

Classical Aversive Conditioning of the Rabbit's

Leg Flexion Response

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LEG FLEXION RESPONSE

by

Lionel J. Quesnel

A thesis submitted to the Faculty of Graduate Studies of  
the University of Manitoba in partial fulfillment of the requirements  
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## Abstract

The basic tenet of central motivational states theory is that conditioned appetitive and aversive motivational systems modulate instrumental performance (Rescorla & Solomon, 1967). It is presumed that multiple motivational activators have a subtractive effect between motivational systems, and a summative effect within systems. Tests of the theory have centered on transfer of control experiments involving the summation of activators across different motivational systems (heterogeneous), as well as within motivational systems (homogeneous). Unfortunately, logical and methodological confounds (Gormezano & Kehoe, 1975; Scavio, 1972) preclude unambiguous support for the central motivational states theory, and leave open to question the possibility that response system interactions and not motivational interactions, control the transfer effects observed (Overmier & Lawry, 1979).

To minimize the possibility that response systems interactions confound the test of central motivational states theory, Scavio (1972, 1974, 1975) employed classical-classical transfer paradigms with the rabbit's appetitive jaw movement and aversive nictitating membrane responses and showed that conditioned responses (CRs) from the two response systems were independent. However, paraorbital shock, the aversive unconditioned stimulus (US), elicits a jaw movement (Dearing & Dickinson, 1979) which under some conditions can lead to a conditioned jaw movement response (TenHave, Moser, Quesnel & Tait, Note 1) to the same conditioned stimulus (CS) as employed by Scavio.

Thus the possibility exists that subtle response interactions were affecting Scavio's results. To be considered independent, response systems should not be elicited by, nor conditioned to, the same US.

The present set of experiments was designed to develop a new conditioning preparation, the albino rabbit's leg flexion response to shock, that could be used to evaluate central motivational states theory. A leg flexion preparation would minimize the problem of response interaction since the site of US application is distal from innervation sites for the nictitating membrane and jaw movement responses. In addition, a leg flexion preparation would allow the examination of homogeneous motivational interactions within classical-classical transfer paradigms.

The purpose of the first experiment was to determine whether or not the rabbit's aversive hind leg flexion could be conditioned without eliciting either a jaw response, or a nictitating membrane response. Rabbits were presented with a tone paired with shock to the phalanges of the right hind leg. Unpaired, CS alone, and US alone control groups were employed to distinguish associative from nonassociative effects of stimulus presentations. In order to observe the effects of tone-leg shock pairings on the jaw movement and the nictitating membrane responses, these systems were also monitored.

The results of Experiment 1 showed that with the parameters employed, the hind leg flexion did not condition. As a consequence, Experiment 2 was undertaken to investigate alternative conditioning

parameters (e.g., CS duration, US delivery site, and US intensity) to ensure that the results of Experiment 1 were not a function of inappropriate parameter selection. Again the results indicated that the hind leg flexion could not be conditioned.

Since the rabbit's hind leg flexion response was insensitive to conditioning procedures, Experiment 3 was undertaken as an attempt to condition the rabbit's front leg flexion. Tone presentations were paired with a shock to the left front paw phalanges. Unpaired, CS alone and US alone control groups were employed to distinguish associative from nonassociative effects. The third experiment clearly showed the development of CRs on the front paw in the paired group, and very low levels of leg flexion in the control groups. Further work should be directed at determining the parameters that will result in optimal conditioning of the leg response and minimal elicitation of the nictitating membrane or jaw movement responses. When such parameters are identified, the leg flexion preparation could be used to evaluate central motivational states theory.

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## Introduction

The present experiments were designed to develop procedures that would permit the assessment of the interactions between conditioned responses in both a cross motivational and within motivational classical-classical transfer. The theoretical importance of this endeavor lies in the contention that instrumental performance is controlled by the interaction of classical and instrumental processes (Amsel, 1958; Konorski, 1967; Logan & Wagner, 1965; Miller & Konorski, 1928; Mowrer, 1947; Overmier & Lawry, 1979; Rescorla & Solomon, 1967; Skinner, 1935, 1938; Spence, 1956; Trapold & Overmier, 1972). While the mechanism of interaction has been a contentious issue, the basic concept is that central or peripheral classically conditioned responses (CRs) modulate instrumental performance through either secondary reinforcement mechanisms (e.g., Hull, 1943, 1957; Mowrer, 1947; Rescorla & Solomon, 1967) or by providing sources of incentive (e.g., Amsel, 1958, 1962; Bindra, 1968; Konorski, 1967; Miller, 1963; Mowrer, 1960). While two research strategies (i.e., concurrent measurement and transfer of control procedures) have been developed to test deductions of the various interactional theories, these research strategies have been challenged as not providing unambiguous support for the theories (Gormezano & Kehoe, 1975; Rescorla & Solomon, 1967; Scavio, 1972, 1974). Since a pertinent theoretical issue rests on the ability of classical CRs to regulate performance outside the original conditioning situation, Scavio (1972, 1974) has advocated

the use of classical-classical transfer paradigms to address the issue of CR mediation. The increased control provided by the classical conditioning paradigm was thought to preclude, or minimize, alternative theoretical explanations, and to provide a means for distinguishing between versions of interactional theories (cf. Dickinson & Pearce, 1977). Yet recent experimentation (e.g., Dearing & Dickinson, 1979; TenHave, Quesnel, Moser & Tait, Note 1) indicates that the response systems employed in classical-classical transfer paradigms may interact and therefore prevent a clear demonstration of whether mediation occurs peripherally or centrally. The present investigations were undertaken to develop a new conditioning preparation that could subsequently be employed to test mediational theory.

In the subsequent sections, the basic postulates of mediational theory will be presented and the major research strategies used to support mediational theories will be reviewed and analyzed. Finally, the logic of, and observations from, classical-classical transfer paradigms will be presented.

### Interactional Theories

The notion that Pavlovian CRs mediate instrumental performance is the result of the contention that there exist two acquisition processes: a conditioning process (i.e., Pavlovian conditioning) and an instrumental learning process (e.g., Hull, 1943; Konorski, 1948, 1967; Mowrer, 1947; Overmier & Lawry, 1979; Rescorla & Solomon, 1967; Spence, 1956; Trapold & Overmier, 1972). At a methodological level,

a clear distinction between the two procedures can be drawn. In Pavlovian conditioning, the experimenter has absolute control over the stimuli in terms of duration and delivery time. Furthermore, the presentation of stimuli are independent of the animal's behavior. However, in instrumental conditioning the experimenter merely arranges the situation such that the occurrence of an arbitrarily chosen behavior will be followed by reinforcement. Some theorists have postulated that, while procedurally distinct, these methodologies need not reflect the operation of different laws or processes. For example, Hearst (1975) suggested that the classical-instrumental distinction is based as much on philosophical-cultural prejudices and traditions as on behavioral experimentation and psychological theories. Nonetheless, a number of theorists maintain the notion of two different sets of learning laws and processes (Amsel, 1958; Konorski, 1969; Miller & Konorski, 1928; Mowrer, 1947; Overmier & Lawry, 1979; Rescorla & Solomon, 1967; Skinner, 1935, 1938; Spence, 1956; Trapold & Overmier, 1972).

As well as suggesting independent laws of learning for Pavlovian and instrumental conditioning, some two-process theories have postulated that Pavlovian conditioning mediates instrumental behavior. This assertion results from the observation that the requirements for classical conditioning are nested within the operations of the instrumental paradigm. Hence it is postulated that instrumental performance is a function of the interaction of two different learning

processes: (1) instrumental conditioning, resulting from response contingent reinforcement; and, (2) Pavlovian or classical conditioning, resulting from stimulus contingent reinforcement.

Although two-process theorists generally agree that Pavlovian conditioning influences instrumental responding, there is little consensus on either the mechanism or on the locus of mediation. The mechanism of mediation has been attributed to either secondary reinforcement (Hull, 1943, 1952; Mowrer, 1947; Rescorla & Solomon, 1967), or to conditioned incentive (Amsel, 1958, 1972; Bindra, 1968; Konorski, 1967; Miller, 1963; Mowrer, 1960). For positions that advocate mediation through secondary reinforcement, the classical CR or its stimulus consequences are thought to reinforce instrumental behavior. Accordingly, components of the instrumental behavior are presumed to occur prior to the observation of CRs. In contrast, theorists who postulate mediation through conditioned incentive argue that CRs or their stimulus consequences instigate instrumental behavior, and therefore should precede the instrumental performance in time.

There is also some disagreement as to the locus of the mediational process. Some theorists (e.g., Bindra, 1968; Konorski, 1967; Miller, 1963; Rescorla & Solomon, 1967) postulate the mediation process to occur centrally, whereas others argue for peripheral mediation (e.g., Hull, 1943, 1952; Logan & Wagner, 1965; Overmier & Lawry, 1979; Spence, 1956). For the centralist position, the locus of mediation is

suggested to be in motivational (e.g., Konorski, 1967; Miller, 1963; Rescorla & Solomon, 1967) or motor (e.g., Bindra, 1968; Konorski, 1963) systems located within the central nervous system with the primary emphasis on the motivational systems. While the postulated locus of mediation varies among central theorists, it is generally accepted that: (1) two motivational systems exist, with one being appetitive and the other aversive; (2) motivational systems are elicited directly by stimulus events and are conditioned following the rules of Pavlovian conditioning; and (3) the sources of activation of the motivational structure are summative within a system, and reciprocally inhibitory between systems.

In contrast, peripheral theorists (Amsel, 1958, 1962; Guthrie, 1933; Hull, 1943, 1952; Logan & Wagner, 1965; Overmier & Lawry, 1979) maintain that mediation is the result of directly observable responses. These CRs may be mechanically compatible or incompatible with the "to be learned" instrumental response (IR), and thereby facilitate or interfere with the instrumental performance (Hull, 1943, 1952; Logan & Wagner, 1965; Overmier & Lawry, 1979). Secondly, the stimulus consequences of CRs are thought to serve as discriminative stimuli for the instrumental behavior (Amsel, 1958, 1962; Spence, 1956).

#### Empirical Tests of Interactional Theories

In an effort to determine if Pavlovian mediation of instrumental performance occurs, as well as the mechanism of the mediation, three research strategies have been employed. The first strategy, the

concurrent measures design, was employed to monitor the temporal relationship between IRs and CRs. Transfer of control experiments were conducted to determine the modulating effect of Pavlovian conditioning on instrumental performance, and finally, classical-classical transfers were conducted to identify classically conditioned mediation. The following sections review the major results obtained utilizing these research designs.

#### Concurrent Measures Design

In the concurrent measures research design, the investigator simultaneously records situational CRs and IRs. The attempt to measure CRs concurrently with instrumental performance was based on the postulate that mediation by Pavlovian CRs was peripheral. This strategy was designed to identify whether CRs were antecedent or consequent to the development of instrumental performance. Concurrent measurement designs have been employed in instrumental tasks maintained by either appetitive or aversive reinforcers. The CRs typically measured during appetitive responding were: (1) salivation (Ellison & Konorski, 1964; Shapiro, 1961, 1962; Williams, 1965; Wolfe, 1963); (2) heart rate (Ehrlich & Malmo, 1967; Soltysik, 1960; Well & Obrist, 1967; Wenzel, 1961); and (3) licking (Deaux & Pattan, 1964; Miller & DeBold, 1965). A number of these studies found that CR acquisition occurred prior to the acquisition of instrumental responding (Ehrlich & Malmo, 1967; Shapiro, 1962), or was at least positively correlated with it (Deaux & Pattan, 1964; Webb & Obrist,



1967). However, the occurrence of the IR prior to conditioned responding was also frequently observed (Kintsch & White, 1962; Konorski & Miller, 1937; Shapiro, 1961; Miller & DeBold, 1965). Other studies have found the order of CR and IR acquisition to vary considerably between subjects under similar experimental protocols (Ellison & Konorski, 1966; Williams, 1965).

Concurrent measures of CRs during instrumental responding maintained by aversive reinforcement have also been taken. For example, heart rate CRs have been measured during both avoidance and suppression studies. Gantt and Dykman (1957) found that heart rate increased prior to the acquisition of an avoidance response. Although Black (1959) replicated these results, he also found that heart rate reached its maximum increase after the avoidance response. In addition, Black found that the conditioned heart rate extinguished prior to the avoidance response. Conversely, Soltysik (1960) found that the heart rate CR preceded the IR, but decreased following it. Bersh, Notterman and Schoenfield (1956) found no concurrent heart rate change prior to, or during, avoidance performance. Slebbins and Smith (1964) found a positive relation between conditioned suppression and heart rate, while DeToledo and Black (1966) found slower heart rate acquisition than suppression.

The lack of any consistent empirical temporal relationship between CRs and instrumental responding appears to preclude support for either secondary reinforcement or for incentive motivational

theorists. However, it can be argued that theoretical interpretations of the results of concurrent measures research are inappropriate, since the basic design contains the following four serious methodological flaws.

First, it is possible that the response systems chosen to index CR mediation were not involved in the mediation. Refuting this contention would require monitoring all response systems elicited by a particular unconditioned stimulus (US). While multiple response system recording is possible, it is impractical and risks leading the experimenter into an infinite regress.

Second, it is possible that any monitored CR may be under the influence of co-existing variables. Conditioned heart rate, for example is known to be affected by metabolic requirements of the organism (Black, 1959; Black & Dalton, 1965; DeToledo, 1971; Roberts & Young, 1971). In addition, heart rate changes often occur at the onset of a stimulus and reflect orientation behavior (Chase, Graham & Graham, 1968). As a result of these co-existing influences, it may be erroneous to suggest that heart rate provides a valid index of mediational CRs.

Third, because the eliciting conditioned stimulus (CS) is not specified, it is impossible to determine the level of conditioning of the CR. Since CR latency is controlled by the level of conditioning, the temporal relation between CRs and IRs will be determined by the eliciting CS. Therefore, without CS specification, the question of

antecedent or consequent responding, cannot be addressed. Finally, the simultaneous measurements of two different responses is a correlational approach, and therefore no causal conclusions can be drawn (Scavio, 1972).

Thus, with these serious flaws in design, the concurrent measures strategy was an inappropriate vehicle for resolving the secondary reinforcement versus incentive motivational issue. While the methodological flaws were not widely recognized, the failure to obtain consistent ordering of CRs and IRs did not result in a rejection of the interactional theory, but rather served as a data base to buttress the move from a peripheral to a central account of mediation (cf. Rescorla & Solomon, 1967). In addition, the failure of the concurrent measures strategy led to an emphasis on the use of transfer of control studies to identify interactional processes.

#### Transfer of Control Design

Transfer of control experiments typically involve three distinct phases: (1) an instrumental phase where an IR is established (2) a Pavlovian pairing phase during which a CS is paired with a US and (3) a test phase in which the CS is presented during instrumental responding. The underlying assumptions of this paradigm are: (1) that the conditioning of each phase is independent of prior, or subsequent, conditioning; (2) that the motivational states supporting conditioning in each phase are also independent of prior, and subsequent, conditioning; (3) that during the test phase there is no decrement

of either Phase 1 or 2 responding due to the interpolated time intervals between these phases and the test phase; and, (4) that test phase changes in instrumental performance reflect the interaction of the central motivational states conditioned in the Pavlovian and instrumental phases.

The transfer of control paradigm has been widely employed and can be dichotomized according to: (1) the hedonic value of the stimuli (appetitive or aversive); and (2) the transfer between or within motivational states. The interaction between the dichotomies can be viewed as a 2 x 2 factorial table, that is, between motivational states transfer (heterogeneous), that employ hedonically similar stimuli in each phase of the experiment (e.g., appetitive to appetitive or aversive to aversive). According to interactional theory (e.g., Rescorla & Solomon, 1967), interactions in heterogeneous transfers should be subtractive, whereas interactions in homogeneous transfers should be summative. Empirically, the transfer of control studies provide some support for the predictions of central motivational states theories.

#### Heterogeneous Transfers

The effect of presenting an aversively conditioned CS during appetitive instrumental performance has typically resulted in decreased instrumental responding (Blackman, 1968; Brady & Hunt, 1955; Brimer & Dockrill, 1966; DeToledo, 1971; DeToledo & Black, 1966; Estes & Skinner, 1941; Hoffman, 1969; Kamin, 1965; Roberts & Young, 1971).

A number of studies using differential Pavlovian procedures have also resulted in suppression of the instrumental baseline, as well as increased level of performance when a CS signaling the absence of a US (CS-) was presented (Hammond, 1966; Hendry, 1967; Ray & Stein, 1959). Kamin and Brimer (1963), in a study manipulating the intensity of the Pavlovian US, found that the suppressive effect of the CS was positively and directly related to the intensity of the US. However, Blackman (1968) also conducted a US intensity manipulation and found that, while performance of an IR maintained on a fixed ratio (FR) schedule was suppressed, instrumental responding maintained on a differential reinforcement of low rates of responding (DRL) schedule was only suppressed with low shock intensity (1.6 to 4.0 ma). Thus, while the results of aversive Pavlovian to appetitive transfers are somewhat consistent, they also suggest that the schedule of reinforcement maintaining the IR may be a pertinent factor in the mediation process.

The effects of a CS previously paired with an appetitive US on instrumental performance maintained by an aversive reinforcer, have also been examined. Coulston and Walsh (1968) conducted one of the earliest studies of this type and showed that the level of instrumental responding increased as a function of CS presentation. However, a large number of studies have yielded results dissonant with those of Coulston and Walsh (1968). Grossen, Kostansek and Bolles (1969), Bull (1970), and Davis and Kreuter (1972) all demonstrated that a CS

previously paired with an appetitive US, decreased the performance of an IR maintained by an aversive reinforcer. Although many of the results from the heterogeneous transfers are consistent with the central motivation states prediction of inhibition, there are sufficient studies which yield dissonant results to suggest the need for further research and to warrant reservations regarding the adequacy of central motivational states theory.

#### Homogeneous Transfers

The effect of presenting a CS, which has previously been paired with an aversive US, has typically been found to enhance or energize avoidance responding (Anisman & Waller, 1972; Grossen & Bolles, 1968; Overmier, 1966a, 1966b; Overmier, 1968; Overmier & Bull, 1969; Martin & Riess, 1969; Rescorla, 1967; Rescorla & LoLordo, 1965; Scobie, 1972; Solomon & Turner, 1962). A number of studies also found that if differential Pavlovian conditioning was administered the superimposition of the CS- inhibited or retarded ongoing avoidance responding (Rescorla & LoLordo, 1965; Solomon & Turner, 1962; Weisman & Litner, 1969). However, it has also been observed that homogeneous aversive transfers result in suppression of instrumental responding (Bryant, 1972; Hurwitz & Roberts, 1969; Pomerleau, 1970; Roberts and Hurwitz, 1970), and that conducting the Pavlovian pairing phase on or off baseline resulted in acceleration and suppression respectively of instrumental responding (Overmeier & Lawry, 1979). Suppression effects were also observed when the US-shock employed in the Pavlovian

phase was very severe (Anisman & Waller, 1972; Scobie, 1972).

A number of transfer studies have also been conducted using an appetitive US paired with a CS which was subsequently superimposed on an instrumental baseline maintained by an appetitive reinforcer. Estes (1943, 1948) found that presenting the Pavlovian CS during extinction enhanced performance. Facilitation was also found by Herrnstein and Morse (1957), Shapiro, Miller & Bresnahan (1966), Trapold & Winokur (1967); Trapold and Overmier (1972), Henton and Brady (1970), LoLordo, McMillan and Riley (1974) and Meltzer and Hamm (1974, 1978). In addition, a number of researchers conducted differential conditioning with an appetitive US and found that the CS enhanced instrumental performance, while CS- inhibited the performance of the IR (Bower & Grusec, 1964; Bower & Kaufman, 1963; Morse & Skinner, 1958). However, some studies have shown that a CS, previously paired with an appetitive US, superimposed on appetitively maintained instrumental responding, resulted in suppression of instrumental performance (Azrin & Hake, 1969; Hake & Powell, 1970; Kelly, 1973a, 1973b; LoLordo, McMillan & Riley, 1974; Meltzer & Brahlek, 1970; Miczek, 1973; Miczek & Grossman, 1971).

Thus, it appears the homogeneous transfer of control studies have been no more consistent than those of heterogeneous transfers. Taken together, the heterogeneous and homogeneous data suggest that the notion of instrumental performance being mediated by two types of conditioned affective states may be overly simplistic.

In an effort to deal with the inconsistent results produced by the transfer of control experiments, Overmier and Lawry (1979) conducted a series of studies from which they concluded that mediation could occur through: (1) motivational interactions; (2) discriminately controlled responses that may facilitate or interfere with the "to be learned" IR, and (3) the signalling capacity of the discriminative stimuli. They argued that the three processes worked in parallel and may be interactive. While Overmier and Lawry (1979) accounted for the inconsistencies observed in transfer of control studies by identifying three different mediational processes, Scavio (1972, 1974) and Gormezano & Kehoe (1975) suggested that the inconsistent results may be due to logical and methodological flaws inherent to the transfer paradigm.

The first of the problems addressed by Scavio (1972) concerned the possible conditioning of an IR during the Pavlovian pairing phase. Such a response could be reinforced by the US and come under the control of the CS. If an IR were conditioned to the CS, then possible interactions between it and the Phase 2 IR could occur. The modulation of instrumental responding observed in the transfer designs might then be the result of the mechanical compatibility or incompatibility of the IR acquired during the Pavlovian phase and the target IR.

Trapold and Overmier (1972), as well as Overmier and Lawry (1979), discussed this problem and suggested a number of strategies to minimize



this type of interaction. First, they suggested restraining the animal in order to minimize possible responses that could alter the receipt of the US. Second, they advocated conducting the Pavlovian phase in an apparatus different from that in which the instrumental and test phase were conducted in order to minimize stimulus generalization of possible mediating IRs. While these strategies may deal with possible IR-IR interactions effectively, two problems raised by Scavio (1972) still remain for the transfer of control experimental design.

The second problem that Scavio addressed was that performance of the targeted IR during the test phase may interact with the interpolated Pavlovian CS and alter its eliciting characteristic. This IR-CR interaction might then result in an alteration of the modulating effect of the CR. While Miller and Konorski (1928) recognized the potential confounding effect of this interaction, no attempt was made to eliminate or measure it.

Finally, the third problem that Scavio (1972) addressed was the possibility that two CRs may be interacting during the test phase. One of the CRs would be elicited by the CS presented during the Pavlovian pairing phase, while the second would be established to situational cues during the original instrumental training. The situationally conditioned CRs, while not specified to affect the transfer of control, are postulated as the normal controlling variables of instrumental behavior (Rescorla & Solomon, 1967), and therefore

should be present at testing. The resulting CR-CR interactions or the possible interactions between CRs and IRs may then yield the modulation of instrumental performance in the test phase. Thus, logically it is not possible to identify the mechanism of the interactional effects, since the same measurement problems that occur with the concurrent measurement procedure are attendant on attempting to measure these situational CRs. To overcome the difficulties associated with the transfer of training experiments, Scavio (1972) suggested determining the effect of CR mediation by employing classical-classical transfer designs.

#### Classical-Classical Transfers

The classical-classical transfer design typically involves two conditioning phases. In the first phase, a CS is paired with the US, and a CR in one response system develops (CR1) according to the empirical laws of classical conditioning. In the second phase, the same CS is paired with a different US and a second CR (CR2) in a different response system develops. During the second phase, both CR1 and CR2 can be monitored and factors controlling their occurrence can be isolated.

The efficiency of the classical-classical design rests on two contentions (Scavio 1972, 1974). First, since during both phases measurable responses are conditioned and monitored, Phase 2 CR2 acquisition may be monitored along with changes in Phase 1 CR1. Thus, if conditioning processes have no mediational properties, the

two phases should be independent and show no functional inter-relationship. If response interaction is the major vehicle of mediation, the two phases will be interactive only to the extent that the responses interact. If mediation occurs through central motivational states, the interaction between the phases should be based on the motivational, and not on the response properties, of the two phases. Finally, if motivational states follow the empirical laws of classical conditioning, then Phase 2 performance should follow the same empirical laws established in Phase 1. Therefore the classical-classical transfer represents a more efficient methodology than either the concurrent measurement technique or the classical-instrumental transfer procedure alone. The second contention supporting the use of the classical-classical research design asserts that restraining the subjects during both phases minimizes the possibility of mediation by instrumental responding and thereby precludes IR-IR interactions. Thus the classical-classical transfer paradigm, although an indirect measurement methodology, allows a clearer assessment of response and/or motivational state interactions in conditioning. A number of studies have been conducted employing classical-classical transfer designs. Again these may be divided into heterogeneous or homogeneous transfers.

#### Heterogeneous Transfers

Scavio (1972, 1974) presented rabbits with tone-paraorbital shock pairings for nictitating membrane (NM) in Phase 1 conditioning

followed by pairing of the same tone with an oral injection of water-US for jaw movement (JM) conditioning in Phase 2. With this procedure, Scavio (1974) observed: (1) that NM conditioning retarded subsequent JM acquisition; (2) that NM extinction was facilitated by pairing the CS with H<sub>2</sub>O; (3) that JM retardation was not a function of the number of tone-shock pairings presented in Phase 1; and (4) that JM CRs were statistically independent of NM CRs. Bromage and Scavio (1978) replicated the results obtained by Scavio (1974) and also demonstrated the unpaired presentation of the tone-paraorbital shock in Phase 1, a presumed inhibitory procedure (cf. Wagner & Rescorla, 1972) facilitated subsequent JM acquisition. These observations led Scavio to conclude that: (1) mediation through classical-classical processes was possible; (2) since the occurrence of the conditioned responses (i.e., the NM and JM) were mathematically independent, mediation was the result of a central mechanism; (3) that since retardation of the JM response occurred, the mediational mechanism was motivational; and (4) that since the retardation was not a function of the manipulated classically conditioned independent variable, the motivational rules did not follow the empirical laws of classical conditioning.

#### Homogeneous Transfers

TenHave, Quesnel, Moser and Tait (Note 1) conducted two experiments within motivational states. In the first, rabbits were presented with tone and jaw shock for aversive JM conditioning, followed by tone-

paraorbital shock for NM conditioning. TenHave et al. (Note 1) found that: (1) NM acquisition was facilitated by prior aversive jaw conditioning; and (2) that the NM response, while not conditioned, was reliably elicited by jaw shock.

In a second experiment, TenHave et al. (Note 1) presented subjects with tone-paraorbital shock for NM conditioning, followed by tone-jaw shock for aversive jaw conditioning. TenHave et al. observed that: (1) prior NM conditioning facilitated aversive JM acquisition; and (2) the paraorbital shock presented in Phase 1 not only reliably elicited, but also conditioned, the aversive JM. TenHave et al. (Note 1) concluded that: (1) mediation through classical-classical processes was possible; and (2) the observed facilitation in both studies supported a motivational interpretation of mediation by showing within motivational system summation.

While the results from the classical-classical transfers appear to support the two-process central mediation account, it may be possible to account for the results on the basis of response competition. In order to do so, it is necessary to (1) identify possible competing responses; and (2) indicate how their occurrence influences the results of the transfers. Both of these requirements can be illustrated. Dearing and Dickinson (1979) and TenHave et al. (Note 1) observed that paraorbital shock elicited both the NM response and an aversive JM response. In addition, TenHave et al. found that the paraorbital shock produced aversive JM conditioning to the tone.

These observations provide the basis for an alternative interpretation of the above results.

The facilitation found in the homogeneous transfers conducted by TenHave et al. may have resulted, not from motivational summation, but from response facilitation due to the use of a more effective US (jaw, as opposed to paraorbital shock) for an already conditioned response. A similar interpretation based on response facilitation, might be suggested for the aversive jaw to aversive NM transfer, where the shock to the jaw also produces reliable NM unconditioned responses. The retardation observed in the heterogeneous NM to appetitive jaw transfers (Bromage & Scavio, 1978; Scavio, 1974) may also be accounted for by a peripheral competing response (i.e., the aversive JM). Since the aversive JM response elicited by the paraorbital shock is topographically dissimilar to the appetitive jaw response (TenHave et al., Note 1), a response interference or competition may be posited to account for the observed retardation of JM responding.

Although the results of classical-classical transfers indicate that classically conditioned variables can mediate performance, they have not yet distinguished between a central motivational state and a peripheral response mediation. In order to determine if mediation is central or peripheral, it is necessary to preclude possible response interference or facilitation. This can be accomplished by conditioning two response systems which can not only be conditioned independently

of one another, but which are also not elicited by the effective US for the alternate system. The requirement of independent response systems (defined as two response systems not elicited by the same US) is important in view of possible conditioning of potentially competing responses (Hull, 1943; Wagner & Rescorla, 1972).

Since the response systems that are typically classically conditioned in the rabbit (NM, eyeball retraction, eyelid closure, JM) are interrelated in terms of identical or proximate innervation, and since the effective US for any one of these response systems elicits responding in many of the others, it was necessary to attempt to develop a new response system which did not elicit at least one alternate appetitively and aversively motivated response. Since sites of elicitation of leg flexion are distal from sites of elicitation of either the NM or JM responses, and since leg flexion has been successfully conditioned in dogs (e.g., Pavlov, 1927) and cats (e.g., Dykman & Shurrager, 1956), the present experiments focused on developing a leg flexion (LF) preparation in the rabbit.

## Experiment 1

The purpose of the first experiment was twofold: first, to determine if the hind LF in the New Zealand white rabbit could be conditioned; and second, to determine if conditioning the hind LF with a shock US could be accomplished without eliciting or conditioning the rabbit's JM or NM responses. Although the hind LF has not been conditioned in the rabbit, it has been conditioned in both cats (Dykman & Shurrager, 1956; Patterson, 1975; Patterson, Cegavske & Thompson, 1973; Wickens, Meyer & Sullivan, 1961; Wickens et al., 1969) and dogs (Gahery, Ioffe, Massion & Polit, 1980; Khodorov, 1959; Kochigena, 1958; Makarov, 1961; Overmier et al., 1979b; Shurrager & Culler, 1938; Shurrager & Culler, 1940; Shurrager & Shurrager, 1946). An analysis of the parameters employed to condition the LF in cats and dogs has shown the following to yield high levels of conditioning: tone, tone-light compound, and cutaneous electrical stimulation CSs; shock USs ranging from 1.7 and 6 ma applied to various areas of the hind leg between the ankle and the pad of the paw; shock durations ranging between 60 and 500 msec; and CS-US intervals between 250 msec and 1500 msec. The optimal CS-US interval appeared to be between 300 and 500 msec (Wickens, 1973). It should be noted that similar parameter ranges yield successful conditioning in the rabbit. For the NM response, tone and light CSs have been paired with paraorbital shock USs that range in duration from 50 to



6000 msec, and in intensity from 1 to 5 ma. Effective CS-US intervals range from 150 to 8000 msec (cf. Gormezano, 1972). For the rabbit's aversive JM response, only a limited range of parameters have been employed. TenHave et al. (Note 1) obtained effective conditioning with a 500 msec tone CS and a 2.5 ma, 100 msec shock US to the lower mandible. The CS-US interval was 500 msec. The commonality of effective parameters between LF conditioning in other species and aversive conditioning in the rabbit suggests that effective LF conditioning in the rabbit could be obtained by employing parameters that control LF responding in other species.

Accordingly, in Experiment 1, the following stimuli were employed: A 500 msec, 1000 Hz tone CS was paired with a 50 msec, 2.5 ma shock US applied to the phalange region of the right hind leg. Pilot work indicated that the chosen site of US application reliably elicited LF URs and supported anticipatory responding. Experiment 1 was designed to confirm that the anticipatory responses were CRs by employing methodological controls such as CS alone, US alone and unpaired groups to evaluate nonassociative contributions to LF responding.

### Method

#### Subjects

The subjects were 24 male and female New Zealand albino rabbits (*Oryctolagus cuniculus*) about 100 days of age and weighing approximately 2.5 kg. The rabbits were obtained from the Kleefeld

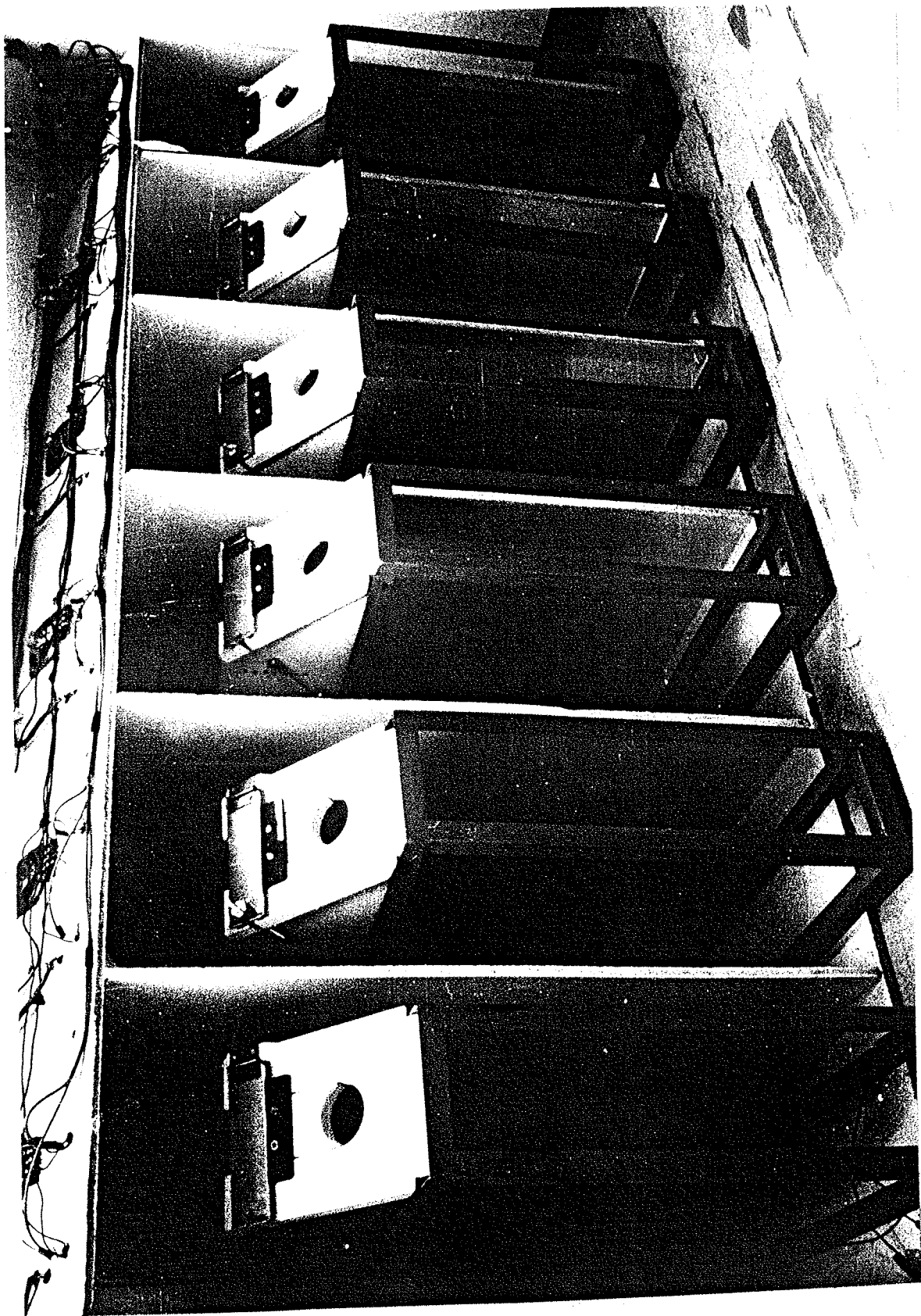
Rabbitry in Tourond, Manitoba.

### Apparatus

The apparatus consisted of six experimental chambers in a room with continuous white noise which acoustically isolated subjects from the programming and recording equipment. Each of the six experimental chambers was 75 cm long, 33 cm wide, and 85 cm high (see Figure 1). Illumination in the chamber was provided by ambient room light. The subjects were placed in restraining boxes that were similar to those detailed by Gormezano (1966), except for the following differences: (1) starting from the back of the restraining box, two slots 4 cm wide and 25 cm long were milled along the length of the interior edges of the bottom of the box to permit the subjects' rear legs to hang down; and (2) a plate was designed which could be locked into place over the length of the subjects' backs to prevent the rabbits from drawing their legs up into the boxes. The restrainer boxes restricted gross body movement while head movement was minimized by adjustable yoke collars and foam-padded pinnae clamps. The restraining boxes were subsequently locked onto support stands and placed in the chambers such that the subjects' heads were 20 cm from the stimulus panels.

Three response systems were monitored throughout the experiment. The JM and NM movements were monitored by two rotary potentiometers (Giannini Type 20) anchored to a ring placed over the subjects' ears prior to their being pinned with the pinnae clamps. For JM

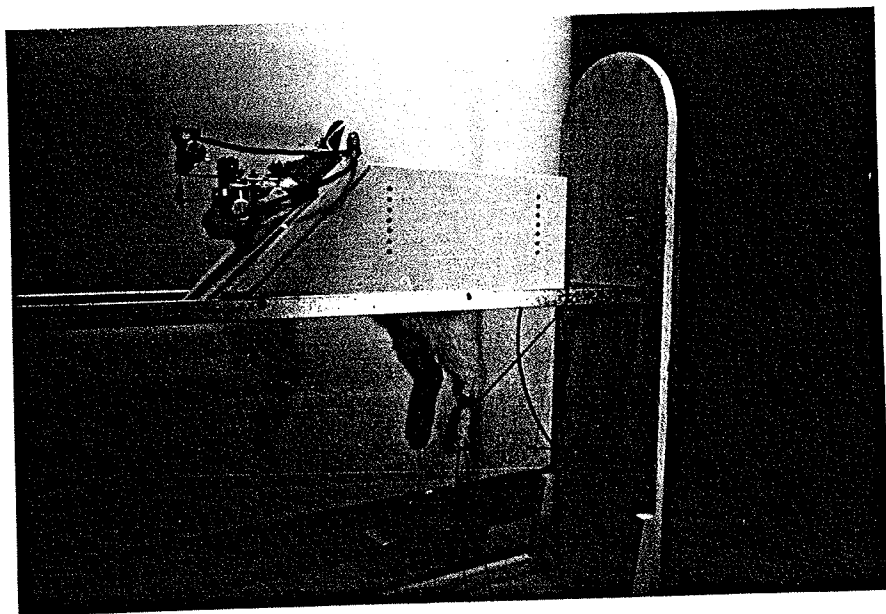
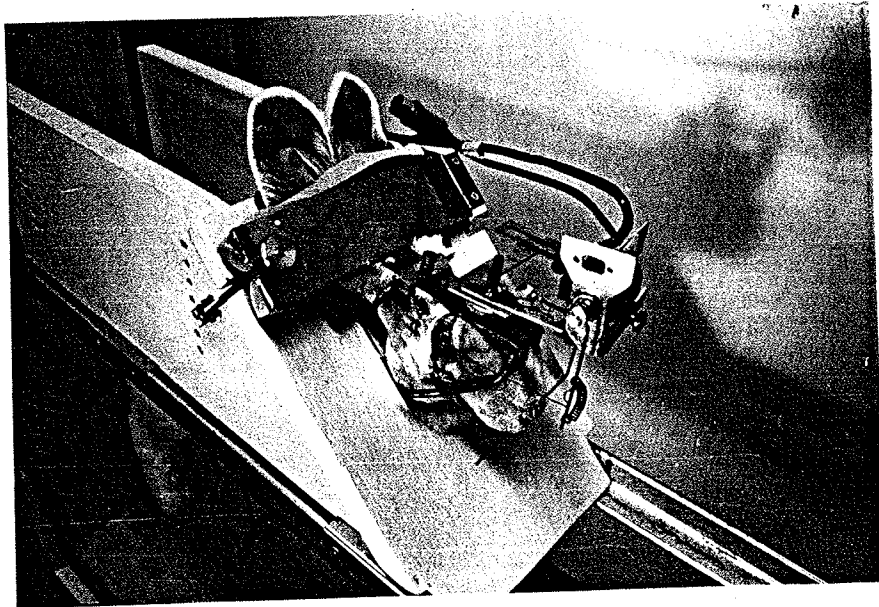
Figure 1. Chambers employed for classical conditioning of the rabbit's leg flexion, jaw movement and nictitating membrane responses.



response transduction, a counterbalanced rod coming off the rotary axle of one of the potentiometers was bent to slip through a 9 mm Autoclip affixed to the subject's lower mandible. For NM response transduction, the outer eyelid of the rabbit was retracted with a #3 tailor hook mounted on an adjustable Velcro strap. A silk thread, affixed at one end to a counterbalanced rod that was mechanically coupled to the shaft of a second potentiometer, was hooked into a small loop of monofilament that had previously been sutured into the right NM of the subject. The LF was transduced by placing a Velcro cuff on the subject's right hind leg, around the metatarsus midway between the joints of the tarsus and the posterior phalanges. A silk thread, affixed to the leg cuff, was connected to a counterbalanced rod which was mechanically coupled to the axle of a rotary potentiometer (Bourns, 6637S).

Pilot work determined that the rabbit's LF sweeps up and forward, then down and behind its resting position in response to shock. It was therefore important to record movements in an arc, as well as those in only the vertical or horizontal planes. In order to maximize accurate transduction of movements, the silk thread affixed to the leg cuff was run up and away from the vertical plane of the resting leg at a 45° angle. The thread was then fed through an eye screw and dropped vertically down to the counterbalanced rod (see Figure 2). This effectively transduced movements in an arc, or those in only the vertical or horizontal planes. Voltage changes in the potentiometers

Figure 2. Apparatus required for the transduction of the jaw movement and nictitating membrane responses (upper panel) and leg flexion response (lower panel).



which resulted from movements of either the jaw, NM or LF, were conducted to the analog to digital (A/D) input channels of a Raytheon 703 computer. The A/D input channels were scanned by the computer every 10 msec. The CS was a 500 msec, 80 db, 1000 Hz tone delivered through a speaker at the center of the stimulus panel. The US, a 2.4 ma, 50 msec shock, was delivered to Autoclips implanted 10 mm apart in the skin, directly behind the midpoint of the center phalanges of the rabbit's right hind leg. The Raytheon 703 was programmed to control the delivery of these stimuli as well as to analyze the dependent variables from the analog record. Response latencies were typed out on an ASR teletype and, during the intertrial interval, the A/D records were plotted on a Tektronic Type 22 point plotter.

#### Procedure

Three days after their arrival, all subjects had a small loop of 00 ethicon monofilament sutured into the outer edge of their right NM, after which a few drops of ophthalmic solution were put into the eye. A 9mm Autoclip was also implanted on the lower mandible of each subject. This permitted the NM movement and the JM to be recorded. Finally, two 9 mm Autoclips were implanted 10 mm apart in the rabbit's right hind leg in order to deliver the shock US.

On the second postoperative day, the subjects were randomly assigned to four squads of six rabbits. The animals were then placed into the restrainer boxes and adapted to the chambers for a period



of time equivalent to the duration of subsequent acquisition sessions. The subjects were given no stimuli during this session. However, monitoring of LF movements for all subjects was undertaken in time periods corresponding to the occurrence of stimulus presentations during subsequent conditioning sessions. JM movements were recorded for the first three subjects and NM movements for the last three subjects in each group during the same periods as LF monitoring occurred.

On the third postoperative day, the acquisition phase consisting of 10 daily sessions was implemented. One squad (P) was given forward pairings of tone and shock; the second squad (U) was given explicitly unpaired presentations of tone and shock; a third squad (CSa) was presented with the tone alone; and the fourth squad (USa) was given shock alone presentations.

In each daily session, Group P received 50 trials separated by a mean intertrial interval of 60 seconds. Each trial consisted of a forward pairing of the tone CS, followed at offset by the onset of the shock US, with a CS-US interval of 500 msec. Group U was presented with 50 USs with the restriction that the minimum intertrial interval be no less than 30 seconds, and that either stimulus not be presented more than three times in succession. Groups CSa and USa were presented with 50 CSs and 50 USs respectively, delivered in time periods corresponding to their delivery in Group P.

LF was monitored for all subjects while the JM and NM were

monitored for the first three and last three subjects, respectively, of each group. Monitoring for CRs was undertaken during the CS-US interval. Monitoring for URs occurred during a one second period after US onset. In the control groups, the monitoring periods corresponded to those of the P group and were determined from CS or US onset.

It is important to note that the UR latencies for the JM and NM, when elicited by a shock US, have been found to be approximately 40 to 50, and 20 to 30 msec respectively (TenHave et al., Note 1). Should either the JM or NM be elicited by the shock used in conditioning the LF, the one second monitoring period after US onset will yield a very liberal measure of responding.

On the day following the last acquisition session, extinction was implemented for all subjects. The extinction session consisted of 50 CS alone trials, with a mean intertrial interval of 60 seconds. Only responses occurring during the CS were monitored.

#### Response Specification

The response criteria for each of the three systems were as follows: (1) a 1 mm movement of the jaw which corresponded to a .6 volt change on the potentiometer and resulted in a 30 A/D change at the computer; (2) a 1 mm extension of the NM which caused a .2 volt change on the potentiometer and a change of 10 on the A/D channel; and (3) a 1 mm movement of the right hind leg. CRs were defined as any movement of the jaw, NM or leg which reached the criteria specified

for a response, and began within the 500 msec CS-US interval. URs were defined as movements reaching criteria and beginning within one second after US onset.

### Results

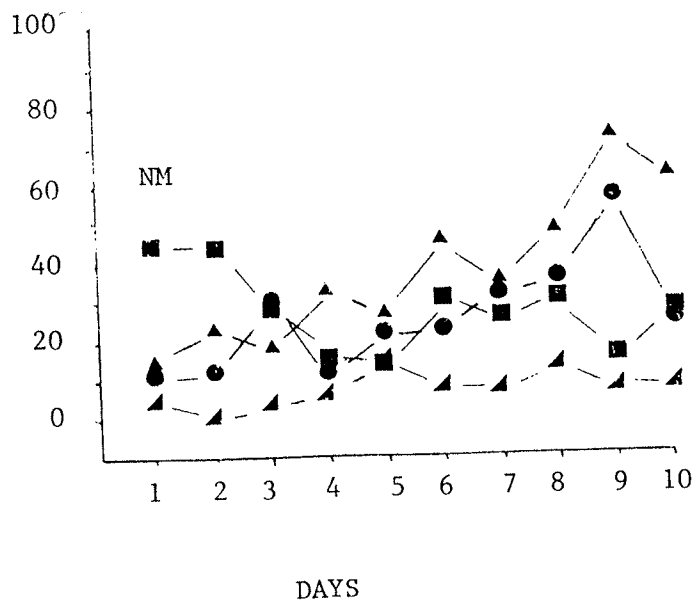
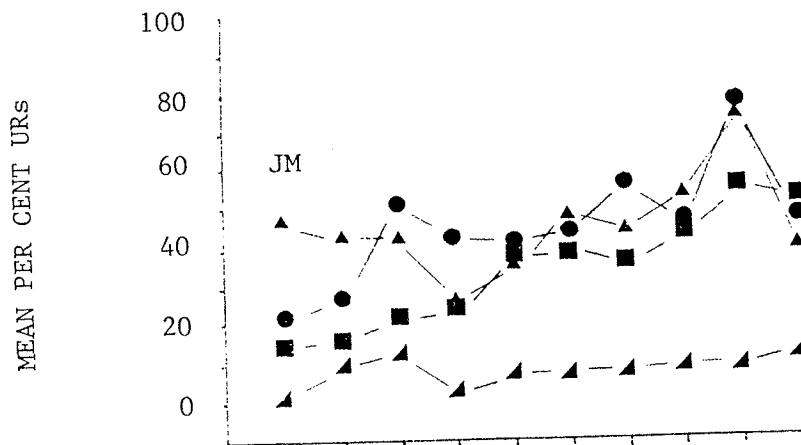
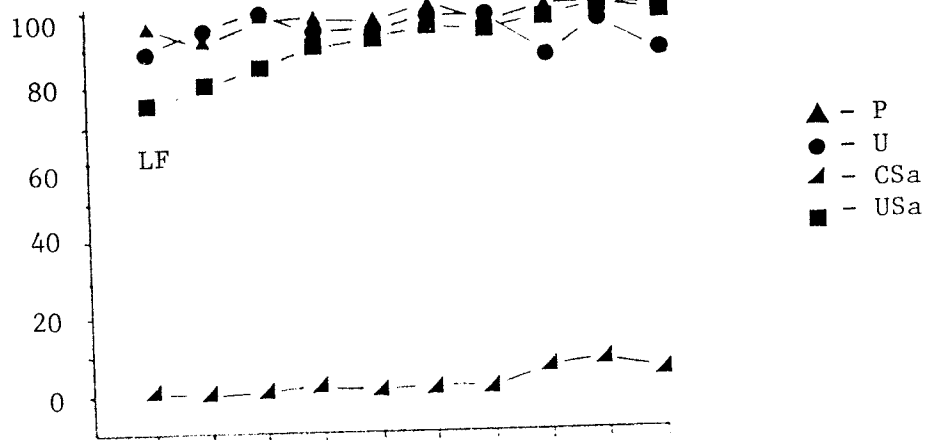
The analysis of Experiment 1 was divided into three sections, one for each of the three response systems. In each group the LF was monitored on all six subjects, the JM on the first three, and the NM on the last three subjects. Both UR elicitation and conditioned responding were monitored and analyzed for each response system during adaptation, acquisition and extinction.

#### Leg Flexion Responding

Adaptation. Mean per cent LF responding during the period corresponding to the interval monitored for URs in acquisition was low (1.0, 4.5, 0.0 and 4.6 for Groups P, U, CSa and USa, respectively). An ANOVA indicated that no significant differences existed ( $F(3, 20) = 1.80, p = 0.17$ ). The mean per cent LF responding during the period monitored for CRs in acquisition was also low (1.0, 0.0, 3.8 and 1.5 for Groups P, U, CSa and USa, respectively), and no significant between group differences were found ( $F(3, 20) = 0.87, p = 0.47$ ).

Acquisition. Figure 3 (upper panel) depicts the mean per cent LF UR elicitation as a function of days for all groups. As can be observed, elicitation for Groups P, U and USa was high and very stable (mean per cent = 97.7, 94.4 and 91.6, respectively). The mean per cent elicitation for Group CSa was 2.4. An ANOVA confirmed the observed

Figure 3. Mean per cent URs during acquisition for the LF response, the JM response and the NM response.



group differences as significant ( $F(3, 20) = 657.54, p = 0.00$ ).

The upper panel of Figure 4 depicts the mean per cent LF CRs for all groups over the 10 days of acquisition. As can be observed, mean per cent responding in all groups was very low (4.8, 1.6, 1.0 and 1.5 for Groups P, U, CSa and USa, respectively), and did not significantly differ between groups ( $F(3, 20) = 0.71, p = 0.55$ ). The ANOVA also indicated that no differences between groups were found over days ( $F(27, 100) = 0.91, p = 0.59$ ).

Figure 5 depicts the mean per cent URs and CRs for Subjects 1 to 6 in Group P during acquisition, showing the levels of LF UR elicitation across subjects to be very high and stable. This is also reflected in the grouped curve (see Figure 3, upper panel). The conditioned responding across days was very low for Subjects 1 to 5. Although Subject 6 showed some conditioning, this was not stable. Therefore, the group curve for these subjects (see Figure 4, upper panel) is representative of individual subject performance.

#### Extinction

The mean per cent LF movement during the period corresponding to that in which URs were monitored during acquisition was low (2.0, 0.0, 2.7 and 3.0 for Groups P, U, CSa and USa, respectively), and no significant differences were found between groups ( $F(3, 20) = 2.14, p = 0.12$ ). The mean per cent CRs during extinction was also very low (1.3, 0.3, 0.8 and 2.6 for Groups P, U, CSa and USa, respectively). No significant differences were found between groups ( $F(3, 20) = 0.87, p = 0.47$ ).

Figure 4. Mean per cent CRs during acquisition for the LF response, the JM response and the NM response.

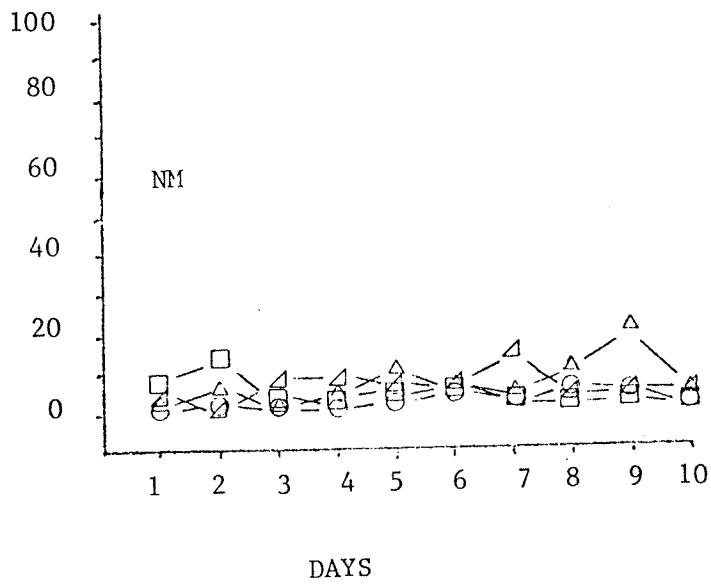
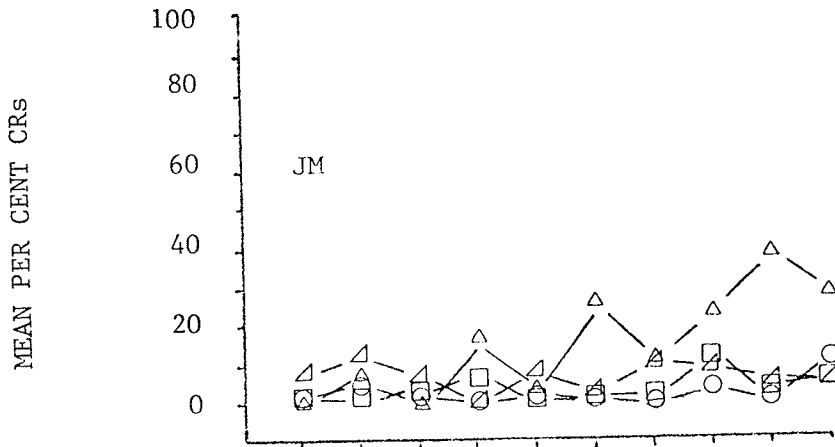
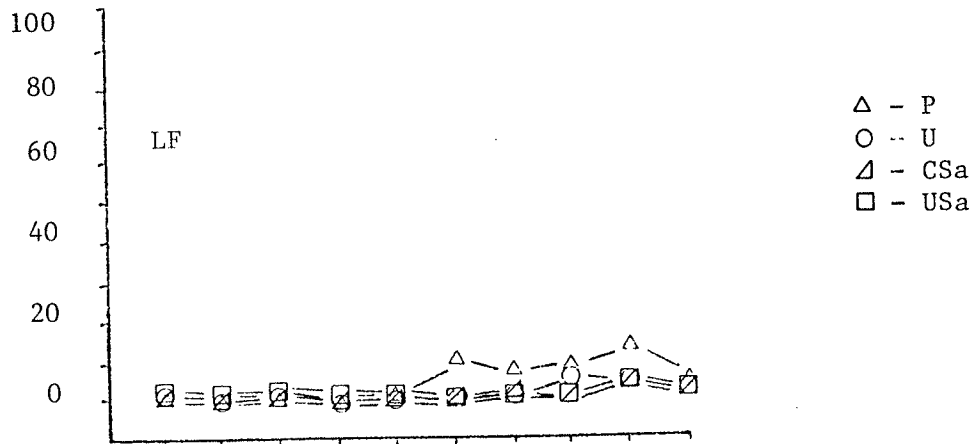
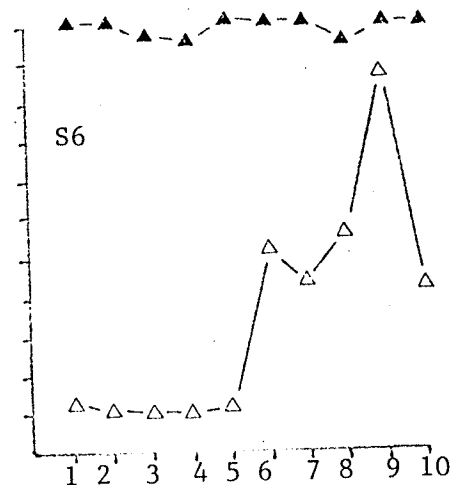
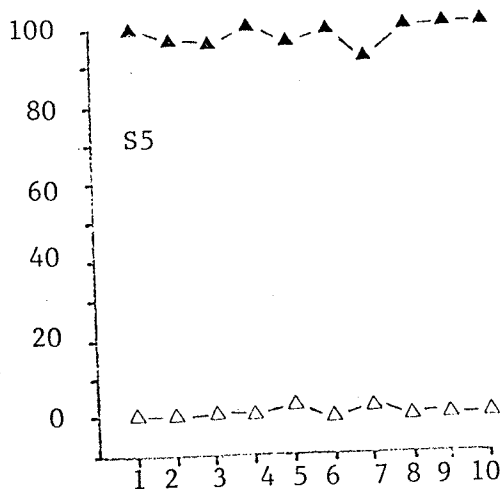
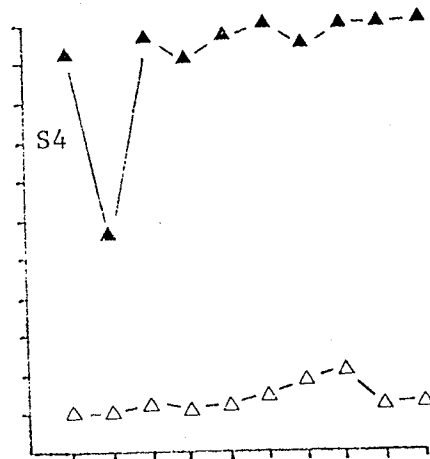
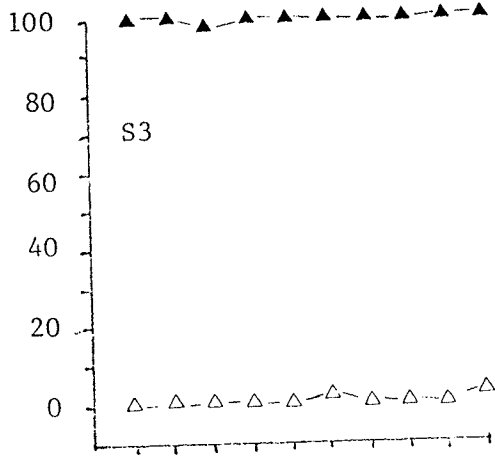
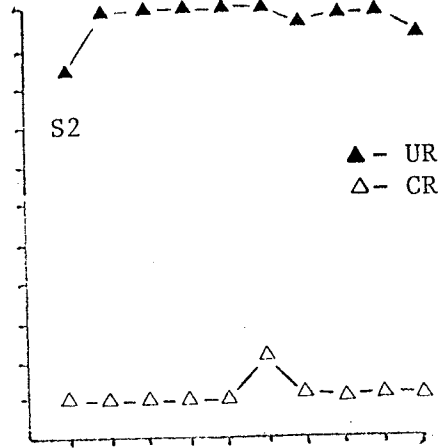
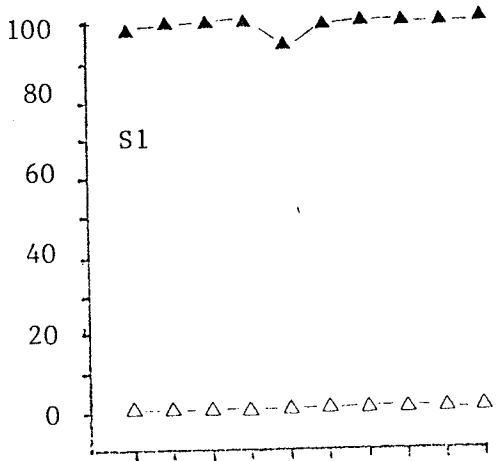




Figure 5. Mean per cent LF URs and CRs for Subjects 1 to 6 in Group P during acquisition.

MEAN PER CENT LF RESPONDING



DAYS

### Jaw Movement Responding

Adaptation. The mean per cent responding in the period corresponding to the period scanned for URs during acquisition was very low (2.6, 0.0, 3.4 and 1.4 for Groups P, U, CSa and USA, respectively), and no significant between group differences were found ( $\underline{F}$  (3, 8) = 1.51,  $\underline{p}$  = 0.28). The mean per cent jaw movement during the period scanned for CRs during acquisition was also very low (1.3, 1.3, 2.0 and 1.3 for Groups P, U, CSa and USA, respectively), and did not differ between groups ( $\underline{F}$  (3, 8) = 0.11,  $\underline{p}$  = .95).

Acquisition. The center panel of Figure 3 depicts the mean per cent JM URs over the 10 sessions of acquisition. This illustrates that elicitation of JM URs by the leg shock in Groups P, U and USA occurred at intermediate levels (44.7, 45.1 and 33.6, respectively), and increased slightly over days ( $\underline{F}$  (9, 72) = 2.16,  $\underline{p}$  = 0.03). The mean per cent UR for Group CSa was very low (7.27) and did not increase over days ( $\underline{F}$  (9, 18) = 1.15,  $\underline{p}$  = 0.14). Planned orthogonal comparisons showed that the level of elicitation in Group CSa was significantly lower than that in Groups P, U, or USA ( $F(1,8)$  = 4.35,  $\underline{p}$  < 0.08).

Figure 4 (center panel) indicates that the mean per cent JM CRs for all groups across the 10 acquisition sessions was low (15.2, 3.0, 7.1 and 3.9 for Groups P, U, CSa and USA, respectively), and did not differ significantly between groups ( $\underline{F}$  (3, 8) = 1.16,  $\underline{p}$  = 0.38).

Figure 6 depicts the mean per cent URs and CRs for Subjects 1, 2 and 3 of Group P. As can be observed, mean per cent elicitation

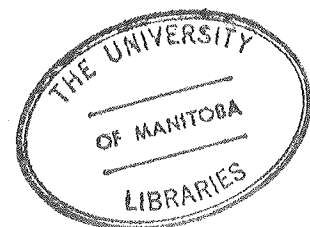
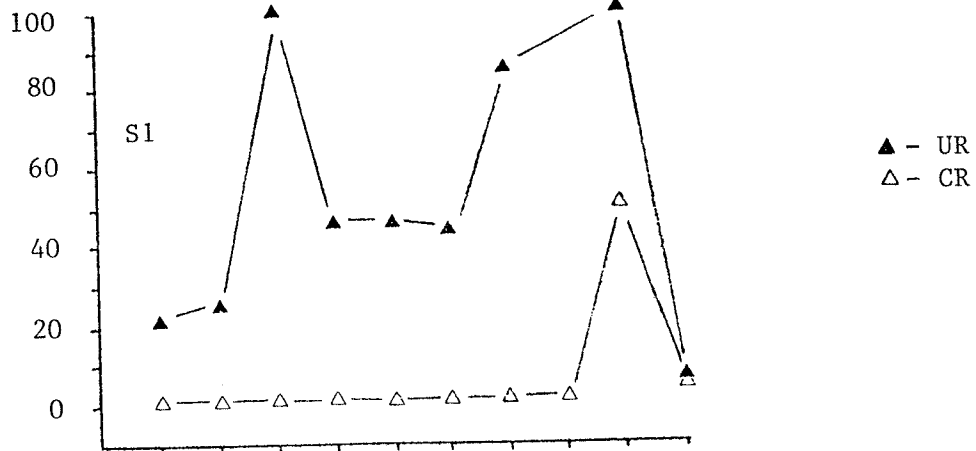
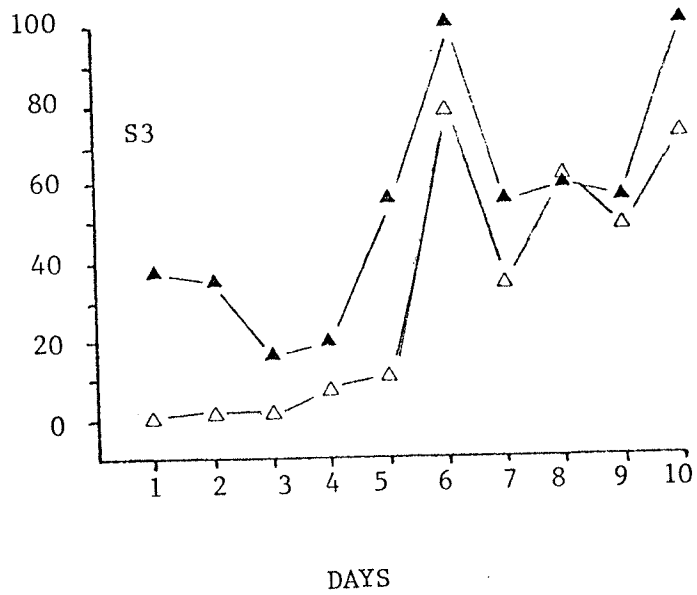
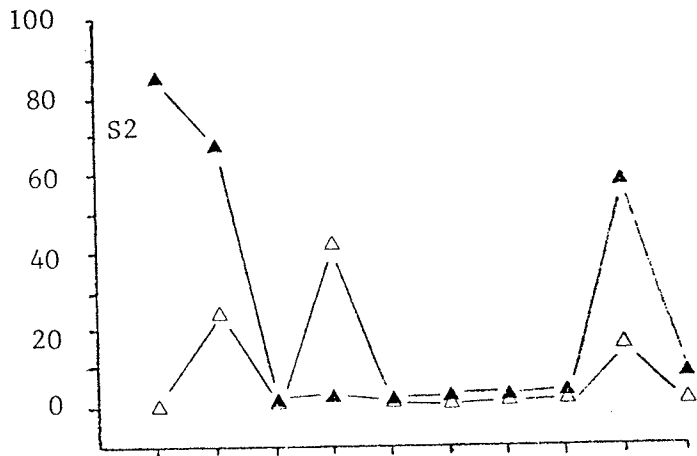


Figure 6. Mean per cent JM URs and CRs for Subjects 1, 2 and 3 in Group P during acquisition.



MEAN PER CENT JM RESPONDING



increased over days for Subjects 1 and 3, but remained low for Subject 2. The mean per cent CRs was low for Subjects 1 and 2 and, while it increased somewhat for Subject 3, responding was generally variable.

Extinction. The mean per cent JM during the period corresponding to that monitored for URs during acquisition was low (1.9, 7.4, 21.3 and 11.7 for Groups P, U, CSa and USa, respectively), and did not differ significantly between groups ( $F(3, 8) = 1.32$ ,  $p = 0.33$ ). The mean per cent CRs for each group during extinction was also very low (15.9, 7.6, 17.3 and 11.1 for Groups P, U, CSa and USa, respectively), and no significant between group differences were found ( $F(3, 8) = 0.20$ ,  $p = 0.89$ ).

#### Nictitating Membrane Responding

Adaptation. The mean per cent elicitation of the NM during the period corresponding to that scanned for URs during acquisition was low (1.0, 1.5, 4.6 and 25.0 for Groups P, U, CSa and USa, respectively), and no significant differences were found between groups ( $F(3, 8) = 3.04$ ,  $p = 0.11$ ). The mean per cent NM movement during the period monitored for CRs in acquisition was also very low (2.8, 1.3, 7.2 and 10.9 for Groups P, U, CSa and USa, respectively), and did not differ significantly between groups ( $F(3, 8) = 2.27$ ,  $p = 0.15$ ).

Acquisition. The mean per cent NM UR during acquisition is depicted in Figure 3 (lower panel). As can be observed, the elicitation by leg shock was at intermediate levels for Groups P, U and USa (37.5, 25.8 and 27.4, respectively), and did not increase over days.

( $F(9, 72) = 1.02, p = 0.43$ ). The mean per cent elicitation for Group CSa was low (6.9) and did not change over days ( $F(9, 18) = 1.23, p = 0.33$ ). Planned orthogonal comparisons showed that the level of elicitation in Group CSa was significantly lower than in Groups P, U, or USa ( $F(1,8) = 9.87, p < 0.025$ )

Figure 4 (lower panel) depicts the mean per cent NM CRs during acquisition for all groups. As illustrated, the mean per cent responding was low (7.1, 3.2, 5.8 and 3.8 for Groups P, U, CSa and USa, respectively), and no significant differences existed between groups ( $F(3, 20) = 1.05, p = 0.42$ ).

Figure 7 shows the mean per cent URs and CRs for Subjects 5, 6 and 7 of Group P during acquisition. As can be observed, unconditioned responding is variable while per cent CRs are low, showing little variability over days.

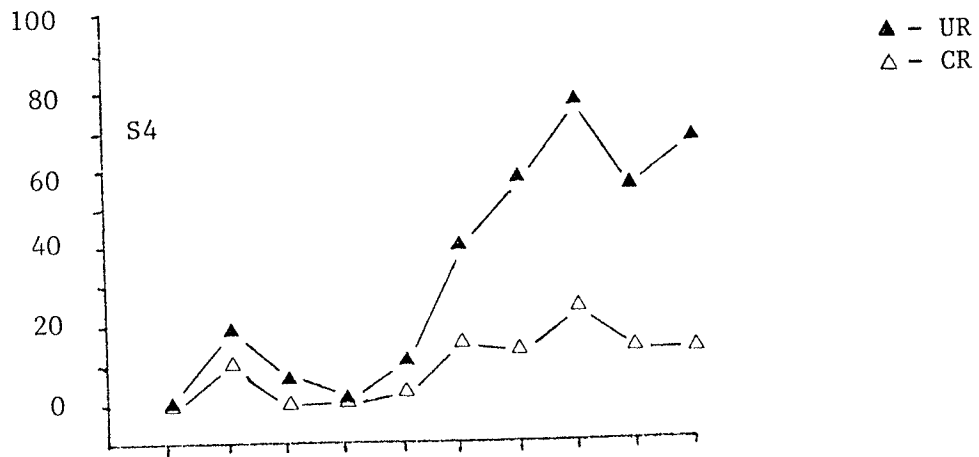
Extinction. The mean per cent NM movements during the period corresponding to that monitored for URs during acquisition were low (10.4, 3.9, 35.8 and 3.7 for Groups P, U, CSa and USa, respectively), and no significant between group differences were found ( $F(3, 8) = 3.39, p = 0.09$ ). The mean per cent CRs during extinction were also very low (12.7, 2.2, 19.0 and 2.9 for Groups P, U, CSa and USa, respectively), with no significant differences between groups ( $F(3, 8) = 1.10, p = 0.40$ ).

#### Discussion

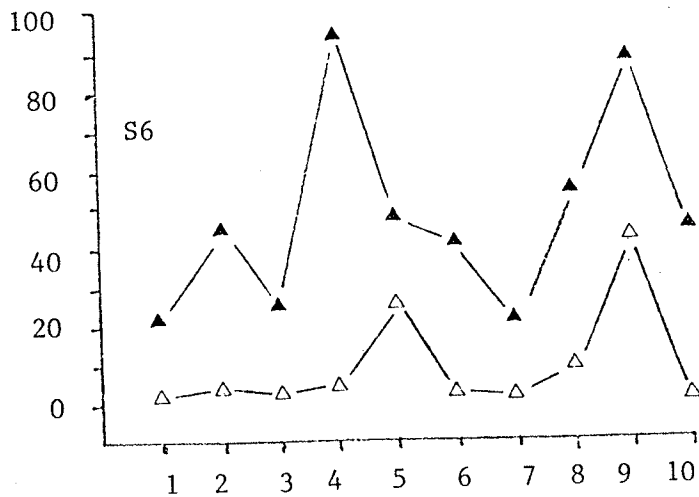
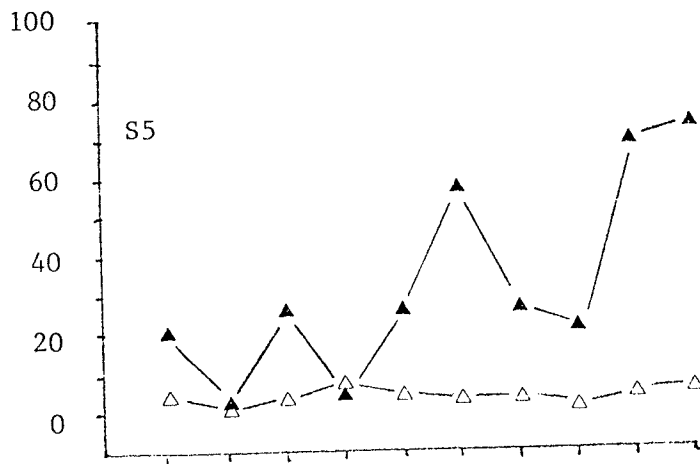
There were a number of important findings in Experiment 1.

Figure 7. Mean per cent NM URs and CRs for Subjects 4, 5 and 6 in Group P during acquisition.





MEAN PER CENT NM RESPONDING



DAYS

First, the leg shock elicited, but did not reliably condition, the JM and NM responses. More importantly, the leg shock also reliably elicited the LF UR, but did not condition this response.

The JM and NM responses elicited may have been part of an overall body reaction to the shock or perhaps just a wince. The JM response was a jaw closure or bite that was not topographically similar to the sinusoidal appetitive JM. The NM response, while similar in form to a membrane response to paraorbital shock, was much lower in amplitude. Although the elicitation of the JM and NM response systems was not reliable, it might result in some subthreshold conditioning. In a transfer, this conditioning could facilitate or retard acquisition of the new response. For example, the UR in appetitive JM conditioning is a sinusoidal movement which cannot occur if the animal bites down. As such, if subthreshold conditioning of jaw closure occurred during LF conditioning, it may well retard the acquisition of the sinusoidal appetitive JM in a transfer experiment due to response competition.

While JM and NM elicitation was problematic, the lack of conditioning of the LF response was a far more fundamental concern, particularly in view of the very high and stable URs elicited. Close observation of the LF UR, however, revealed an unusual characteristic in its form. The typical UR observed in aversive NM and appetitive JM conditioning starts shortly after the US, recruits to its full magnitude during the US, and tapers off until it finally ends well after the US. These features were also observed for the JM UR to leg shock in Experiment 1.

The LF UR to leg shock, however, differed with respect to these features. That is, while the LF UR started shortly after US onset and recruited to its full magnitude during the US, it ended very abruptly with the US offset. Thus it appeared that the LF response was constrained in some manner. This was further supported by the observation that very little movement of the leg occurred between trials. Due to these observations, in Experiment 2 a number of conditioning parameters were altered in an attempt to minimize JM and NM elicitation, alter the LF UR features and condition the LF response.

## Experiment 2

The purpose of Experiment 2 was to investigate a range of conditioning parameters in an attempt to find a combination that would yield hind leg flexion conditioning. The parameters varied were: CS-US interval; intertrial interval and trial density; US application sites; method of US delivery; and US intensity. The actual values for the selected parameters were within the range that produce successful LF conditioning in dogs and cats. Thus, it was anticipated that some combination of the parameters would yield LF conditioning. An indirect measure of CS-US association was also undertaken in Experiment 2 in order to determine if such associations had been made in the absence of any CS-UR links.

### Method

#### Subjects

The subjects were 23 male and female New Zealand Albino rabbits (*Oryctolagus cuniculus*) approximately 100 days of age, and weighing approximately 2.5 kg. The animals were obtained from the Kleefeld Rabbitry in Tourond, Manitoba.

#### Apparatus

The apparatus was identical to that described in Experiment 1.

#### Procedure

Three days after their arrival subjects were randomly assigned to one of four groups. On the same day, subjects in Groups P1, P2 and P3 had a small loop of 00 ethicon monofilament sutured into their right

NM and a 9 mm Autoclip implanted on their lower mandible. A more detailed account of this procedure can be found in Experiment 1. For the fourth squad, Group P4, neither the NM nor the JM responses were monitored and, as such, sutures were not put into the NM nor were Autoclips implanted on the lower mandible.

On the fourth day after their arrival all subjects were placed in the chambers for an adaptation session. No stimuli were presented, but responses were monitored in the time periods corresponding to the timing of stimulus presentations in subsequent acquisition sessions. For Groups P1, P2 and P3 the LF response was monitored for all subjects on all days. In addition, the JM response was monitored for the first three subjects of each group and the NM response for the last three subjects. In Group P4 only the LF was monitored for each subject.

The various procedures used with each group are described below. For all groups, the acquisition phase began on the fifth day following their arrival, the CS was a 1000 Hz 80 db tone, and the US was a constant current AC shock.

#### Group P1

Subjects in Group P1 were presented with 30 pairings of tone and shock with a mean intertrial interval of two minutes for nine consecutive days. The CS duration was a 1500 msec tone, the offset of which corresponded to the offset of the 50 msec shock US. On Days 1 through 7, US intensity was 2.5 ma, which was increased on Days 8 and 9 to 4.0 ma. The US was delivered to the phalange area of the right hind leg as in

### Experiment 1.

On Day 10 the subjects were presented with 200 pairings of a 500 msec tone and a 50 msec 2.5 paraorbital shock US. The offset of the tone coincided with the onset of the shock, and the US was delivered through two 9 mm Autoclips implanted as in Experiment 1. Mean inter-trial interval was 30 seconds and the LF and NM were monitored for all subjects.

On the following day the subjects were given one more session of LF conditioning using parameters identical to those employed on Days 7 and 8 of the acquisition phase.

### Group P2

During the acquisition phase the second group (P2) was presented with 50 tone-shock pairings for eight consecutive days. The CS was a 500 msec tone and the offset of the CS coincided with the onset of a 50 msec 4.0 ma shock. The mean intertrial interval was two minutes. On Day 1 the US was delivered through two stainless steel sutures implanted 10 mm apart through the skin midway between the knee and ankle joints on the back of the calf. From Day 2 on, the US was delivered via two 9 mm Autoclips placed 10 mm apart in various locations along the back and sides of the calf.

On Day 9 all subjects were presented with 100 pairings of tone and paraorbital shock. The offset of the 500 msec tone coincided with the onset of the 2.5 ma 50 msec US shock delivered as in Experiment 1. LF and NM responses only were monitored on Day 9.

Group P3

For the third squad, Group P3, eight consecutive acquisition sessions were implemented. Each day the subjects were presented with 50 pairings of a 500 msec tone followed at offset by a 50 msec 4.0 ma shock US. On the first day the US was delivered to all subjects through two stainless steel filament sutures implanted 10 mm apart into the skin, 25 mm directly above the front of the knee. On subsequent days the US was delivered through two 9 mm Autoclips implanted 10 mm apart in a variety of areas within a 2.0 cm radius around the knee cap. Subjects were presented with 100 tone paraorbital shocks for NM conditioning on Day 9. The CS and US delivery and parameters were the same as for Group P2. LF and NM responses were defined as in Experiment 1.

Group P4

The fourth group (P4) was presented with pairings of a 50 msec tone followed at offset by a 50 msec shock US. The US intensity employed was 2.5 ma for Subjects 1 and 2, and 4.0 ma for Subjects 3, 4 and 5. Subjects in Group P4 were given nine consecutive days of acquisition. The number of pairings on each day was as follows: Day 1, 100 trials; Day 2, 50 trials; Day 3, 125 trials; Day 4, 55 trials; Day 5, 50 trials; Day 6, 90 trials; and Days 7, 8 and 9, 50 trials each. The mean intertrial interval on all days was one minute.

The US application sites for all subjects on Days 1 and 2 were as follows: Subjects 1 and 2, one inch above the front of the knee; Subjects 3 and 4, directly behind the knee joint; and Subject 5, at the base

of the spine. On Days 3 and 4 the US delivery site for Subjects 1 to 4 was moved to the outside of the thigh, midway between the hip and knee joints. On Days 5, 6 and 7 the US delivery site was moved to the front of the knee for Subjects 1, 2 and 3, respectively. No other changes in US delivery sites were made. Following Day 6, Subject 5 was eliminated from the group. For all subjects in Group P4, only the LF response was monitored.

### Results

#### Group P1

Figure 8 depicts the mean per cent LF URs and CRs for each subject in Group P1. As can be observed, elicitation was consistently high and stable across all nine days of conditioning, and was independent of the specific US intensity being applied. On the other hand, the mean per cent LF CRs were either nonexistent (Subjects 2, 3, 4 and 6) or transient (Subjects 1 and 5).

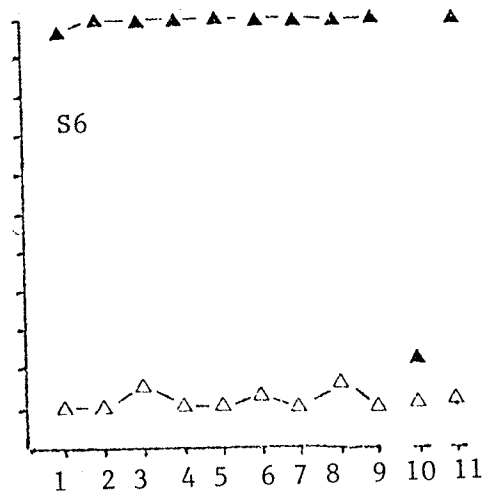
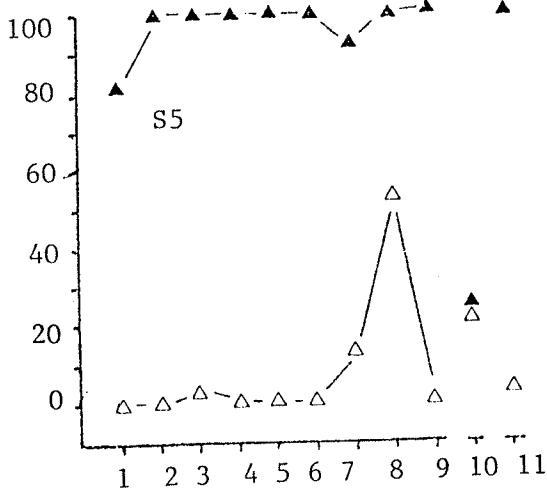
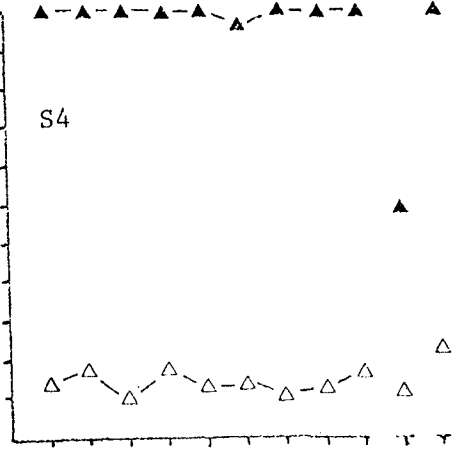
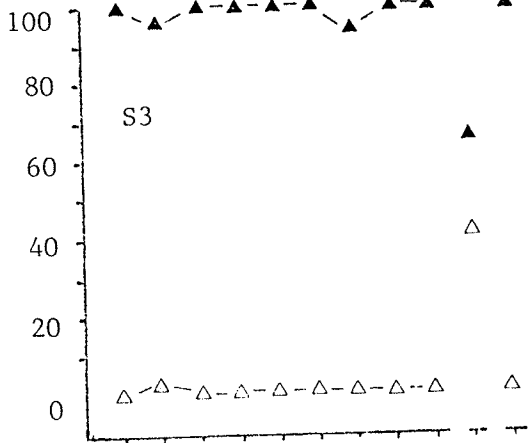
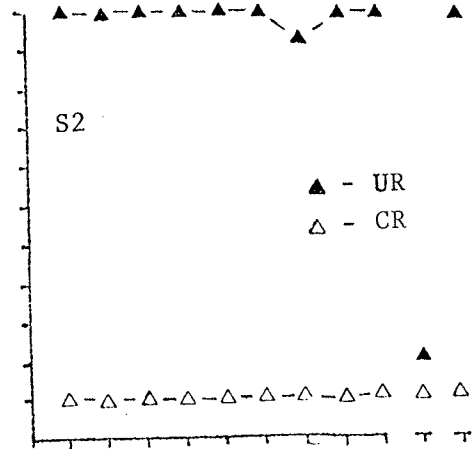
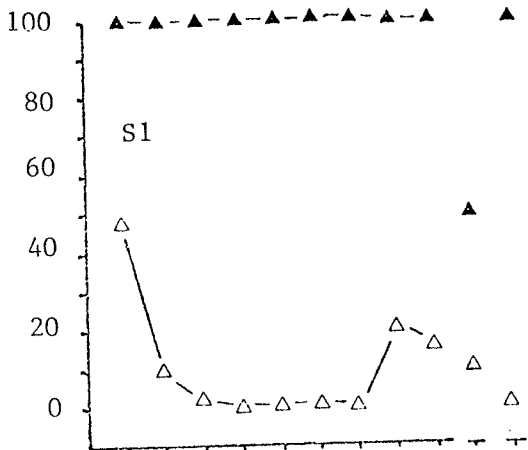
On Day 10 subjects were given 200 pairings of tone-paraorbital shock for NM conditioning. As indicated in Figure 8, the LF UR elicitation to paraorbital shock was lower than that to leg shock, and mean per cent CRs did not increase from the very low per cent during LF acquisition. On Day 11, the final day of tone-leg shock pairings, the mean per cent URs were once again very high while the mean per cent CRs remained low.

Figure 9 depicts the mean per cent JM responding during LF acquisition for the first three subjects. For Subjects 2 and 3, mean per cent UR elicitation was high but not stable across days. The mean per cent



Figure 8. Mean per cent LF URs and CRs for individual subjects  
in Group P1.

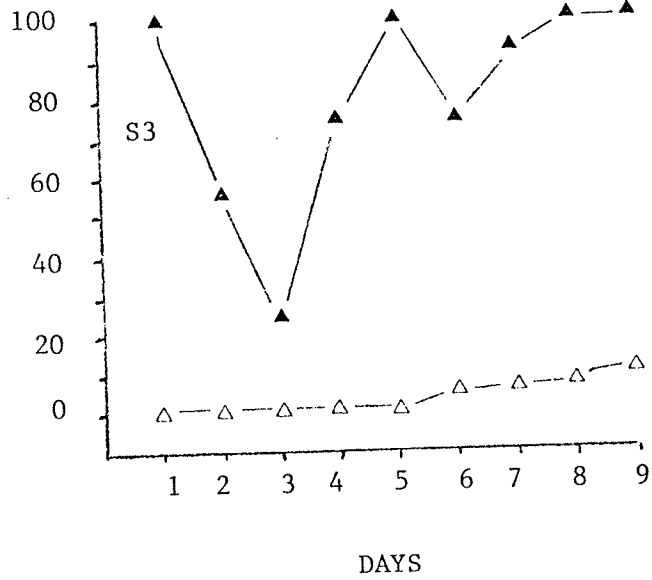
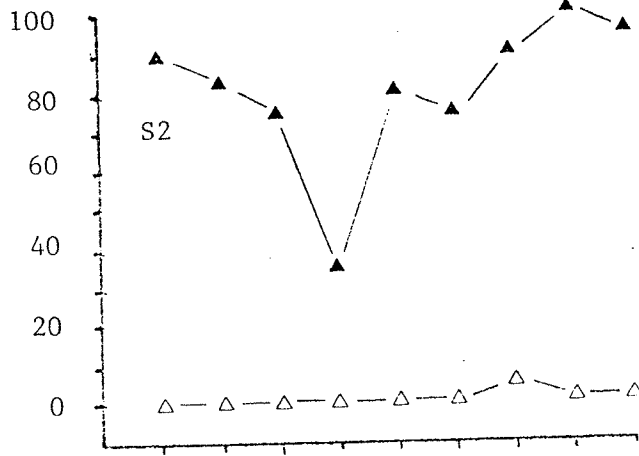
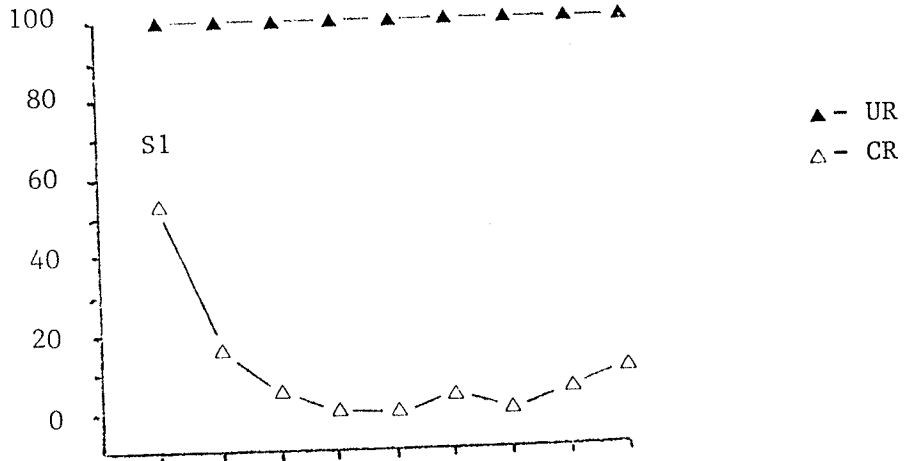
MEAN PER CENT LF RESPONDING



DAYS

Figure 9. Mean per cent JM URs and CRs for Subjects 1, 2 and 3  
in Group P1.

MEAN PER CENT JM RESPONDING



CRs, however, was consistently low for all subjects.

Figure 10 depicts the mean per cent NM respondings for Subjects 4, 5 and 6 on Days 1 to 11, and Subjects 1, 2 and 3 on Days 10 and 11. This illustrates that the mean per cent NM UR elicitation during LF acquisition for Subjects 4, 5 and 6 was initially low but appeared to increase over days. The mean per cent NM CRs, while very low and variable, also appeared to increase.

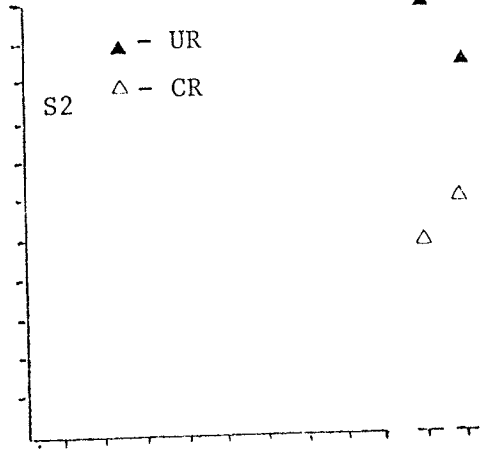
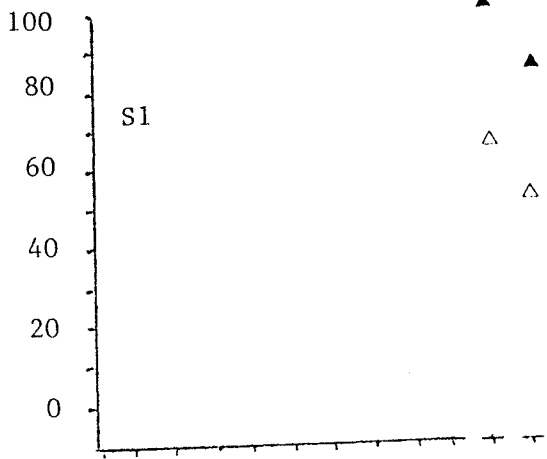
On Day 10, during tone-paraorbital shock pairings, the NM response was monitored for all subjects. As can be observed in Figure 10, the mean per cent NM UR elicitation for all subjects was very high. The mean per cent CRs, however, varied considerably between subjects, ranging from no conditioned responding (Subjects 4 and 6) to high levels of responding (Subjects 3 and 5).

On the final day (Day 11) of LF conditioning, the mean per cent NM elicitation decreased to intermediate levels, while conditioned responding maintained its high degree of variability (e.g., 100% for Subject 3 and 2% for Subject 6).

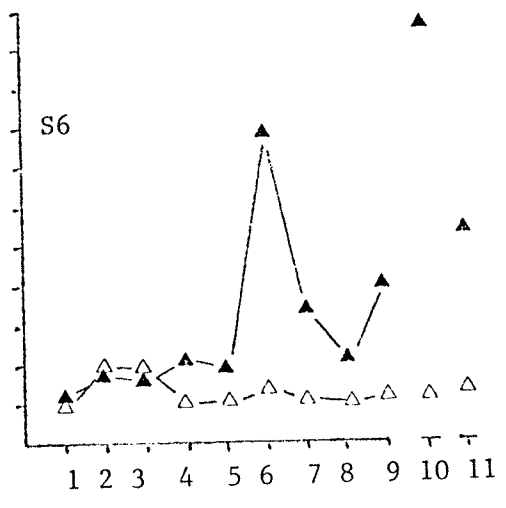
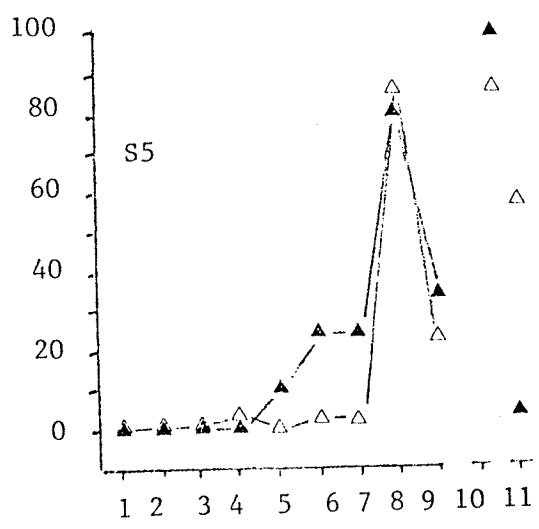
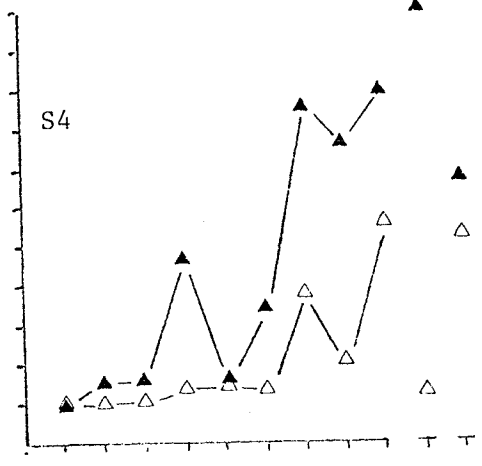
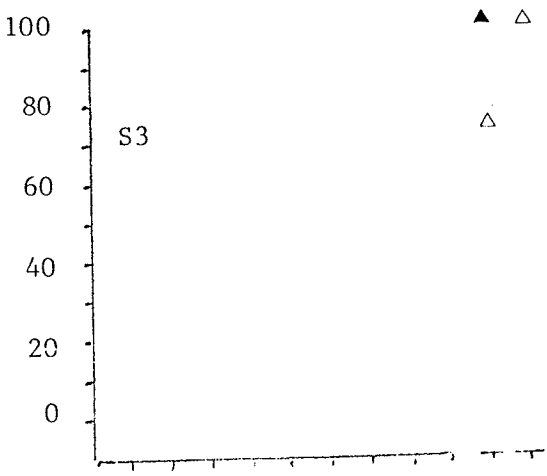
#### Group P2

Figure 11 depicts the mean per cent LF URs and CRs for individual subjects in Group P2. As illustrated, elicitation was generally high, although somewhat variable, between subjects. The mean per cent conditioned responding was virtually nonexistent for all subjects, except Subjects 1 and 2 for which it was low and variable. During tone-paraorbital shock pairings, the LF elicitation dropped to intermediate

Figure 10. Mean per cent NM URs and CRs for Subjects 1, 2 and 3 on Days 10 and 11 and Subjects 4, 5 and 6 on Days 1 to 11.



MEAN PER CENT NM RESPONDING

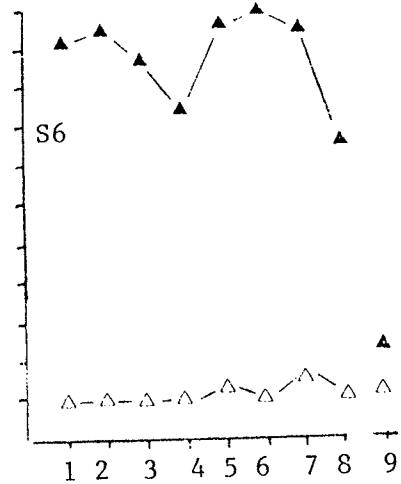
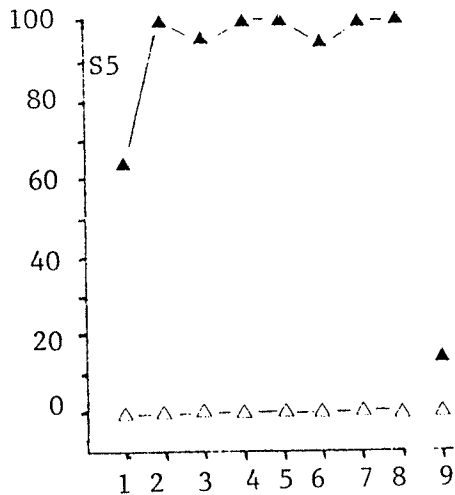
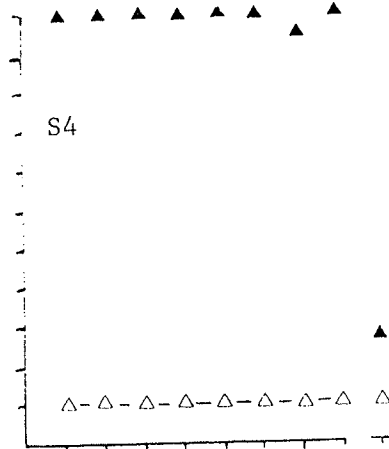
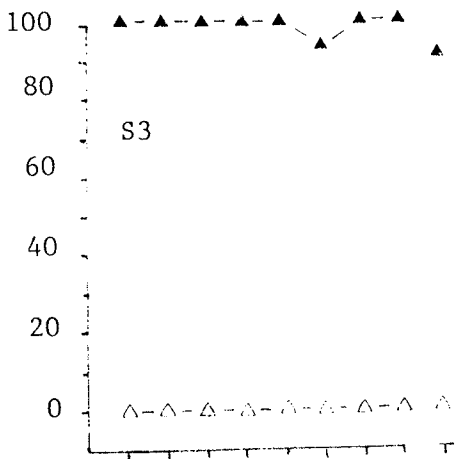
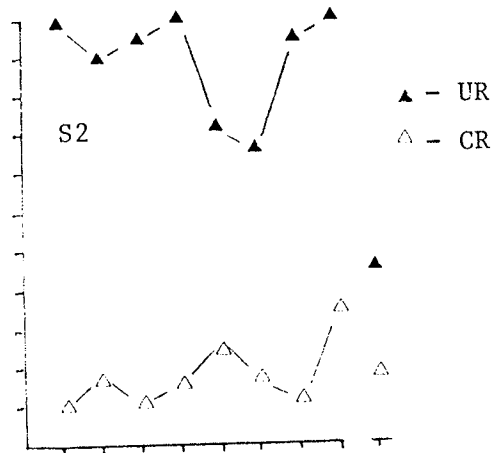
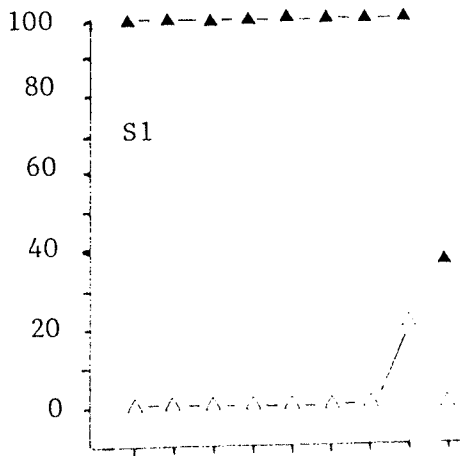


DAYS

Figure 11. Mean per cent LF URs and CRs for individual subjects  
in Group P2.



MEAN PER CENT LF RESPONDING



DAYS

levels and the mean per cent conditioned responding remained at very low levels.

Figure 12 depicts the mean per cent JM responding during LF acquisition. The level of JM elicitation by leg shock was generally very low and conditioned responding was virtually nonexistent.

Figure 13 depicts the mean per cent NM responding. This illustrates that NM elicitation for Subjects 4, 5 and 6 was very variable and conditioned responding was virtually nonexistent across subjects.

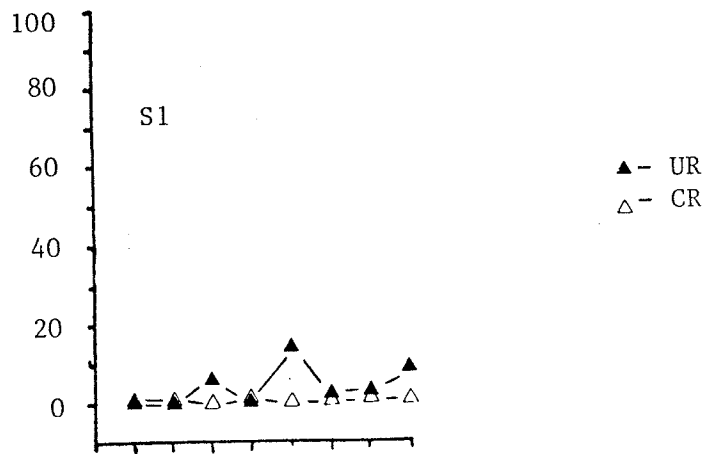
On Day 9, during tone-paraorbital shock pairings, NM elicitation for all subjects was very high. Conditioned responding was generally low and variable with daily per cents ranging from 63% (Subject 2) to 0% responding (Subjects 1, 5 and 6).

#### Group P3

Figure 14 illustrates the mean per cent LF URs and CRs for individual subjects in Group P3. As depicted, the LF elicitation was quite high although somewhat variable. Conditioned LF responding was generally very low and, for those subjects that did show conditioning, it was not reliable (Subjects 2 and 5). During tone-paraorbital shock pairings (Day 9), the LF URs dropped to intermediate levels and conditioned responding disappeared entirely.

The mean per cent JM responding during LF acquisition for Subjects 1, 2 and 3 is shown in Figure 15. The JM elicitation by knee shock was very low with some variability within subjects, and mean per cent conditioned responding was also very low.

Figure 12. Mean per cent JM URs and CRs for Subjects 1, 2 and 3 in Group P2 during LF acquisition. (Data for Subject 2 on Days 2 to 7 lost due to computer failure.)



MEAN PER CENT JM RESPONDING

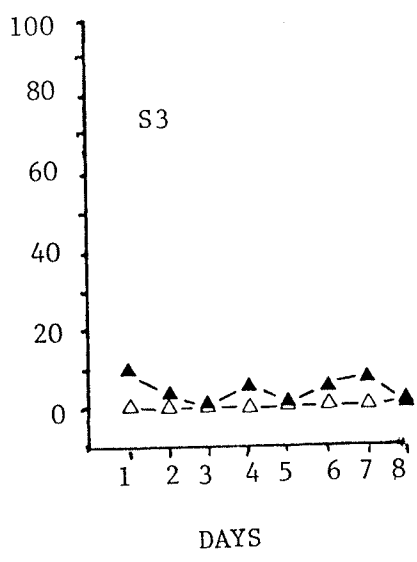
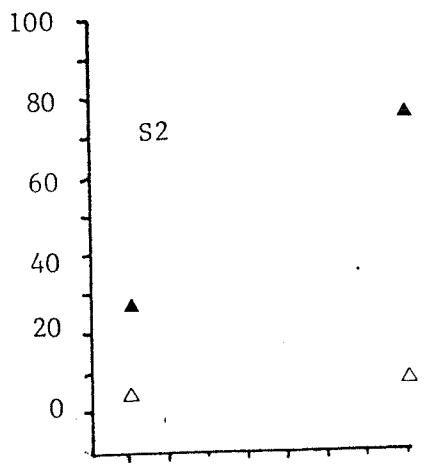
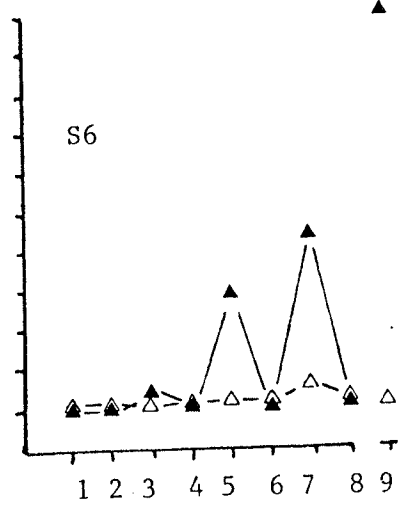
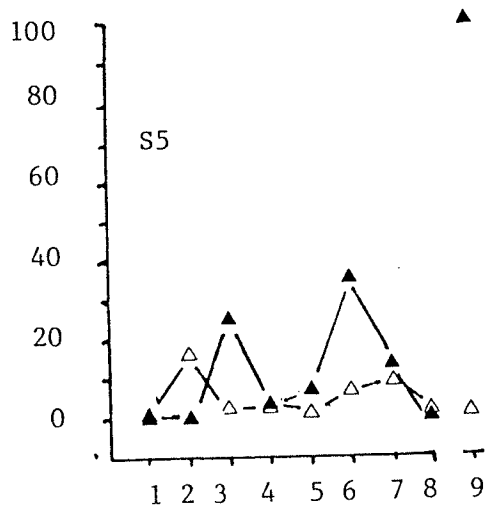
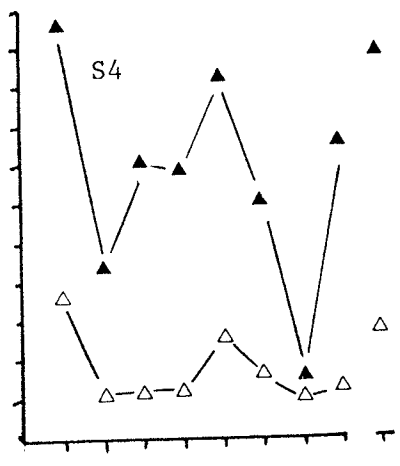
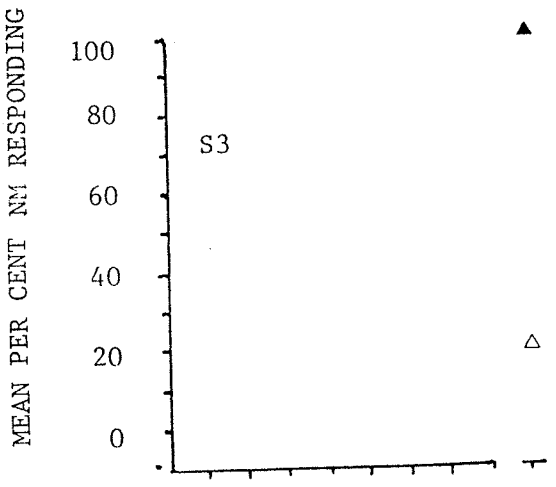
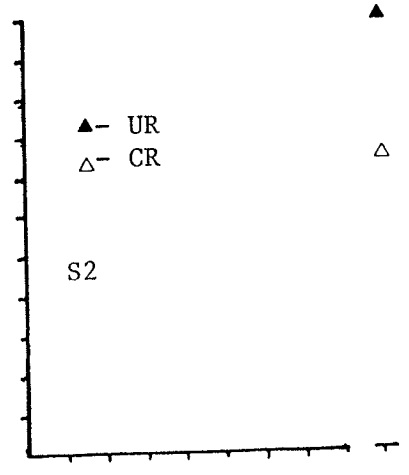
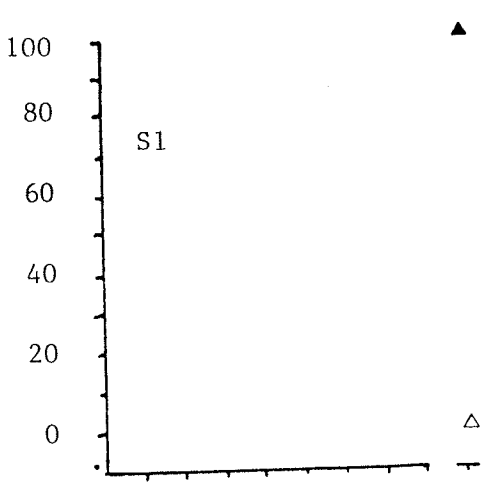


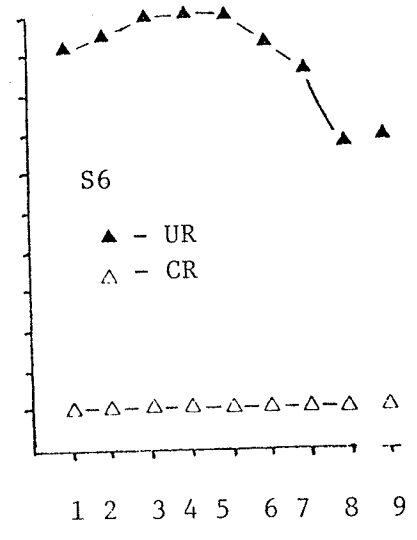
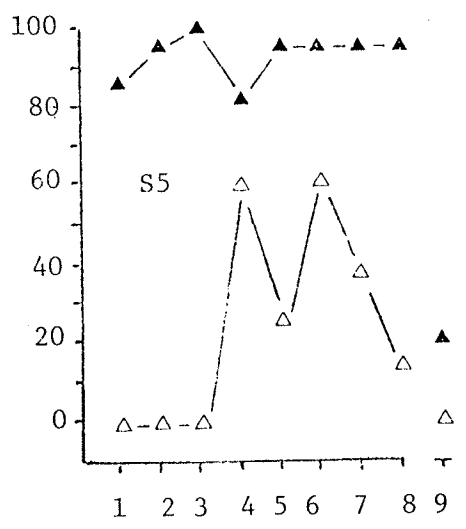
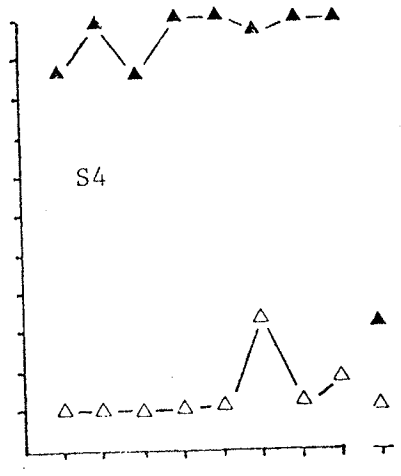
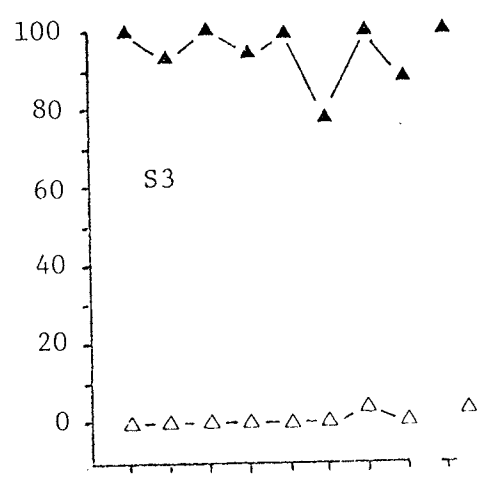
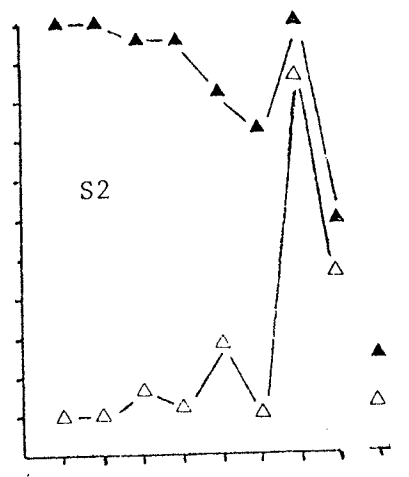
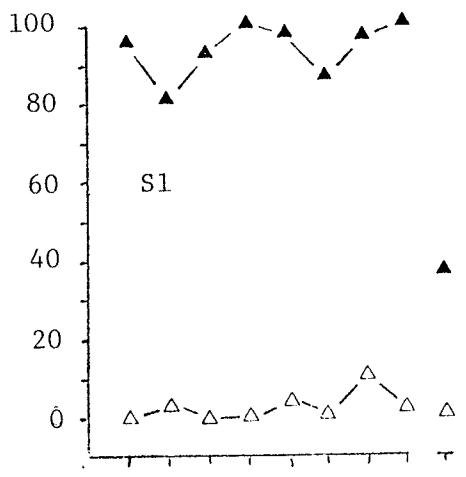
Figure 13. Mean per cent NM URs and CRs for Subjects 4, 5 and 6 on Days 1 to 9 and Subjects 1, 2 and 3 on Day 9.



DAYS

Figure 14. Mean per cent LF URs and CRs for individual subjects  
in Group P3.

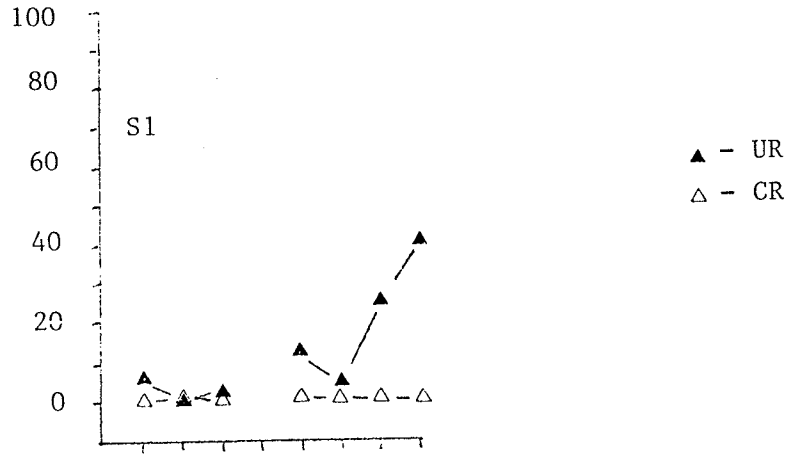
MEAN PER CENT LF RESPONDING



DAYS



Figure 15. Mean per cent JM URs and CRs for Subjects 1, 2 and 3 in Group P3 during LF acquisition. (Data on Day 4 lost due to computer failure.)



MEAN PER CENT JM RESPONDING

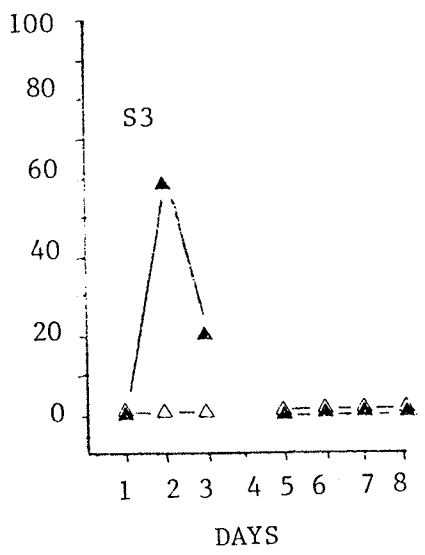
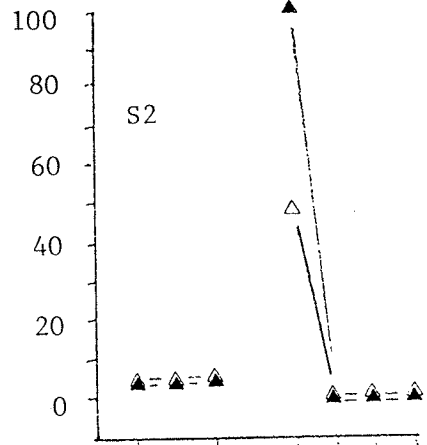


Figure 16 depicts the mean per cent NM responding during LF acquisition. Elicitation for Subjects 4, 5 and 6 was vary variable both within and between subjects. Conditioned responding, while low, increased over days for Subjects 4 and 5.

On Day 9 during tone-paraorbital shock pairings, NM elicitation for all subjects was very high, and conditioned responding occurred at intermediate levels for Subjects 2, 3, 4 and 5.

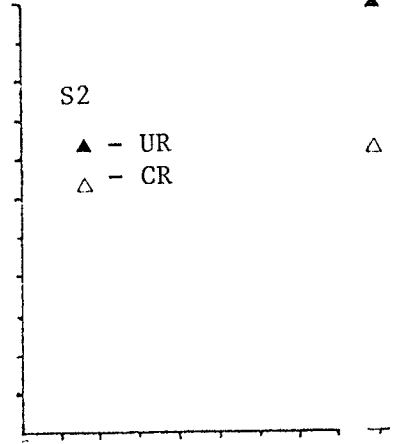
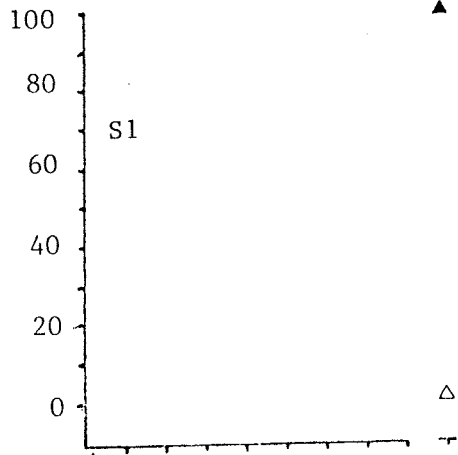
#### Group P4

The mean per cent LF responding for individual subjects in Group P4 is shown in Figure 17. This indicates that on Days 1 and 2 elicitation for all subjects was very high, independent of US placement or intensity. Conditioned responding, however, was nonexistent.

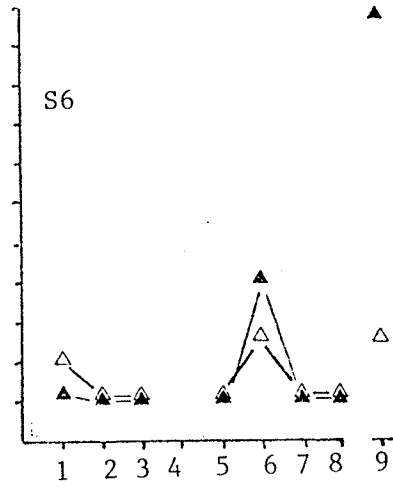
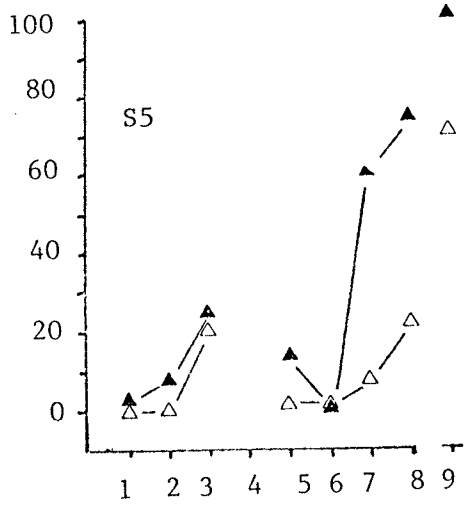
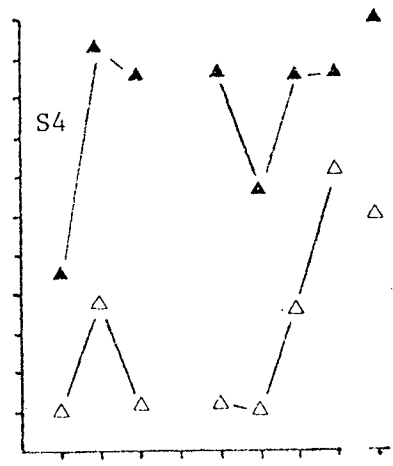
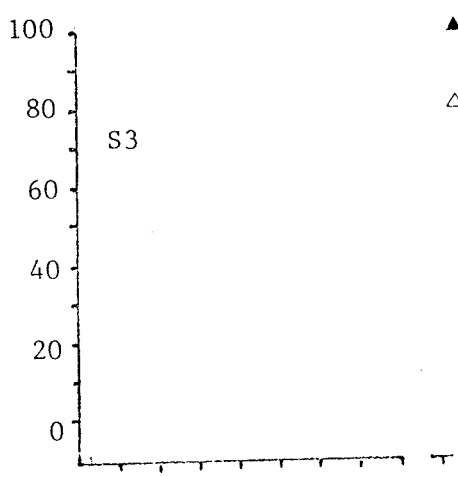
On Days 3 and 4, the US delivery site for Subjects 1 to 4 was moved to the mid-thigh area. As can be observed in Figure 17, the LF elicitation for these subjects was very high, while conditioned responding remained very low.

The US delivery site for Subject 2 was moved back to the knee on Day 5, with no changes being made on the other subjects. The mean per cent elicitation for Subject 2 remained high and the mean per cent conditioning increased dramatically (see Figure 17). In view of this development, on Day 6 the US delivery site for Subject 1 was moved to the knee. While UR elicitation remained high, only a small increase in conditioned responding was observed. On Day 7 the US delivery site for Subject 3 was also moved to the knee. This change did not, however,

Figure 16. Mean per cent NM URs and CRs for Subjects 4, 5 and 6 on Days 1 to 9 and Subjects 1, 2 and 3 on Day 9. (Data on Day 4 lost due to computer failure.)

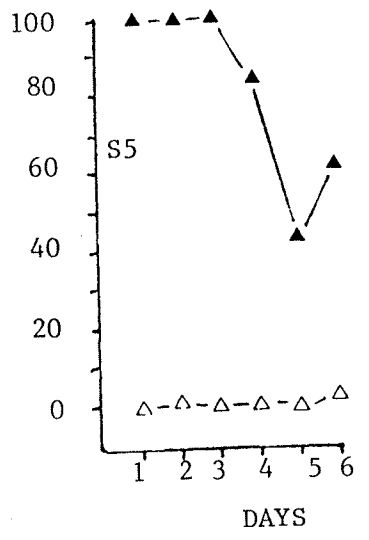
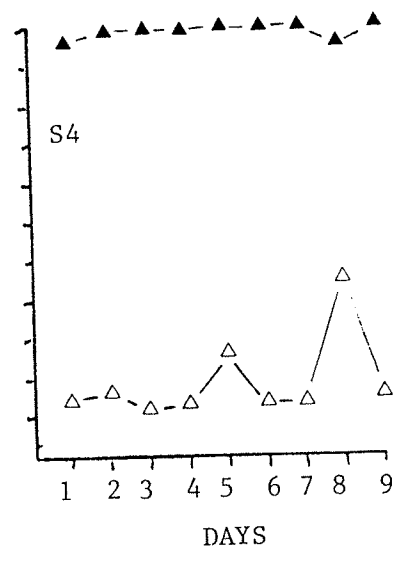
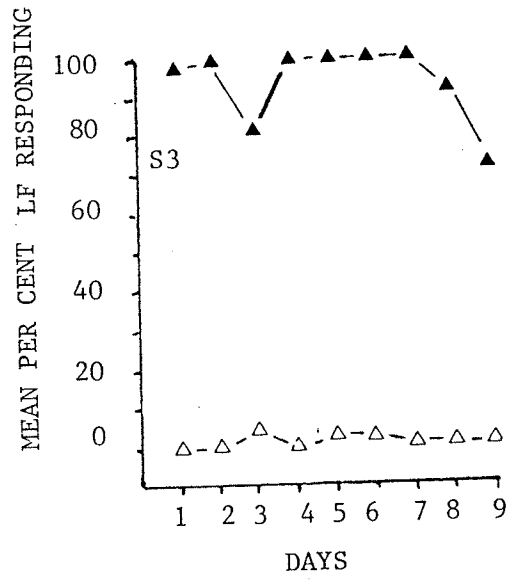
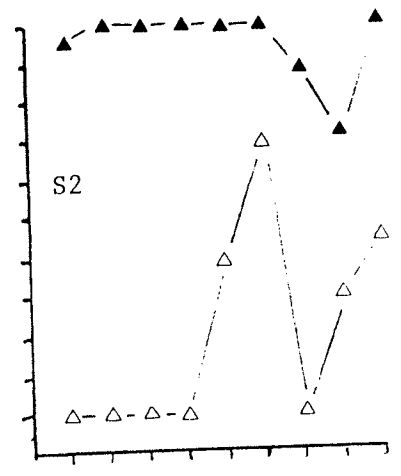
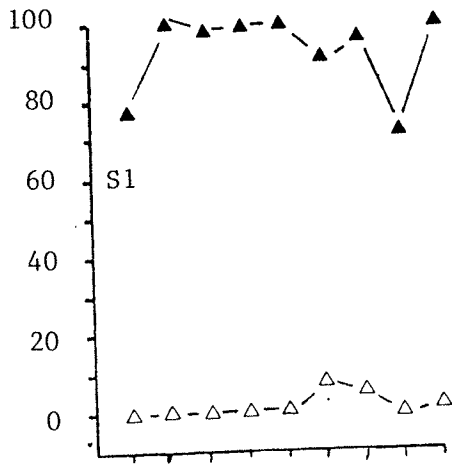


MEAN PER CENT NM RESPONDING



DAYS

Figure 17. Mean per cent LF URs and CRs for individual subjects  
in Group P4.



▲ - UR  
 △ - CR

result in an increase in conditioned responding. For Subjects 1, 2 and 3, the US delivery site was not changed after it was moved to the knee. As indicated in Figure 17, this US delivery site resulted in an increased variability of UR elicitation. While conditioned responding increased during knee shock for Subject 2, the level of CRs was variable. No similar increases in CRs were observed for Subjects 1 and 2.

The US delivery site for Subject 4 did not change from the mid-thigh. For this subject, the level of LF elicitation was high and stable (see Figure 17). While some conditioned responding occurred, it was at low levels and very variable.

For Subject 5, the US delivery site was in the low spine region. This site did not support high levels of elicitation and no conditioned responding occurred. As a result of the low levels of elicitation by shock to the spine, no sessions were conducted with this subject after Day 6.

#### Discussion

A number of pertinent observations resulted from Experiment 2. As in Experiment 1 leg shock, regardless of delivery site or intensity, elicited the JM response. The level of JM elicitation, however, decreased as the leg shock delivery site moved away from the phalanges to the knee region. The level of LF CRs was consistently low and did not appear to be affected by any experimental manipulations.

NM elicitation remained variable across all groups. Where conditioned responding occurred, it was at low levels and transient. None of



the variables manipulated in Experiment 2 appeared to result in consistent changes on either NM elicitation or conditioned responding.

An interesting observation can be made regarding those subjects who were monitored for NM movements during LF acquisition, as well as during tone-paraorbital shock pairings (Subjects 4, 5 and 6 in Groups P1, P2 and P3). Those that exhibited some NM conditioned responding during LF acquisition also showed conditioned responding during tone-paraorbital shock pairings. However, subjects that showed no NM conditioned responding during LF acquisition showed no NM CRs during subsequent pairings. It would therefore appear that NM CRs during tone-paraorbital shock pairings were facilitated by prior NM conditioned responding during tone-leg shock pairings, although this conditioned responding was low and transient. This observation indicates that a CS-US association was made.

The level of LF elicitation became less reliable as the US delivery site moved away from the phalange to the knee area. Elicitation was, however, very reliable when the US was delivered to the thigh region. The constraint of UR topography (detailed in the discussion of Experiment 1) was also observed for all subjects in Experiment 2, independent of US intensity or delivery site.

LF conditioned responding was either nonexistent or at a very low and transient level. When conditioned responding occurred it could not be ascribed to any of the experimental manipulations. These included:

(1) different US intensities (2.5 and 4.0 ma); (2) a variety of US delivery sites ranging from the phalanges of the hind leg to the lower spine; (3) two different interstimulus intervals (500 msec and 1000 msec); (4) two different mean intertrial intervals (1 minute and 2 minutes); and (5) two different temporal CS-US arrangements, one in which the CS overlapped the US and the other in which the CS offset corresponded with US onset. These manipulations encompassed conditioning parameters that produce large functional differences in conditioning levels for other response systems (i.e., JM and NM) in the rabbit and for hind leg flexion conditioning in cats and dogs (Gormezano, 1972).

Due to this failure to obtain reliable LF conditioned responding in spite of the range of variables manipulated, Experiment 3 attempted to condition the front leg flexion response. Wickens (1961; 1969) has demonstrated this response to be conditionable in both cats and dogs.

### Experiment 3

Experiments 1 and 2 clearly showed that with the methodology and variables employed, the aversive hind leg of the rabbit could not be conditioned. Since Wickens et al. (1961; 1969) showed that both the cat's and dog's front LF could be conditioned, Experiment 3 attempted to replicate these findings with the rabbit.

Pilot work indicated that the rabbit's front LF could be reliably elicited and conditioned by a shock to the phalanges of the front paw. Pilot work also indicated, however, that the JM and NM were elicited at intermediate levels and conditioned at very low levels, as was found with hind leg shock in Experiments 1 and 2. Experiment 3 was designed to determine whether the front LF anticipatory responses that were observed in pilot work were CRs. As such, the following control groups were employed to evaluate nonassociative contributions to the level of LF CRs: US alone, CS alone and an explicitly unpaired group. Since the purpose of Experiment 3 focused on the conditioning of the front LF, the JM and NM movements were not monitored.

#### Method

##### Subjects

The subjects were 18 male and female New Zealand Albino rabbits (*Oryctolagus cuniculus*) about 100 days of age and weighing approximately 2.5 kg. The animals were obtained from the Kleefeld Rabbitry in Tourond, Manitoba.

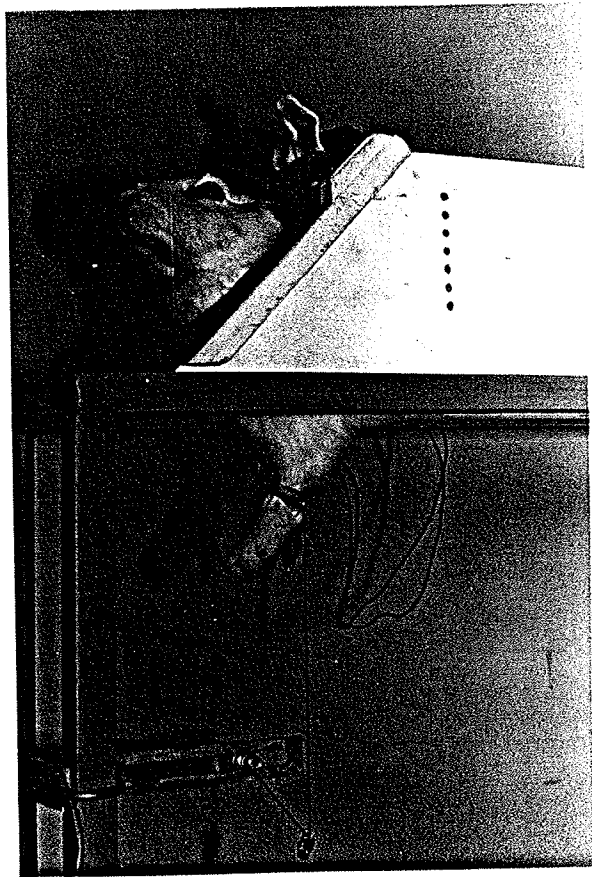
### Apparatus

Figure 18 depicts the apparatus required for transduction of the front LF response, which required the following changes from that used in the previous experiments. The restrainer box had a single slot, 4 cm wide by 8 cm long, milled out along the front left side. This permitted the subject's left front leg to hang down through the bottom of the box. In order to transduce the leg movement, a Velcro cuff was securely placed around the leg just above the ankle joint. A silk thread attached to the cuff was coupled directly to a counterbalanced rod beneath the front leg. The rod was, in turn, affixed to the axle of a rotary potentiometer. Since pilot work showed that the front LF movement was predominantly in the vertical plane, this method of movement transduction was found to be very effective. Voltage changes from the potentiometers, stimuli delivery and response recording were handled as in Experiment 1. The CS was a 500 msec, 80 db, 1000 Hz tone delivered through a speaker at the center of the stimulus panel. The US was a 2.5 ma, 50 msec shock delivered to two Autoclips, one implanted in each of the pads on the center two phalanges of the subject's left front paw. The remaining apparatus was the same as in Experiment 1.

### Procedure

Three days after their arrival, the subjects were randomly assigned to four groups of six. They were then placed into the restrainer boxes and adapted to the chambers for a period of time equivalent to the duration of subsequent acquisition sessions. Although the animals were given

Figure 18. Apparatus required for transduction of the front leg flexion response.



no stimuli during this session, the LF was monitored during time periods that corresponded to the trials in subsequent conditioning sessions.

On the day following the adaptation session, an acquisition phase consisting of 12 consecutive daily sessions was implemented. One group (P) was given forward pairings of tone and shock; a second (U) was given explicitly unpaired presentations of tone and shock; a third (CSa) was given tone alone presentations; and the fourth group (USa) was given shock alone presentations.

In each daily session, Group P received 50 trials separated by a mean intertrial interval of 60 seconds. Forty-five of these trials consisted of a tone CS presentation, followed at offset by the shock US, resulting in a CS-US interval of 500 msec. The remaining five were CS-alone test trials which were sequenced as follows: on Days 1, 4, 7 and 10, Trials 10, 18, 24, 33 and 42 served as test trials; on Days 2, 5, 8 and 11, Trials 6, 12, 25, 37 and 45 were test trials; and on Days 3, 6, 9 and 12, Trials 9, 19, 27, 39 and 48 were test trials. Randomizing the order of test trials minimized the possibility that subjects would learn their sequence.

Group U received 50 CSs and 45 USs with the stimulus presentation order randomized, under the restrictions that the minimum intertrial interval be no less than 30 seconds, and that neither stimulus be presented more than three times in succession. Group CSa received 50 CS-alone presentations. Group USa was presented with 45 USs, the occurrence of which was temporally matched to the US delivery in Group P.

The LF was monitored for CRs in Group P during the 500 msec CS-US interval for paired trials and for 500 msec after CS onset for test trials. Periods monitored for CRs in the control groups, for both paired and test trials, corresponded to those monitored in Group P. In Group U, LF monitoring was undertaken for 500 msec after CS onset and for 500 msec prior to US onset. Monitoring for Group CSa occurred for 500 msec after CS onset and, in Group USA, LF CRs were monitored during a 500 msec interval prior to US onset.

#### Response Specification

The response criterion for LF URs and CRs was the same as that in Experiment 1.

#### Results

The mean per cent LF responding for all groups during adaptation was very low (0.4, 0.8, 2.9 and 1.5 for Groups P, U, CSa and USA, respectively). No significant differences between groups were observed ( $F(3, 20) = 0.45, p = 0.72$ ).

Figure 19 depicts the mean per cent LF CRs for all groups over the 10 days of acquisition. Group P had a faster rate of acquisition and reached a higher level of conditioning than did Groups U, CSa or USA, which maintained adaptation levels of responding. The mean per cent CRs for Groups P, U, CSa and USA were 31.5, 1.7, 0.5 and 1.1, respectively. An ANOVA substantiated the graphical interpretation by yielding a significant Groups effect ( $F(3, 20) = 14.29, p = 0.00$ ) and GROUP X DAYS effect ( $F(27, 180) = 4.64, p = 0.00$ ).



Figure 19. Mean per cent LF CRs for Groups P, U, CSa and USa during acquisition.

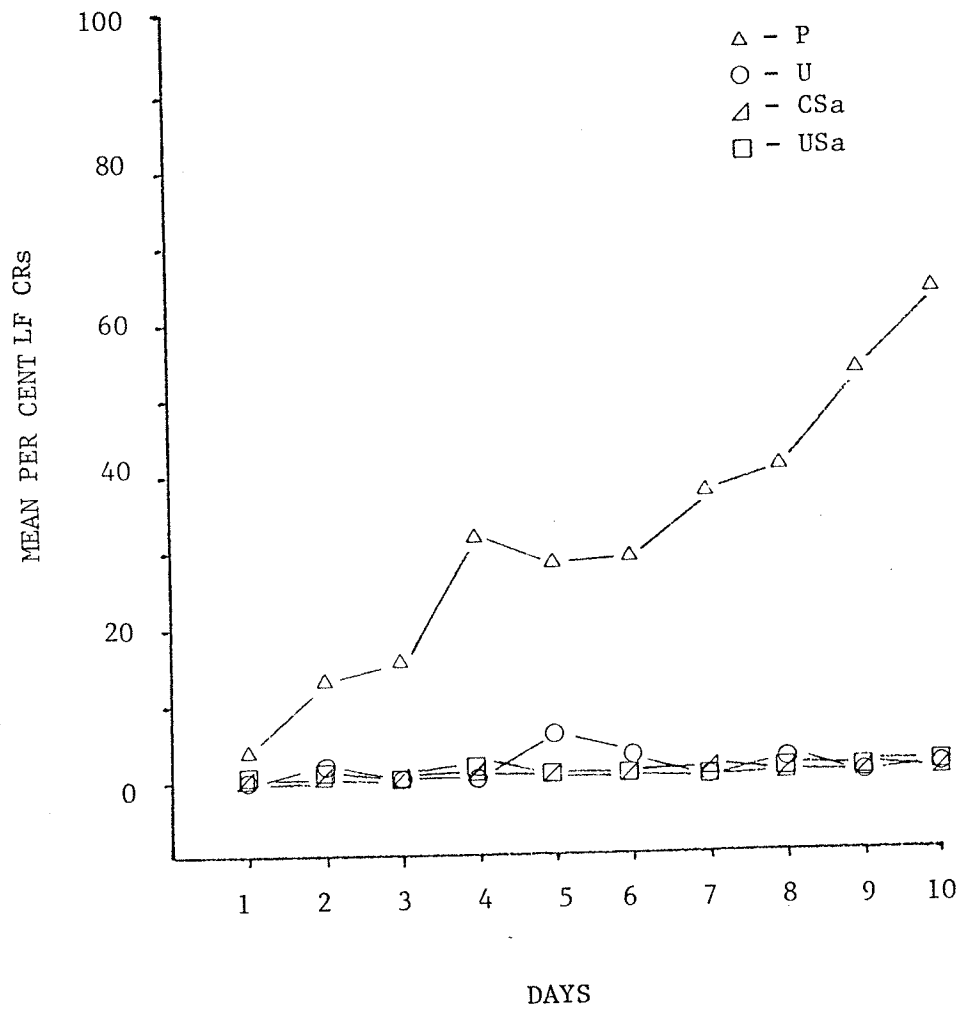


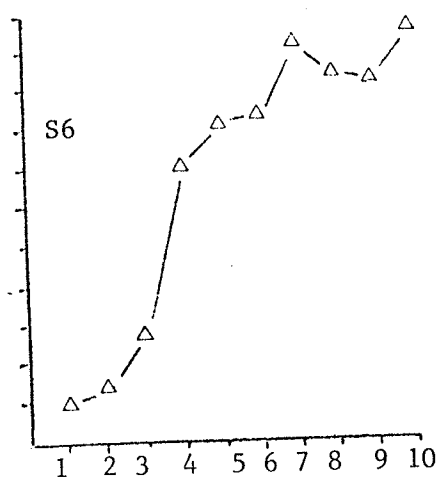
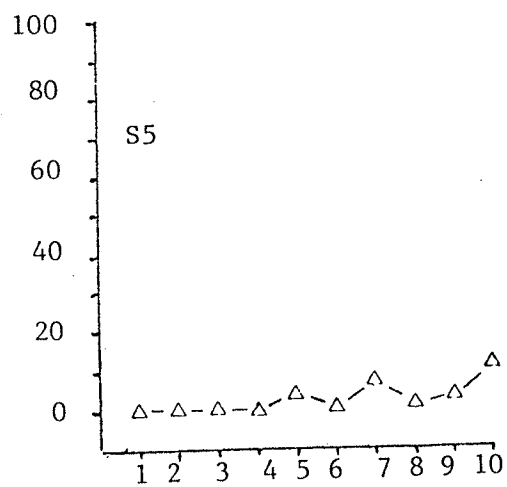
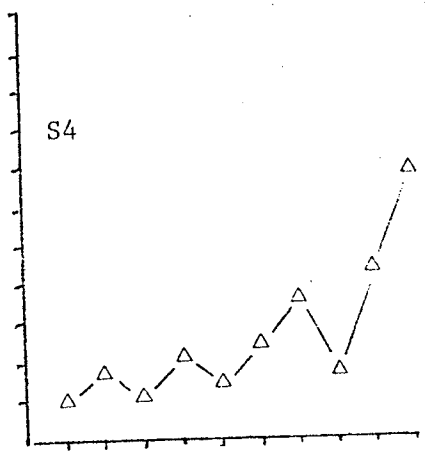
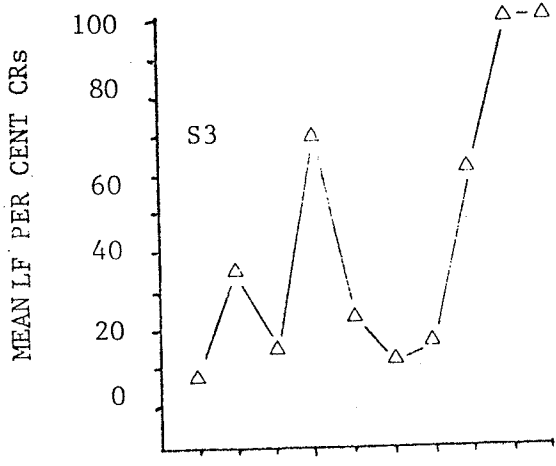
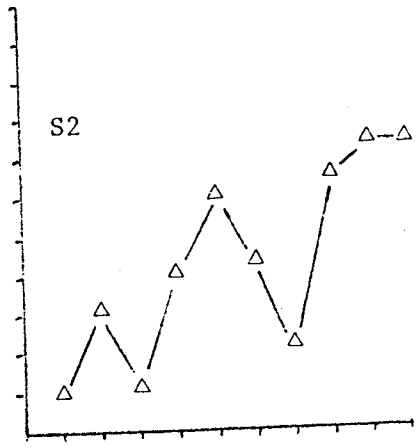
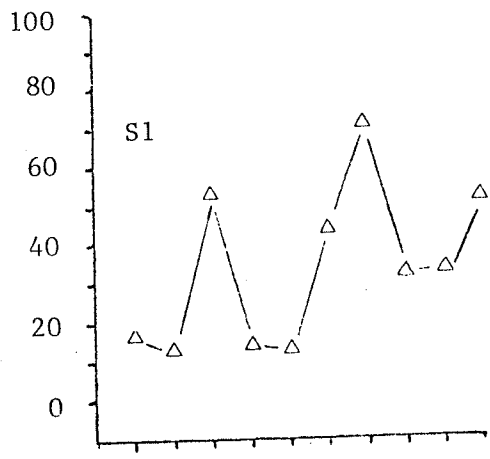
Figure 20 depicts the mean per cent responding for individual subjects in Group P. As can be observed, five of the six subjects showed high, though variable, levels of conditioning. Therefore the acquisition curve for Group P is fairly representative of individual performance.

#### Discussion

The major finding in Experiment 3 was that the front LF could successfully be conditioned. However, the rate of conditioned responding observed was somewhat lower and more variable, both within and between subjects, than conditioning in either the rabbit's JM and NM response systems (cf. Gormezano, 1972). Both the rate and variability of conditioning may have been a function of the parameters employed. Further research should be directed at determining conditioning parameters that will maximize the rate of acquisition and minimize variability.

A second observation from Experiment 3 relates to the form of the UR. In both Experiments 1 and 2, it was observed that the hind LF UR was unusual because its onset and offset corresponded to the onset and offset of the shock US. This finding was not typical of other response systems successfully conditioned in the rabbit. It is interesting to note that the front LF elicited in Experiment 3 conformed to traditional URs (JM and NM) in that its offset did not occur with shock offset. Instead, the front leg returned gradually to its resting position well after US offset.

Figure 20. Mean per cent LF CRs for individual subjects in Group P during acquisition.



DAYS

## General Discussion

The major experimental findings from the preceding series of experiments were as follow. Experiment 1 revealed that with the parameters that are optimal for LF conditioning in the cat and dog, the rabbit's hind LF could be elicited, but not conditioned. It was also observed that during hind LF acquisition both the JM and NM responses were elicited and showed low transient levels of conditioning.

Experiment 2 demonstrated a further failure to condition the hind LF, despite attempts employing a range of conditioning parameters encompassing those found to result in optimal conditioning of other responses systems in the rabbit. The JM and NM, however, continued to be elicited and conditioned at low and transient levels. It was also observed in both experiments that the hind LF UR in paired groups appeared to be constrained. That is, its onset and offset corresponded closely with that of the US.

Experiment 3 was designed to condition the front LF response. Results indicated that the front LF could successfully be conditioned, although the rate of acquisition was slow and variable. It is important to note that the front LF UR did not assume the constraint form that had been observed in paired groups receiving hind leg shock. Pilot work conducted prior to Experiment 3 revealed that the front LF US also elicited and conditioned the JM and NM at levels similar to those observed in Experiments 1 and 2.

It will be recalled that the original purpose of this research was to develop procedures that would permit the assessment of the interaction between CRs in both across motivational and within motivational classical-classical transfers. In order to accomplish this goal, it was determined that a response system must be developed which could be conditioned without eliciting or conditioning at least one alternate appetitively and one aversively motivated response. Experiment 2 illustrates the problems that can develop if response separation is not obtained. It was noted in Experiment 2 that low level NM conditioning occurred in some subjects during LF conditioning. When NM conditioning was subsequently attempted, only the subjects that had previously given NM CRs reached high performance levels. This outcome suggests that LF training produced response facilitation of the NM, and does not need an appeal to motivational mechanisms such as summation within motivational states.

The lack of hind LF conditioning in Experiments 1 and 2 clearly demonstrated that hind LF response system could not serve as a vehicle for the assessment of interactions between CRs. The virtually complete absence of conditioned responding in a response system which is so reliably elicited is, however, notable. Gormezano and Kehoe (1975) suggested that the basic requirements for classical conditioning are as follow: (1) that a US reliably elicit a UR; and (2) that a previously neutral stimulus be repeatedly paired with the US. After a number of such pairings, a CR in the effector system elicited by the UR should

develop. While Experiments 1 and 2 met these requirements for classical conditioning, no conditioned responding was observed.

It may be possible to explain the lack of conditioned responding in the following manner. It has been suggested by Bolles (1970) that an aversive event elicits a number of species specific defense reactions (SSDRs). Freezing, or the assumption of an alert, immobile posture, is one of the SSDRs commonly observed in a number of species and probably is one of the rabbit's SSDRs elicited by shock. Bolles and Riley (1973) found that this appeared to be the case in rats. After receiving a shock, a brief period of jumping or movement away from the aversive event was observed to be followed by long duration freezing. Analogously, a very low frequency of leg movement during the intertrial interval was observed for the rabbits receiving hind leg shock. Further, during conditioning sessions in both Experiments 1 and 2, the experimenter watched the animals and observed that they were rigidly holding their hind quarters in place. Considering these observations, it appears reasonable to suggest that the animals were freezing.

Blanchard, Fukanaga and Blanchard (1976a; 1976b) found that the environment in which an aversive event was presented to rats, controlled in part the defensive reaction that would be dominant. When presented with a stimulus signaling danger, they would respond by either freezing or attempting to flee. Those rats who were familiar with the experimental chamber being inescapable, responded predominantly by freezing, while those unfamiliar with the chamber attempted to escape. It is possible that an analogous situation has been created by restraining the rabbits in Experiments 1 and 2. The rabbits would learn that escape was



impossible, and therefore freezing would be the predominant response.

Blanchard and Blanchard (1969a) found that after a single tone-shock pairing, rats responded to a tone presentation by crouching and freezing, suggesting that this response is very quickly acquired. In addition, Blanchard and Blanchard (1969b) reported that the crouching and freezing behavior interfered with active avoidance responding. Having observed what appeared to be freezing in the rabbit during tone-shock pairing in an inescapable context, it might be that freezing becomes the predominant response which is quickly conditioned to the tone and interferes with hind LF acquisition.

While freezing appeared to seriously interfere with the conditioning of gross skeletal movement (hind LF), it did not eliminate conditioning of the NM response during tone-leg shock pairings. Thus, although freezing may become the predominant CR, other responses elicited may also be conditioned at a rate which may vary to some degree as a function of their disruptiveness to the freezing response.

In Experiment 3 the front LF was successfully conditioned, but at lower levels than those obtained in other response systems (JM and NM) after the same number of pairings. This may appear to conflict with the evidence just presented which suggests that rabbits acquire a conditioned freezing response to tone-leg shock pairings. The following alternative explanation is, however, very tentatively advanced.

Assuming that tone-shock pairings result in conditioned freezing in the rabbit, it must also be accepted that other URs to the shock US can be conditioned simultaneously. For example, tone-paraorbital shock

pairings result in very high and stable levels of NM conditioning. It could be further postulated that conditioning occurs in the NM at such high levels due to its minimal disruption of overall skeletal immobility. If it is also recognized that front LF movement is less disruptive to general immobility than is hind leg movement, it can be suggested that the front LF should be easier to condition. In the natural environment, the rabbit has been observed to freeze in two positions: crouching and standing erect. In both these positions, movement of the hind limbs would result in greater movement of the body in general. However, front leg movement would not greatly affect whole body movement. Accordingly, front LF should be easier to obtain.

Regardless of why the front LF conditioned while the hind LF did not, in view of the original purpose of these experiments, front LF conditioning was an important accomplishment. Future research should be directed at determining conditioning parameters which will maximize front LF conditioning and minimize elicitation of the JM and NM responses. This response system could then serve as a functional vehicle for assessing interactions between CRs both across and within motivational classical-classical transfers.

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