposed to 6.)

Visual examination of the trial to acquisition data for three 90-volt groups (1, 3, and 5) does suggest trends of theoretical importance for future research. Where the safety signal is redundant with the CS for shock, conditioning to that signal seems not as strong as when only the safety signal is present (Groups 1 and 3 with mean trials to acquisition of 94.0 and 126.0 respectively). Theoretically, it seems that when a safety signal is the only predictor of events, conditioning to this stimulus is stronger. Redundancy, as is the case when both a SS and a CS+ are present, produces weaker conditioning. Egger and Miller (1963) suggested that just because a stimulus is repeatedly explicitly paired with reinforcement, it does not guarantee conditioning. Other authors have noted that when two stimuli were redundant, the stimulus that provided the "most" information regarding reinforcement was the stimulus to which the organism was conditioned (Schwartz & Gamzu, 1977).

This possibility of redundancy effect leads to the question of whether the CS preceding shock is in fact conditioned when a SS is present and, if so, how strong this conditioning is. Group 8, which was autoshaped to the CS for shock following aversive conditioning identical (except for stimulus colors) to Group 1, was included to answer just this question. The mean trials to acquisition for Group 8 ($\overline{X} = 101.6$) show that conditioning is similar to that of Group 1 ($\overline{X} = 94.0$). However, as discussed above, this group appears to contain two types of birds--those which were conditioned in 80 trials and those which were not.

In examining single subject data, it is apparent that the two birds in Group 8 which did have delays in trials to acquisition were more similar to the birds in Group 3 than to those in Group 1. This makes interpretation difficult. It is unknown whether the conditioning to a SS, which is redundant to a CS for shock, is weaker than the conditioning to the CS for shock. In any case, conditioning to the SS, where no specific CS for shock is present, seems stronger than conditioning to the SS where a specific CS for shock is present.

Finally, Group 5 (no signals and 90 volts) had a mean trials to acquisition of 76.7, which is somewhat less than Groups 1 (signaled 90 volts) and 3 (unsignaled 90 volts). Therefore, while no statistically significant differences were found among signal type, it is possible, again due to the low power, that true differences are being rejected. These data, as they currently stand, suggest that mere preexposure to 90 volts of shock--signaled, unsignaled, or no signals--is sufficient to retard acquisition of the response. This would be an important finding with respect to learned helplessness and classical conditioning. The phenomenon of learned helplessness occurs in classical aversive conditioning, and second, the presence or absence of signals for shock and safety have no differential effect.

Due to the lack of power in this study and the presence of possible differences among signal types, these data can neither support nor reject the hypothesis that differing signal types which are present in classical aversive conditioning result in differential effects on subsequent classical appetitive conditioning. Questions about these differences warrant further investigation.

Facilitation of response acquisition was predicted by the opponent process model. However, in this study, conditioning strength appeared as retardation of response acquisition. There are at least three possible reasons for this. First, "safety signals" were only present in situations where shock occurred. Their presence was therefore somewhat predictive of shock. Secondly, the conditioned response developed during preexposure to the safety signal (whatever this might be) may preclude keypecking, such that extinction of this response must occur prior to acquisition of a new response. Thirdly, it was possible that a signal predicting the absence of shock did not in fact acquire an hedonic value opposite to that of shock. As currently discussed, the world of events is defined into those which are appetitive and those which are aversive. However, safety from an aversive event may not in itself be appetitive. The opponent process model may be too simple to explain all transfer effects. For example, there may be differences between those stimuli which predict the occurrence of a specific event (e.g., shock or food) and those which predict the absence of a specific event.

These findings are somewhat contradictory to those of the Bromage and Scavio (1978) study. Initially in the Bromage and Scavio study, a stimulus was explicitly unpaired with shock delivered to elicit the nictitating membrane response. Subsequent conditioning of the jaw movement response using this stimulus as a CS+ resulted in slightly greater precentage of jaw movement CRs over no treatment controls from the second day of conditioning on to the seventh. However, on the first day of conditioning, the no treatment group had approximately 15 percent more responses than the experimental group. Since the present study has shown that voltage levels are an important factor, it may be that stronger shock was needed in the Bromage and Scavio (1978) study. Shock delivered to elicit the nictitating membrane response was milder (4 mA) than the shock used in this study (6.6 mA). Additionally, the differences found on the first day in the Bromage and Scavio study may have been indicative of retardation of response conditioning, as in the present study.

Scavio and Gormezano (1980) reported that in an aversive-aversive transfer retardation of response acquisition occurred rather than facilitation as predicted by the opponent process model. Since effects found in the current study were not dependent on the presence or absence of signals, the data cannot confirm or reject retardation of response acquisition in an appetitive-appetitive transfer. However, the trends regarding possible differences between safety signals in signaled, unsignaled, and no signal shock situations, if subsequently confirmed, would not support the opponent process model. The research of Scavio and Gormezano and the present study found retardation of response acquisition where facilitation was predicted by the model in a like-to-like transfer situation. This suggests that the opponent process model is in need of reexamination to account for these findings as previously called for by Scavio and Gormezano (1980).

However, it should also be noted that none of the research performed by Scavio and colleagues (Bromage & Scavio, 1978; Scavio, 1974; Scavio & Gormezano, 1980) utilized shock with no stimuli present. The principal finding of the present study indicates that this is an important factor. If preexposure to aversive USs alone causes changes in response acquisition alone, the implications are that prior research, in neglecting this aspect, has based a model on research that lacked appropriate controls. In that research has detected problems with the opponent process model (e.g., Scavio & Gormezano, 1980), further research in the area of safety signals may indicate additional problems.

Performance Measures

For all groups, daily rates varied greatly among subjects within each group. Previous autoshaping studies have shown suppression of post-acquisition responding (rate) following various pretreatments (Poling & Thompson, 1977; Tranberg & Rilling, 1978; Wesp et al., 1977; Woodard et al., 1974) where the post-acquisition responding measure was either median trials with at least one CS peck and/or mean responses per CS trial. In the present study, no statistically significant differences were found on these two measures on any of the four post-acquisition sessions. This suggests that preexposure to shock does not effect post-acquisition performance. However, differences in slopes of the lines of best fit to these data warrant discussion. The only important differences are among 90-volt groups in that the 30-volt groups demonstrated little apparent conditioning in terms of trials to acquisition, and the slopes for signaled and unsignaled 30-volt groups were similar to that of the no signal 30-volt group and the no treatment group. However, Group 1 (signaled 90 volts) showed a larger positive acceleration in rate which was not seen in other groups (Figure 3).

The performance of Group 5 (shock with no signals) would indicate that prior exposure to shock alone does tend to accelerate rate during subsequent autoshaping. The slope of Group 1 does not differ statistically significantly from Group 5. However, other groups (3, 7, 8, and 9) are statistically significantly different from Group 1.

The positively accelerating rate of Group 1 may be indicative of the facilitation which was predicted by the opponent process model. Specifically, while the acquisition of the reflexive keypeck response was not facilitated, maintenance of the response was facilitated. Automaintenance is considered to be more operant in nature than acquisition (Schwartz & Gamzu, 1977). This may indicate that the opponent process model is predictive of classical-operant transfers (aversive conditioning - subsequent automaintenance) as opposed to classical-classical transfers (aversive conditioning - subsequent

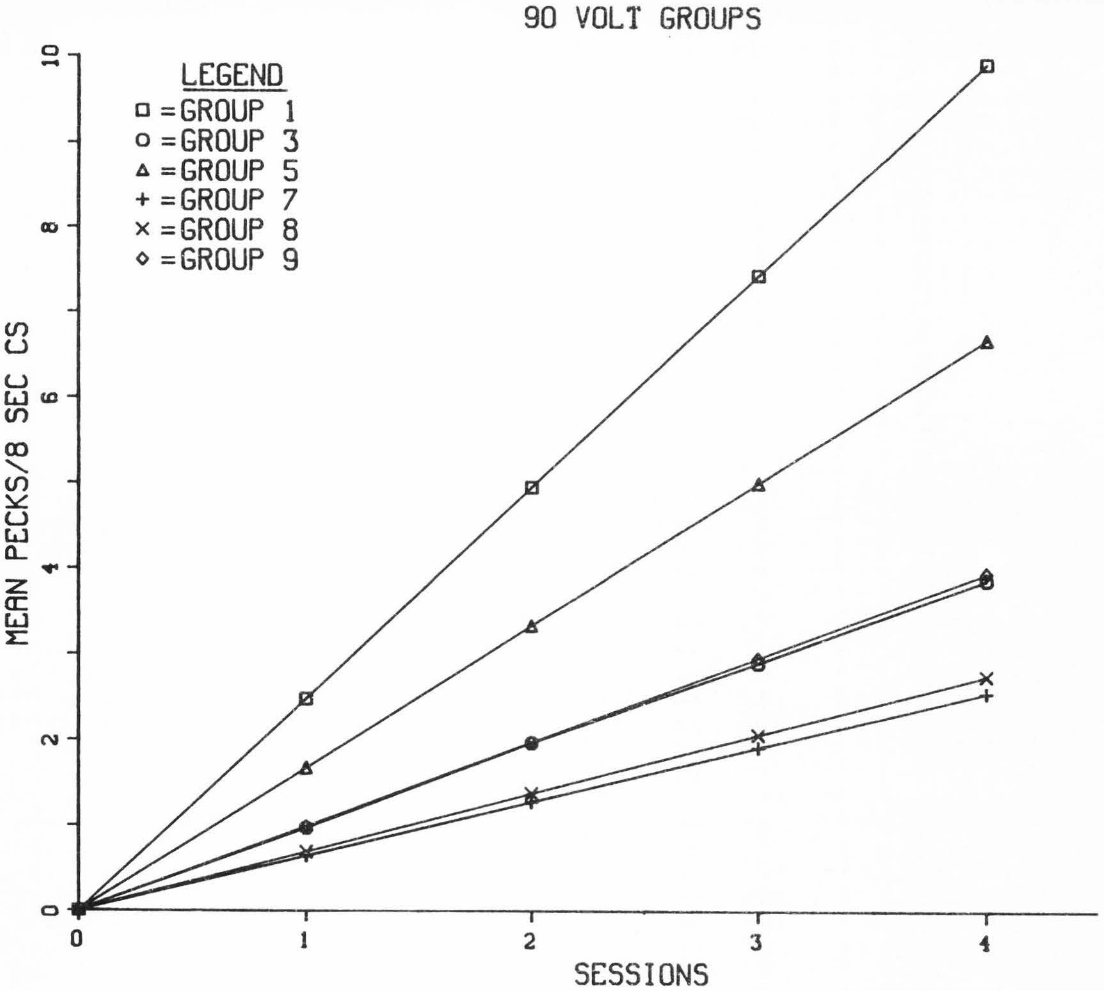


Figure 3. Slopes of the lines of best fit for rate by session data for all 90-volt and no treatment groups adjusted for a y-intercept = 0. Statistically significant differences were found between Group 1 and Groups 3, 7, 8, and 9.

autoshaping). The actual importance of differing slopes is unknown. However, because of these implications for the opponent process model with regard to the model's applicability to classical-classical transfers, examination of this measure in future research should be considered.

Summary

This study neither confirmed nor rejected various premises regarding the nature of safety signals or appetitive to appetitive transfers. The primary finding was that preexposure to strong shock resulted in delays in response acquisition during subsequent autoshaping. This finding suggests that the learned helplessness hypothesis obtains with classically conditioned responding. One basic problem in the study was the lack of statistical power. Visual examination of the data revealed two trends which should be further examined in future research.

The first trend was with regard to signal redundancy. Safety signals in signaled shock situations are redundant to the CS for shock, whereas safety signals in unsignaled shock situations are the only predictors of events. Visual examination indicated that redundancy seemed to result in weaker conditioning as measured by trials to acquisition when compared to the non-redundant safety signals.

The second trend was relatively minor and merely suggested that future research examine slopes of the lines of best fit. This variation may have impact upon the opponent-process model as a model for classical-operant transfer effects.

In addition, two areas of the opponent-process model may require further attention. First, differences may exist between those stimuli which predict the occurrence of an event and those which predict the absence of an event. Secondly, division of the world of events into appetitive and aversive may be too simplistic in that safety from an aversive event may not be appetitive to the same extent that food is appetitive.

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APPENDICES

Appendix A

Individual Subject Data

INDIVIDUAL SUBJECT DATA

Acquisition Measures

	Subject	Trials to Acquisition	Percent Trials with One or More CS Pecks for First 5 Sessions 1	2	3	4	5
Group 1	14	140	0	0	20	64	70
	15	104	0	24	92	96	100
	16	138	0	2	46	74	98
	18	33	48	88	98	96	100
	110	64	4	78	98	100	98
	111	85	0	24	88	98	94
Group 2	22	59	16	70	96	98	86
	23	115	0	2	74	96	96
	25	104	26	98	98	98	100
	29	38	34	96	88	88	98
	210	78	0	46	98	100	100
	211	61	0	52	72	92	80
Group 3	32	110	0	12	90	94	100
	33	154	0	0	12	96	90
	34	119	0	2	82	100	100
	35	54	0	88	98	100	84
	39	141	2	44	54	62	56
	310	178	0	0	50	96	98
Group 4	42	62	0	70	98	98	86
	45	55	26	46	74	82	100
	47	137	0	2	28	86	96
	48	93	0	16	96	90	92
	49	2	96	98	98	98	100
	410	81	0	50	82	72	100
Group 5	52	83	0	42	82	92	100
	54	65	10	72	96	90	92
	58	74	2	50	86	88	86
	59	120	0	0	40	82	94
	510	58	2	84	82	86	98
	511	60	8	90	98	100	96
Group 6	61	30	40	100	100	100	100
	62	85	0	42	70	72	84
	65	4	52	78	94	90	88
	67	115	0	0	76	98	100
	68	53	14	96	100	100	100
	610	58	0	80	96	100	100

INDIVIDUAL SUBJECT DATA (Cont'd)

Acquisition Measures

	Subject	Trials to Acquisition	Percent Trials with One or More CS Pecks for First 5 Sessions				
			1	2	3	4	5
Group 7	73	94	2	29	98	100	100
	75	35	44	58	64	94	100
	76	51	0	80	92	100	100
	78	84	2	68	92	80	100
	79	52	4	96	98	100	100
	710	64	0	72	92	100	98
Group 8	84	154	0	0	28	94	58
	87	164	0	10	26	76	80
	88	79	0	48	80	92	92
	811	68	0	62	78	94	94
	812	43	20	98	98	98	100
Group 9	91	153	0	0	8	86	86
	92	65	2	64	90	96	98
	95	79	0	52	94	98	98
	98	76	2	38	74	74	98
Group 10	102	42	22	96	98	100	100
	103	64	0	76	88	94	96
	104	131	0	0	40	100	96
	105	65	10	70	96	82	98
	106	57	2	88	94	96	94
	107	88	4	30	86	88	98

INDIVIDUAL SUBJECT DATA

Post-Acquisition Performance Measures

	Subject	Percent Trials with One or More CS Pecks for 4 Post Acquisition Sessions				Mean Pecks Per 8 Sec CS Trial for 4 Post Acquisition Sessions			
		1	2	3	4	1	2	3	4
Group 1	14	64	76	78	88	6.2	6.3	9.7	16.9
	15	96	100	100	100	6.2	15.0	18.8	19.8
	16	74	98	100	98	3.1	9.1	12.7	15.4
	18	88	98	96	100	13.8	16.3	14.5	14.2
	110	98	100	98	94	9.6	12.7	13.6	12.3
	111	92	98	94	98	4.4	5.9	8.0	10.2
Group 2	22	94	98	86	96	3.9	4.6	5.1	6.8
	23	96	96	100	94	19.1	18.4	19.7	20.5
	25	98	98	100	100	5.8	9.1	9.1	7.0
	29	96	88	88	98	10.5	12.6	14.8	18.6
	210	98	100	100	100	19.8	22.0	24.2	25.2
	211	72	92	80	88	3.3	5.7	3.0	6.9
Group 3	32	94	100	100	100	7.1	8.7	9.3	9.6
	33	90	98	92	100	5.0	9.3	10.2	11.9
	34	100	100	100	98	5.1	5.5	5.7	3.4
	35	98	100	84	100	9.8	11.6	12.0	15.9
	39	62	56	74	74	1.0	.9	1.5	1.0
	310	96	98	100	100	13.0	16.4	15.6	18.0
Group 4	42	98	98	86	90	12.5	13.5	12.0	8.6
	45	74	82	100	76	5.0	7.6	11.0	7.9
	47	86	96	92	100	4.9	8.7	11.7	13.3
	48	96	90	92	100	4.2	6.8	9.8	10.8
	49	96	98	98	100	4.3	5.1	6.4	4.6
	410	82	72	100	100	6.0	2.1	11.5	12.2
Group 5	52	82	92	100	100	2.3	4.0	9.2	13.3
	54	96	90	92	92	6.2	3.6	3.1	4.4
	58	86	88	86	88	2.2	3.6	4.9	6.6
	59	82	94	100	96	3.4	8.2	12.8	13.4
	510	98	86	98	96	13.8	15.0	14.6	18.0
	511	98	100	96	98	16.0	17.8	18.3	18.1
Group 6	61	100	100	100	100	7.0	6.4	11.2	12.2
	62	70	72	84	100	.7	2.2	2.9	5.1
	65	78	94	90	88	15.9	20.4	14.8	20.4
	67	98	100	100	100	9.9	10.1	10.9	12.5
	68	100	100	100	100	19.0	19.4	21.2	18.7
	610	96	98	100	100	6.4	7.2	12.7	15.0

INDIVIDUAL SUBJECT DATA (Cont'd)

Post-Acquisition Performance Measures

	Subject	Percent Trials with One or More CS Pecks for 4 Post Acquisition Sessions				Mean Pecks Per 8 Sec CS Trial for 4 Post Acquisition Sessions			
		1	2	3	4	1	2	3	4
Group 7	73	98	100	100	100	10.8	13.2	13.0	10.0
	75	58	64	94	100	1.0	1.1	2.7	5.7
	76	88	100	100	100	2.4	7.0	7.0	8.4
	78	92	80	100	86	3.5	2.9	3.8	3.1
	79	98	100	100	100	8.0	10.7	8.9	8.3
	710	92	100	96	98	3.4	4.9	4.6	6.3
Group 8	84	58	86	84	84	1.9	2.0	2.8	2.4
	87	80	90	94	100	3.7	5.2	6.6	8.8
	88	80	92	92	94	1.8	2.4	3.1	3.6
	811	78	94	94	100	3.6	5.6	6.2	6.6
	812	98	98	100	100	6.7	6.3	8.6	NA
Group 9	91	86	100	100	100	5.8	8.9	10.7	12.5
	92	90	96	98	100	8.2	10.3	6.3	6.2
	95	94	98	98	100	9.5	14.2	16.2	16.5
	98	74	74	98	74	1.4	1.6	3.7	2.2
Group 10	102	96	98	100	100	7.1	11.1	16.5	21.0
	103	88	94	96	96	13.5	14.9	12.8	15.1
	104	100	96	96	96	6.1	5.6	5.0	4.2
	105	96	84	98	98	8.2	3.1	5.9	9.9
	106	94	96	94	76	6.2	5.1	3.9	2.7
	107	86	88	98	90	2.7	4.7	10.2	14.0

Appendix B

Attrition Per Group

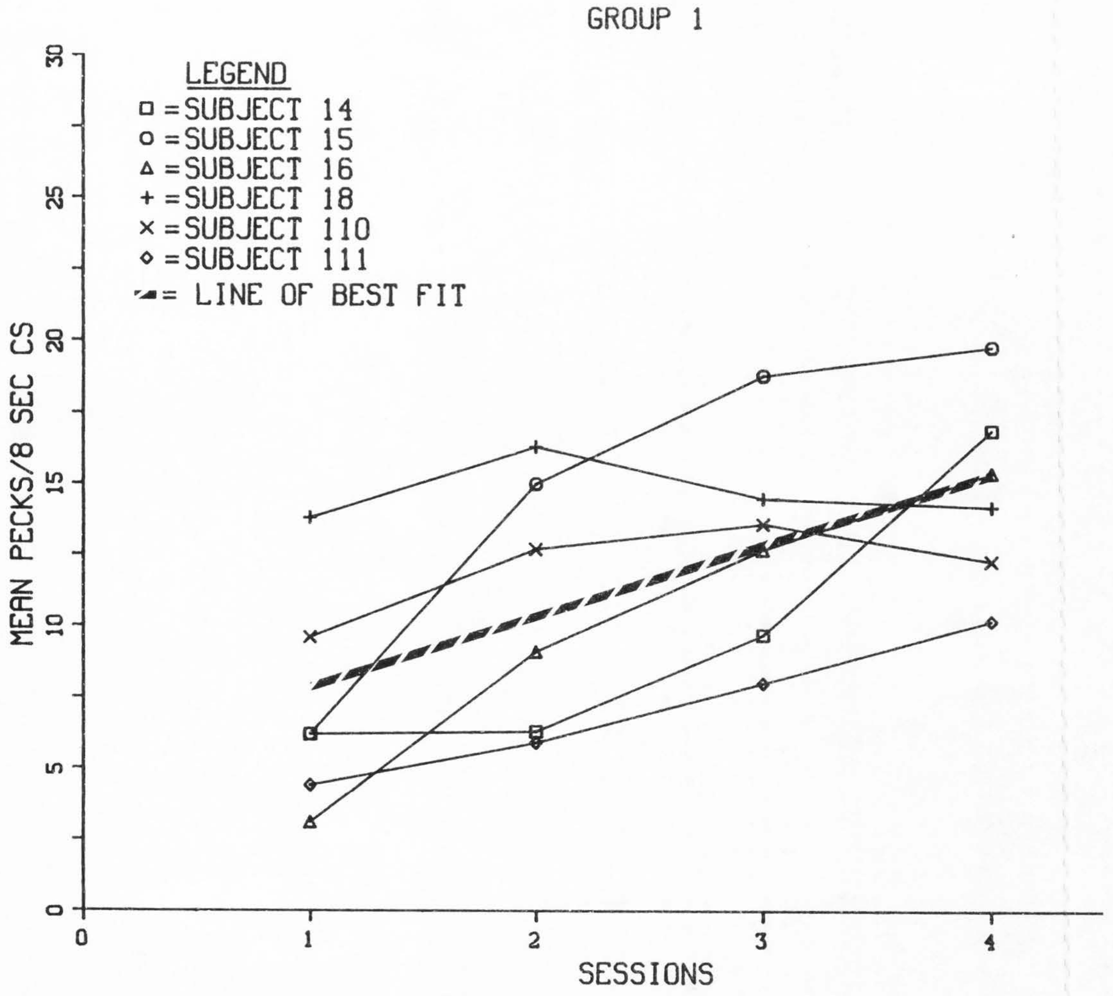
ATTRITION PER GROUP

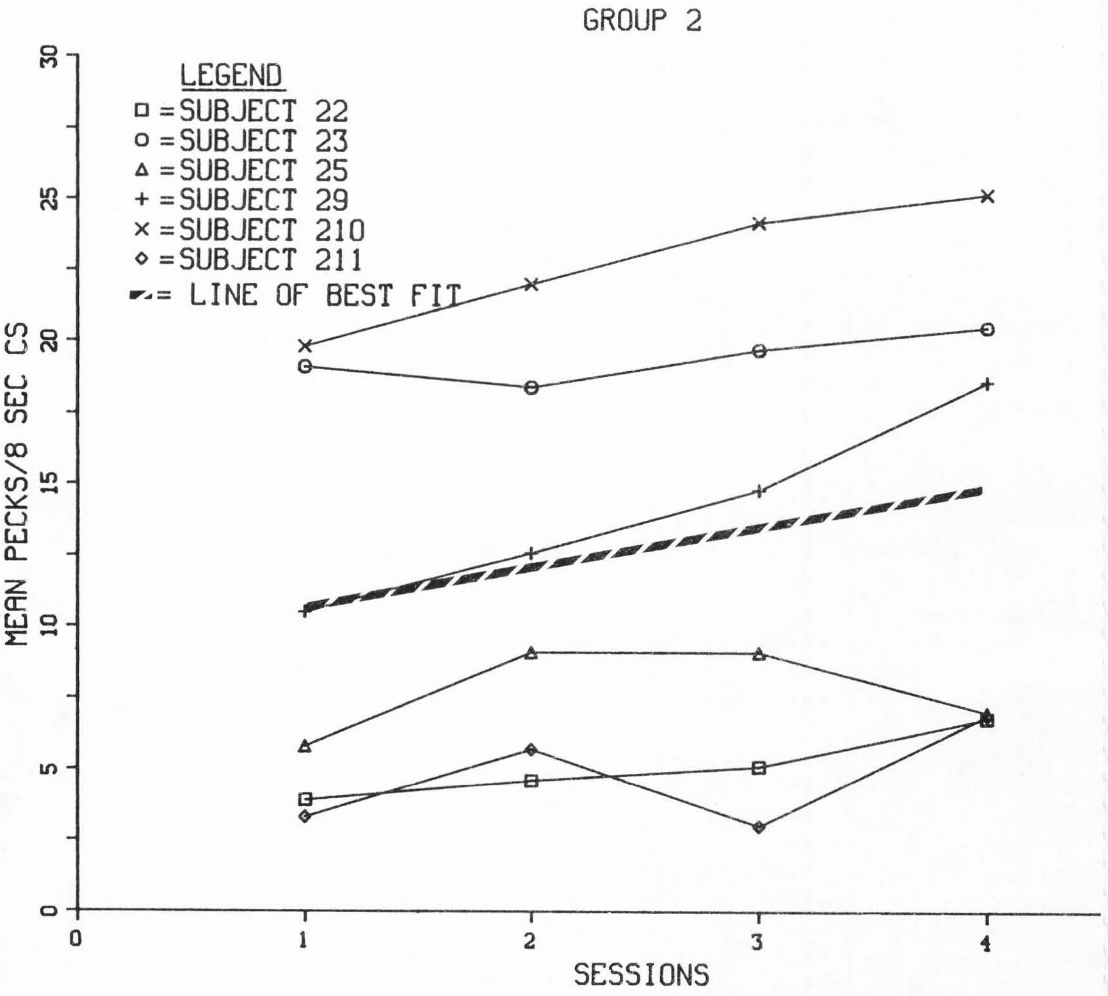
Group	Death	Mechanical Failure	Did Not Acquire	Did Not Eat Consistently	Total
1	1	0	4 (2*)	0	5
2	0	0	2	1	3
3	0	0	2	1	3
4	0	0	2 (1*)	0	2
5	0	2	1	2	5
6	0	2	0	1	3
7	0	1	2 (1*)	1	4
8	1	0	5 (3*)	2	8
9	0	0	2 (1*)	2	4
10	0	0	1	0	1
Total	2	5	21	10	38

*Met criterion of at least one peck on 5 consecutive trials, but subsequent and possibly prior pecks too weak to activate key mechanism.

Appendix C

Slopes of the Lines of Best Fit for Each Group, Adjusted for y-intercept = 0


GROUP 1
LEGEND
□ = SUBJECT 14
○ = SUBJECT 15
△ = SUBJECT 16
+ = SUBJECT 18
× = SUBJECT 110
◇ = SUBJECT 111
▨ = LINE OF BEST FIT
MEAN PECKS/8 SEC CS
0
5
10
15
20
25
30
0
1
2
3
4
SESSIONS


GROUP 2
LEGEND
□ = SUBJECT 22
○ = SUBJECT 23
△ = SUBJECT 25
+ = SUBJECT 29
× = SUBJECT 210
◇ = SUBJECT 211
▨ = LINE OF BEST FIT
MEAN PECKS/8 SEC CS
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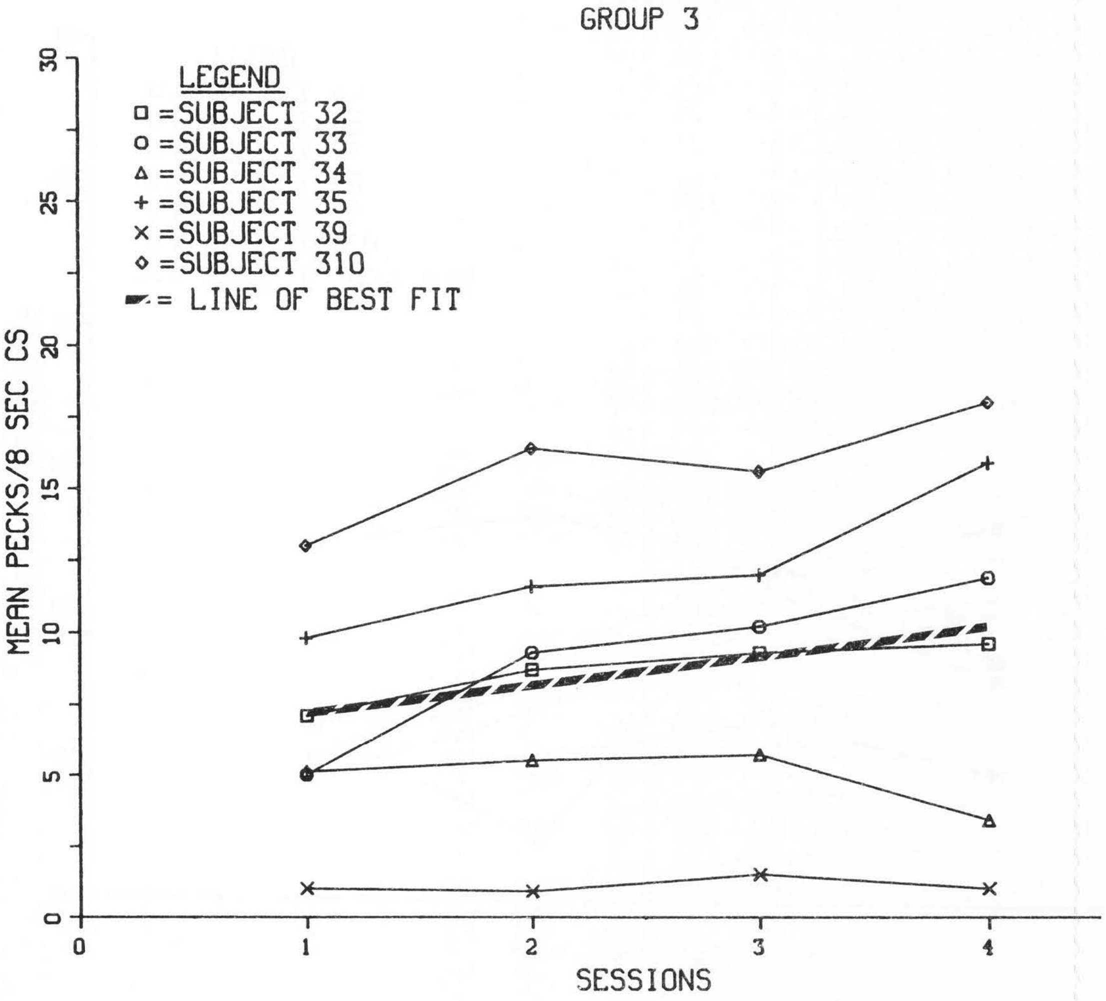
5
10
15
20
25
30
SESSIONS
0
1
2
3
4


GROUP 3
LEGEND
□ = SUBJECT 32
○ = SUBJECT 33
△ = SUBJECT 34
+ = SUBJECT 35
× = SUBJECT 39
◇ = SUBJECT 310
▨ = LINE OF BEST FIT
MEAN PECKS/8 SEC CS
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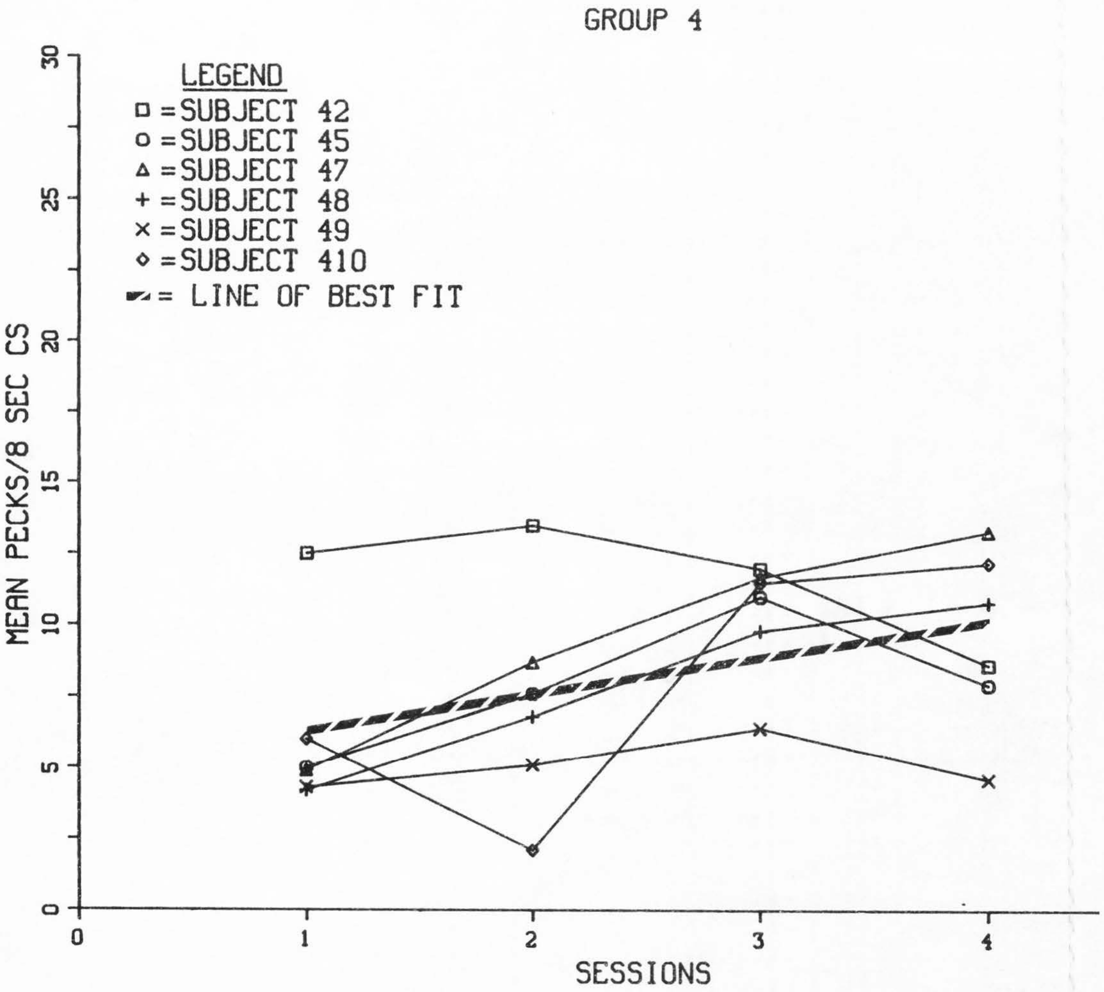
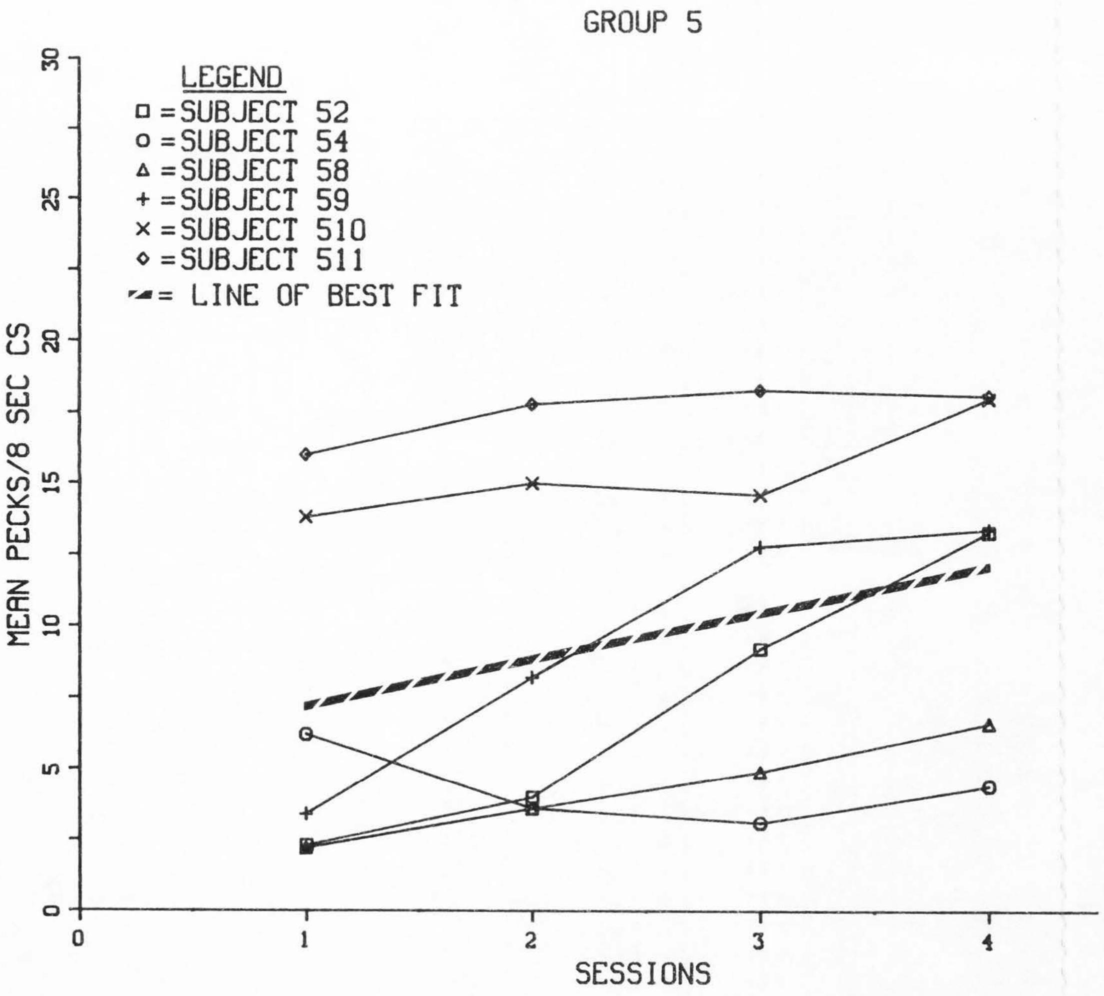
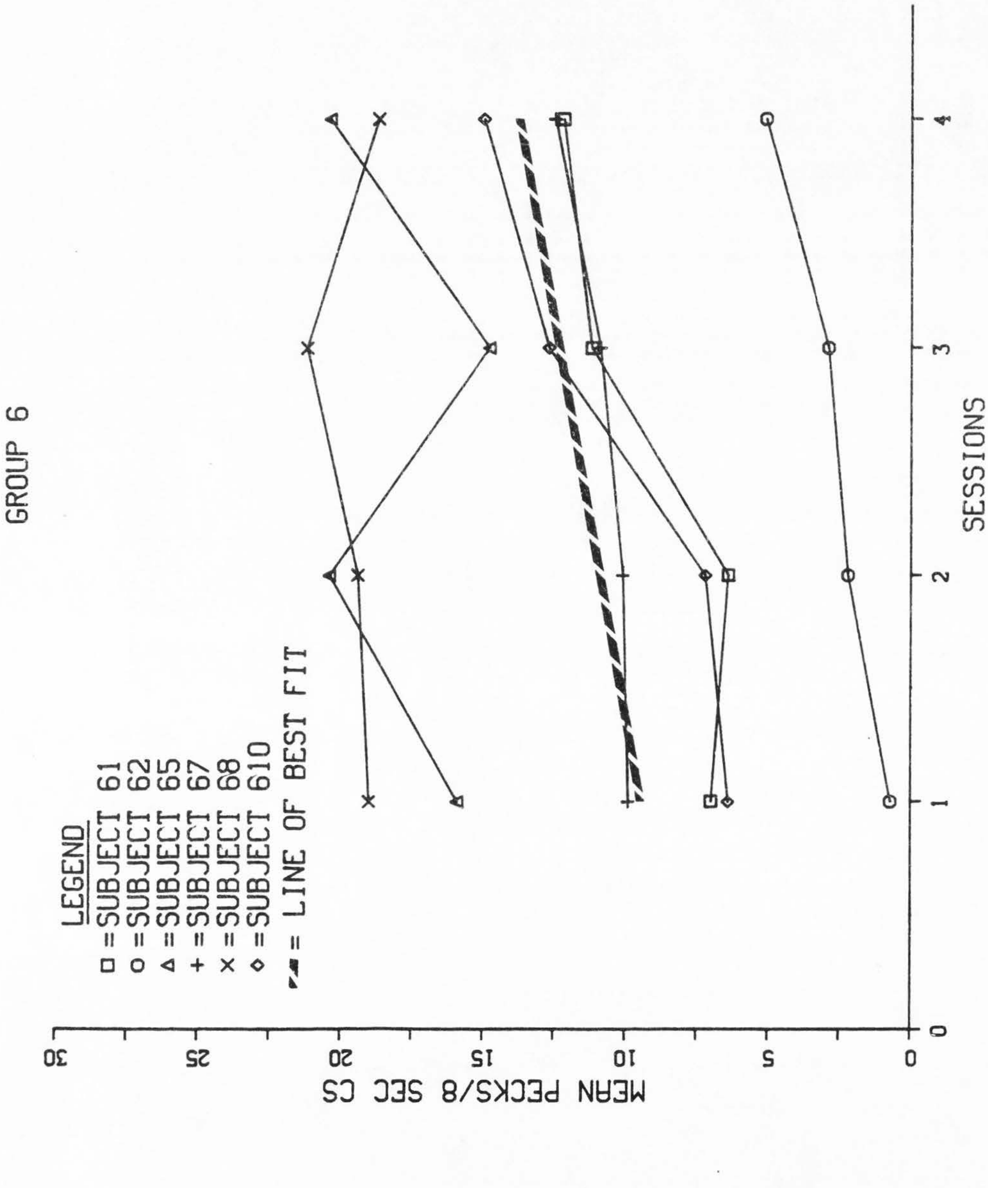
30
0
1
2
3
4
SESSIONS


GROUP 4
LEGEND
□ = SUBJECT 42
○ = SUBJECT 45
△ = SUBJECT 47
+ = SUBJECT 48
× = SUBJECT 49
◇ = SUBJECT 410
▨ = LINE OF BEST FIT
MEAN PECKS/8 SEC CS
0
5
10
15
20
25
30
SESSIONS
0
1
2
3
4


GROUP 5
LEGEND
□ = SUBJECT 52
○ = SUBJECT 54
△ = SUBJECT 58
+ = SUBJECT 59
× = SUBJECT 510
◇ = SUBJECT 511
▰ = LINE OF BEST FIT
MEAN PECKS/8 SEC CS
0
5
10
15
20
25
30
SESSIONS
0
1
2
3
4


GROUP 6
LEGEND
□ = SUBJECT 61
○ = SUBJECT 62
△ = SUBJECT 65
+ = SUBJECT 67
× = SUBJECT 68
◇ = SUBJECT 610
▨ = LINE OF BEST FIT
MEAN PECKS/8 SEC CS
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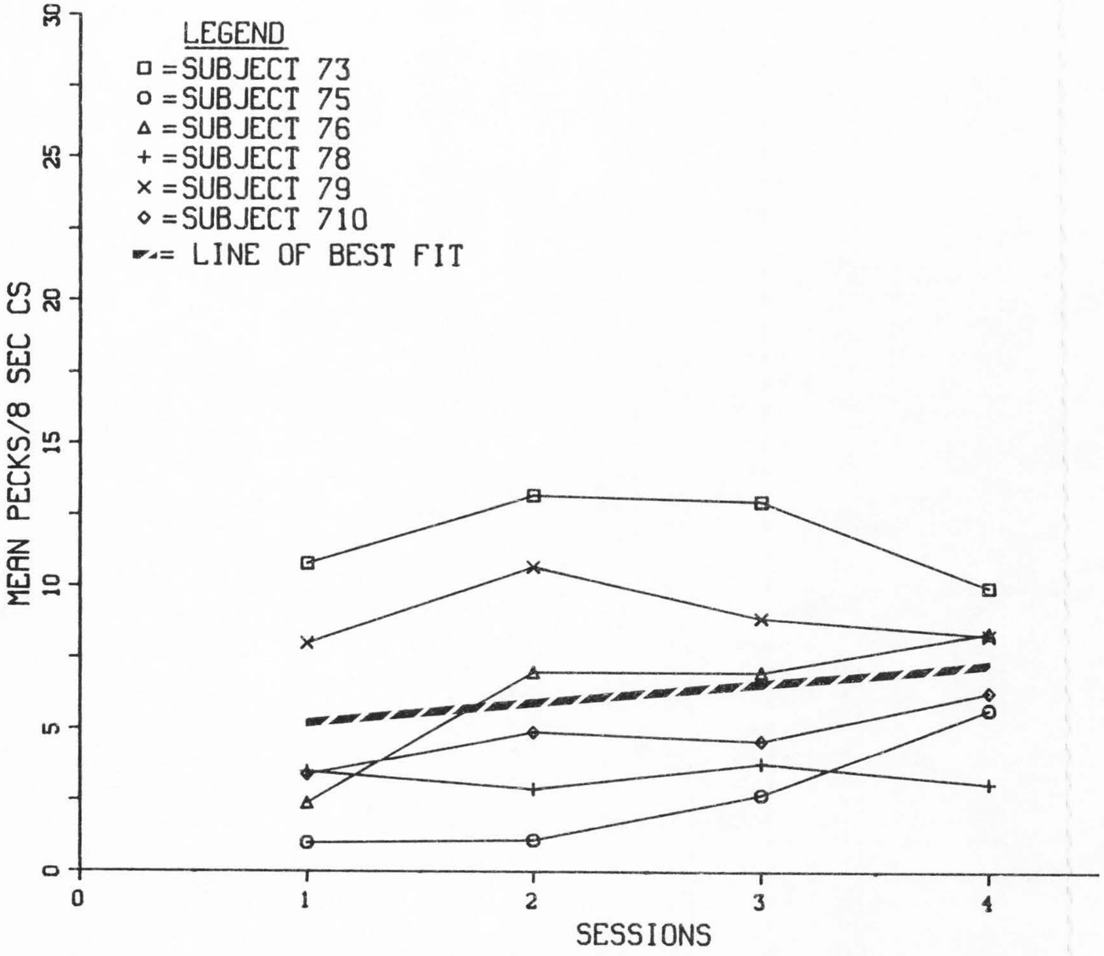
5
10
15
20
25
30
SESSIONS
0
1
2
3
4



GROUP 7

LEGEND
□ = SUBJECT 73
○ = SUBJECT 75
△ = SUBJECT 76
+ = SUBJECT 78
× = SUBJECT 79
◇ = SUBJECT 710
▰ = LINE OF BEST FIT
MEAN PECKS/8 SEC CS
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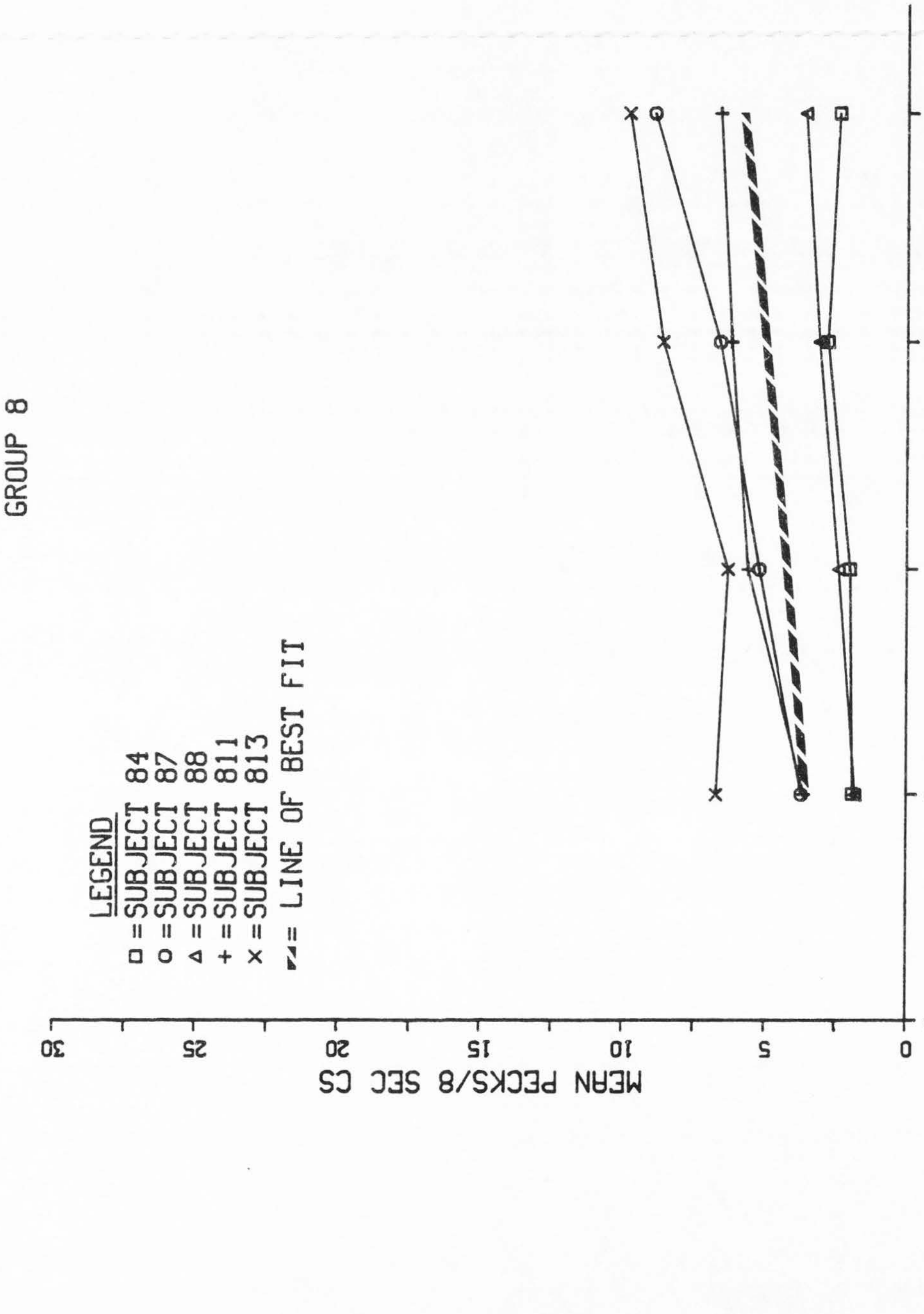
5
10
15
20
25
30
SESSIONS
0
1
2
3
4


GROUP 8
LEGEND
□ = SUBJECT 84
o = SUBJECT 87
Δ = SUBJECT 88
+ = SUBJECT 811
× = SUBJECT 813
▨ = LINE OF BEST FIT
MEAN PECKS/8 SEC CS
0
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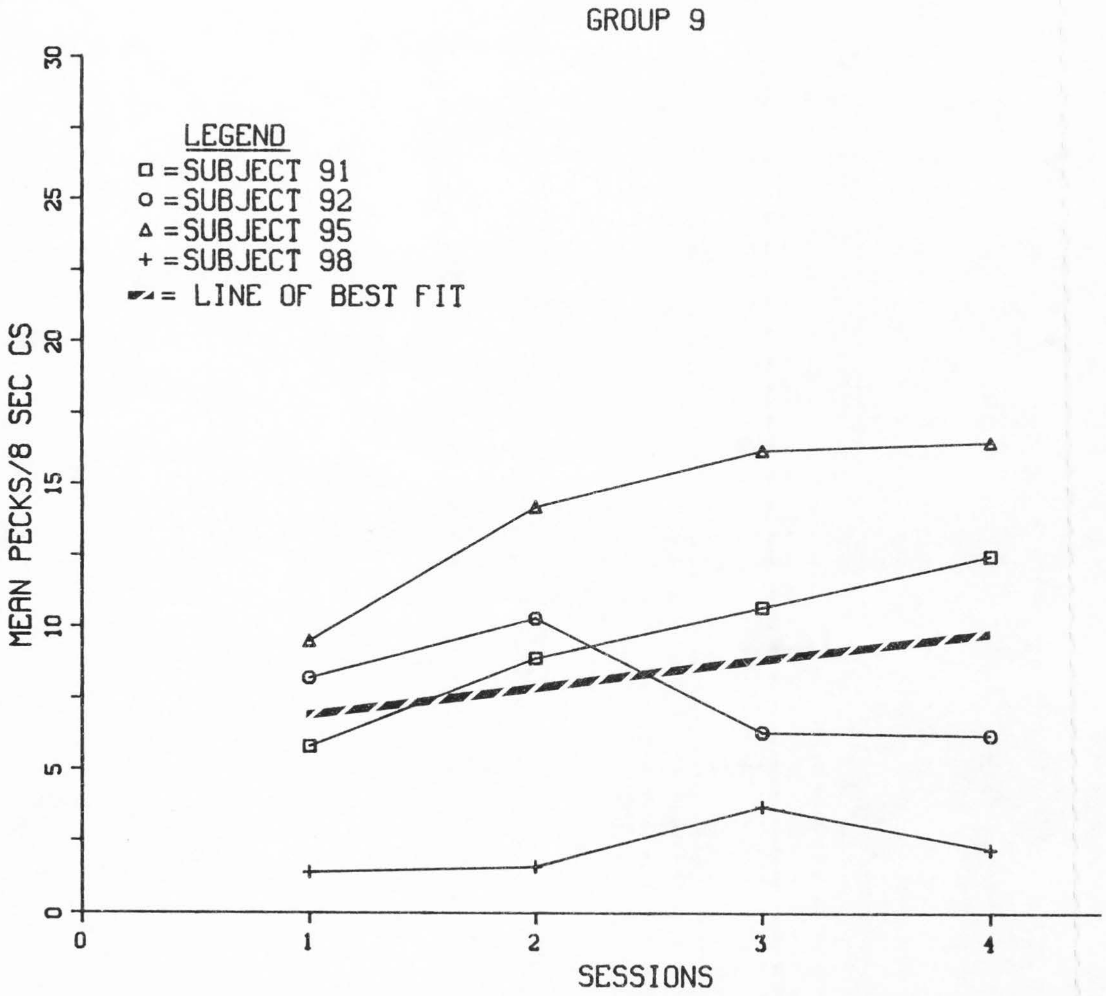
10
15
20
25
30
SESSIONS
0
1
2
3
4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LEGEND
□ = SUBJECT 91
○ = SUBJECT 92
△ = SUBJECT 95
+ = SUBJECT 98
▨ = LINE OF BEST FIT
MEAN PECKS/8 SEC CS
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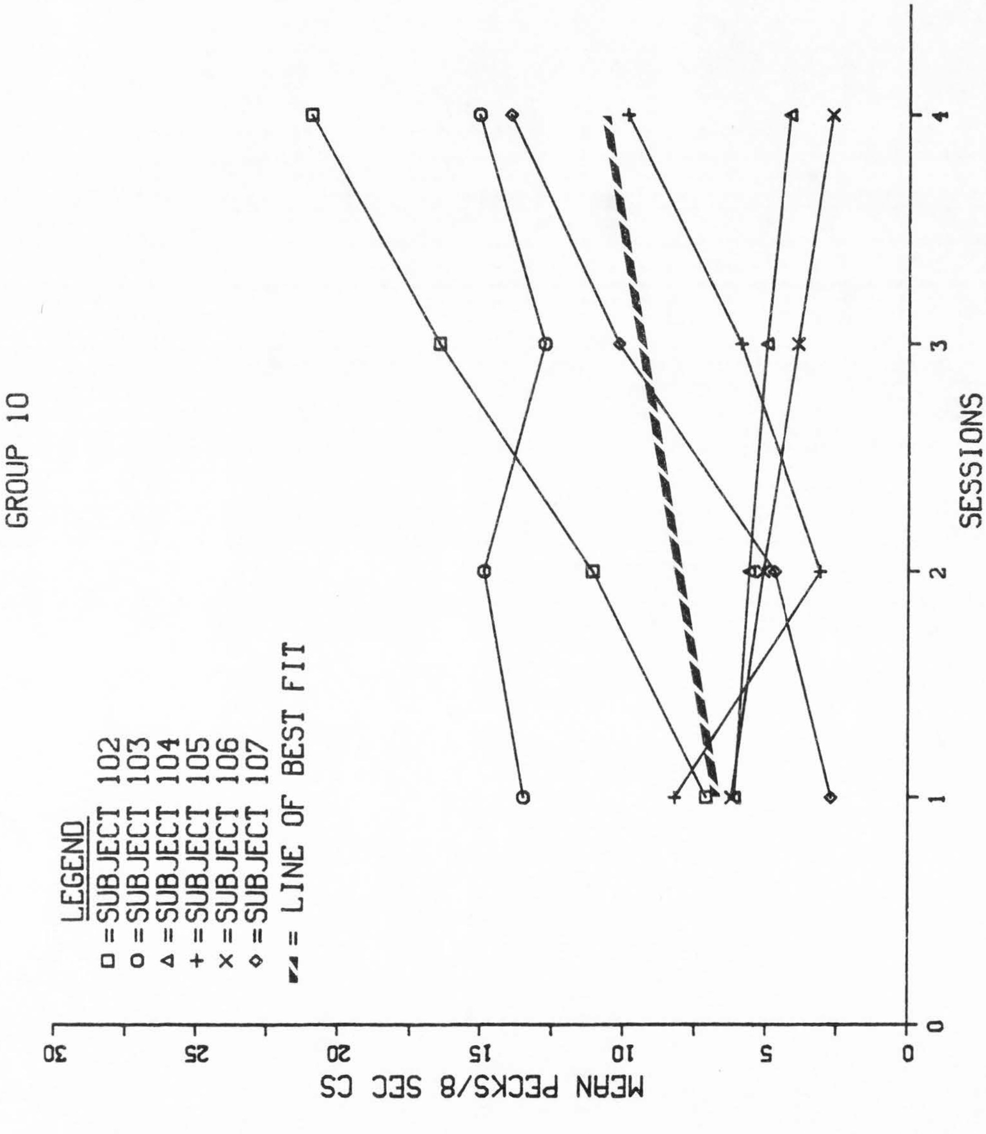
15
20
25
30
SESSIONS
0
1
2
3
4


GROUP 10
LEGEND
□ = SUBJECT 102
○ = SUBJECT 103
△ = SUBJECT 104
+ = SUBJECT 105
× = SUBJECT 106
◇ = SUBJECT 107
▨ = LINE OF BEST FIT
MEAN PECKS/8 SEC CS
0
5
10
15
20
25
30
SESSIONS
0
1
2
3
4

VITA

Nancy L. Eldred

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EDUCATION

Bachelor of Science, Oregon State University, 1975
Major: Zoology
Minor: Chemistry

Master of Arts, Oregon State University, 1977
Multidisciplinary: Psychology, Zoology, and General Science (History and Philosophy)

Ph.D., Utah State University, Expected Completion, 1981
Major: Psychology

VITA HIGHLIGHTS

* 2 years experience in the development of grant proposals for research.

* 1 year teaching experience including: Introductory Psychology (Teaching Assistant, OSU), Analysis of Behavior (sole responsibility, USU), and Behavior Modification (sole responsibility, USU extension).

* 2 years experience in the development of computer programs (SKED and SUPERSKED) for use in a variety of research projects. 3 years experience with electromechanical programming devices.

* 3 years experience in assessment of developmentally and behaviorally disabled children and youth including design and implementation of treatment programs, parent training, and counseling.

* 3 years experience in supervision of undergraduates in animal research.

* 1 year experience as Psychology Lab Manager, responsible for the care and maintenance of wolves, foxes, coyotes, opossums, as well as rats and pigeons.

* 2 years experience in design and construction of behavioral engineering exhibits for research on a wide variety of mammals, Portland, Oregon, Zoo.

PROFESSIONAL EXPERIENCE

Researcher Portland Oregon Zoo 1975-1977	As part of master's degree requirements, designed and constructed behavioral engineering exhibits. Gathered and evaluated observational data on gibbons, diana monkeys, seals, polar bears, and wallaroos. Produced videotapes for instructional use. Acted as consultant on marsupial behavior and physiology. Supervised and trained undergraduate volunteers. Supervisor: Hal Markowitz, Ph.D.
Teaching Assistant Introductory Psychology Oregon State University 1976-1977	Lectured and led discussion groups. Supervised testing and evaluation of 100 to 130 undergraduates each term. Assisted in construction of computerized test question battery for those students opting for self-paced instruction. Counseled undergraduates. Supervisor: Theodore Madden, Ph.D.
Assistant Manager USU Psychology Lab 1977-1978	Maintained experimental animals including wolves, several species of foxes, coyotes, opossums as well as rats and pigeons. Ordered and received lab supplies. Supervised rat breeding program. Kept lab records. Interacted with researchers and undergraduate research assistants. Prepared chemicals and pharmaceuticals. Performed autopsies. Supervisor: C. D. Cheney, Ph.D.
Teaching Assistant Analysis of Behavior Utah State University 1978-1979	Sole responsibility for course content and structure. Gave lectures and supervised discussion groups. Tested and evaluated students. Counseled undergraduates. Supervised lab section of the course and undergraduate teaching apprentices in laboratory instruction of the students. Supervisor: C. D. Cheney, Ph.D.

Behavior Modification USU Extension	Sole responsibility for course structure and content. Duties similar to Analysis of Behavior course. Course taught in Vernal and Roosevelt, Utah, so I was flown down one night each week.
Practicum Student Exceptional Child Center Utah State University 1979-1980	Team member and/or case coordinator for Clinical Services Division. Conducted interviews. Assessed developmentally and behaviorally handicapped children. Designed and implemented treatment programs, parent training, and counseling. Wrote reports. Supervisor: Phyllis Cole, Ph.D.
Research Assistant Early Childhood Research Program, USU 1979-1981	Development of proposals for research. Budget development. Implementation of funded research programs. Investigation of appropriate instrumentation. Visitor to similar programs at other universities to examine governing structure and initiate cooperative research. Responsible for on-campus colloquium series. Supervisor: Glendon Casto, Ph.D.

GRANT PROPOSALS DEVELOPED

"A Demonstration Project Utilizing Augmented Day Care to Ameliorate Stresses Experienced by Parents and Preschool Children of Single-Parent Families." $123,005. Submitted: 12/1/80 to DHEW. Written with Gerald Adams, Frank Dalley, Brent Miller, Glendon Casto, and Carolle Bell. Status: Pending.

"Social Competency and Cultural-Familial Retardation." $99,836. Submitted: 2/10/80 to NICHD. Written with Glendon Casto, Karl White, Craig Peery, and Frank Ascione. Rewritten and resubmitted at request of funding agency on 11/1/80. Status: Pending.

"The Longitudinal Effects of Various Types of Day Care on Children, Families, and Immediate Environment." $109,061. Submitted: 9/79 to DHEW. Written with: Glendon Casto, Karl White, and Frank Ascione. Status: Approved, funding unavailable.

PROFESSIONAL ACTIVITIES

Consultant on budget preparation for Regional Resource Center grant proposal, May, 1980; $353,700. Status: Funded.

Consultant to Multi-Agency Project for Preschoolers, 1979-present (preschool handicapped screening and evaluation).

Consultant to Fort Defiance Assessment Project, September, 1980 (adolescent Native Americans handicapped evaluation).

Consultant on data collection methodology, Head Start teachers workshops, July, 1979; September, 1979.

Student representative on the following committees: selection committees for USU Psychology Department Chairman, 1979; OSU Psychology Department Chairman, 1976; OSU Psychology Assistant Professor, 1977. Student co-representative to USU Psychology Department, 1979.

Member: Animal Behavior Society

Student Affiliate: American Psychological Association
Rocky Mountain Psychological Association

PUBLICATIONS, PRESENTATIONS, AND WORK IN PROGRESS

Cheney, C. D., & Eldred, N. L. Lithium chloride induced aversion in the opossum. *Physiological Psychology*, 1980, *8*, 383-385.

Eldred, N. L. Initial learning studies in the wallaroo, *Macropus robustus* (Gould). Unpublished master's report, Oregon State University, 1977.

Eldred, N. L. Effects of preexposure to shock on autoshaping. Dissertation in progress. Expected completion, September, 1981.

Eldred, N. L., & Cheney, C. D. Taste aversion in the opossum. Presented at the annual meeting of the Rocky Mountain Psychological Association, Denver, April, 1978.

Eldred, N. L., & Cheney, C. D. Behavioral changes following induced illness in the opossum, *Didelphis virginiana*. Presented at the annual meeting of the Animal Behavior Society, Seattle, 1978.

Eldred, N. L., & Cheney, C. D. Autoshaping to previously conditioned aversive conditioned stimuli. To be presented at the annual meeting of the Rocky Mountain Psychological Association, Denver, 1981.

Eldred, N. L., Mitchell, H., & Casto, G. Research update: Enhancing social-emotional competency in preschoolers. Paper presented at the fifth annual Early Childhood Conference, Midvale, Utah, June, 1980.

Eldred, N. L., & White, K. R. A critical review of the RMC evaluation model for Title I programs. In preparation for submission to: Educational Evaluation and Policy Analysis. Expected completion: September, 1981.

Zufelt, S., Eldred, N. L., & Cheney, C. D. Color (taste) aversion and autoshaping. Presented at the annual meeting of the Rocky Mountain Psychological Association, Las Vegas, April, 1979.

TEACHING INTERESTS

Basic Principles of Analysis of Behavior
Advanced Principles of Analysis of Behavior
Behavior Modification/Behavior Therapy
Statistics for the Social Sciences
Research Methodology and Design
Comparative Psychology/Ethology and Learning Theory
Introductory Psychology
Experimental Psychology
Developmental Psychology
Undergraduate Research Program

REFERENCES

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