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An Experimental Analysis of Second-Order Conditioned Taste Aversion: Drug Pairing Facilitated Through Excitation of Geotactic Behavior

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AN EXPERIMENTAL ANALYSIS OF SECOND-ORDER CONDITIONED TASTE AVERSION: DRUG PAIRING FACILITATED THROUGH EXCITATION OF GEOTACTIC BEHAVIOR

by

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John H. Gatling

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ABSTRACT

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by

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In two experiments, second-order conditioned taste aversion techniques were employed to develop aversions in rats, with a geotactic-excitation procedure as the independent variable. Periodic tilting of an experimental apparatus resulted in angular orientation changes of all subjects located within compartments of the chamber. The effect was excitation of geotactic behaviors, expressed as locomotor activity within the confines of these compartments.

In the first experiment, two groups of rats (n = 6) were exposed to experimental protocols which were identical with the exception of the independent variable. Three conditioning trials were presented, separated by five to seven days, within which strychnine

injections preceded LiCl injections by 15 minutes. A treatment trial was presented five days following the last drug pairing, in which a novel flavor was available in lieu of tap water. Immediately following the 10-min water-access period, an injection of the CS-drug was administered. Testing for evidence of second-order CTA was conducted via presentation of the flavored solution on the fifth day following treatment. Statistically significant results were obtained in terms of Learned Aversion Ratios and CTA Suppression Ratios. A second experiment was conducted in an attempt to isolate the influence of the excitation procedures with other drug-pairings. Five groups of rats (n = 6 in each group) were run in which hypertonic saline was paired with LiCl, strychnine, or hypertonic saline. Combinations of saline and the US-drugs were tested with and without the excitation procedures. A no-injection group (n = 6) received exposure to the flavor stimulus followed only by the excitation procedure. Results obtained on the Learned Aversion Ratios were statistically significant and in the predicted direction. The excitation group in which saline had been paired with LiCl showed a significant aversion ratio compared to the appropriate control groups, the Saline-Saline Group and the No-Injection Group. The Saline-Strychnine Excitation Group also showed a significant Learned Aversion Ratio

compared to its respective control group and to the No-Injection Excitation Group.

The implications of these results for such issues as stimulus equipotentiality, avfail, and research methodology and CTA research in general may provide additional foundations for future research in this experimental area.

(147 pages)

CHAPTER I

INTRODUCTION

The study reported in this dissertation is an attempt to demonstrate the establishment of second-order conditioned taste aversion by pairing antagonistic drugs (drugs with opposing effects). The variable employed to facilitate this conditioning and the logic for proposing its use necessitate a thorough review of the underlying principles involved. Various substrates, including physiology and pharmacology as well as stimulus control and conditioned-taste-aversion techniques, that impinge the outcomes of the research are presented.

Since Pavlov's (1927) research on the conditioning of physiological responses, the technique which came to be known as respondent or classical conditioning has grown to encompass a wide range of neurobehavioral phenomena. Within the broad parameters of classical conditioning, Conditioned Taste (Flavor) Aversion has come to be of particular interest as a formal area of study during the past three decades.

The survival of an organism such as the rat is dependent upon the regulation of two opposing environments, the milieu interne and the milieu externe (Garcia, Hankins, & Rusiniak, 1974). The

relationship of the environmental-stimulus conditions to the consequence of the animal's behavior significantly affects the acquisition of conditioned adaptive behavior (Garcia & Koelling, 1966). In Garcia and Koelling's study, pairing external stimuli ("bright-noisy" water) with internal distress or pairing internal stimuli ("tasty" water) with external distress (shock) resulted in relatively poor conditioning. However, pairing the "tasty" water with radiation or a toxin or pairing the "bright-noisy" water with peripheral pain readily resulted in the production of avoidance behaviors (Garcia & Koelling, 1966). The cues that control the animal's behavior relate to the consequences of that behavior. That is, animals learn that external environmental consequences that befall them are related to external environmental stimuli and that internal consequences (illness) are related to or associated with ingestive behaviors.

Neophobic behavior in rats, that is, the behavior of rejecting novel (new) substances, has been observed both in the wild (Barnett, 1963; Richter, 1953; Rzoska, 1954) and in the laboratory (Best & Batson, 1977; Domjan, 1975; Revusky & Bedarf, 1967). This behavior is enhanced when rats have experienced illness subsequent to food ingestion (Carroll, Dinc, Levy, & Smith, 1975; Richter, 1953; Rozin, 1968), but not when illness has

been experienced in the absence of prior (within several hours) food intake (Best & Batson, 1977; Domjan, 1975; Revusky, Parker, Coombes, & Coombes, 1976). This former effect has been referred to as "bait-shyness" (Garcia, Ervin, & Koelling, 1967).

Several general principles resulting from taste-aversion research have been delineated. The more intense the flavor stimulus, the greater the degree of measurable aversion induced by subsequent illness (Archer, 1989). Furthermore, the greater the degree of illness, given a constant taste intensity, the stronger will be the aversion. If intensities of taste and illness severity are equated, the strength of the aversion is inversely related to the time interval separating consumption and illness.

In order to fully appreciate the rationale for the current study, it will be necessary to review a number of areas as they relate to research in the area of conditioned taste aversion.

Reflexive Behavior

The term reflex, as applied to the subject matter of behavioral conditioning, can be traced to the writings of Descartes (translated by L. J. Lafleur, 1956). It was commonly believed that animals behaved simply as machines; every response was a necessary reaction to an external stimulus. It was postulated

that a definite nerve path linked a stimulus and a subsequent behavioral response. This connection was presumed to be the fundamental purpose of neural structures within the body of an animal.

Descartes' concept of the nervous reflex was a starting point for Pavlov's conceptualizations and subsequent research on what he referred to as the conditioned reflex. Pavlov operated on the assumption that external stimuli impinged upon nerve receptors, which in turn initiated the propagation of nervous impulses (action potentials), ultimately resulting in excitation of cellular structures at the end of the nerve chain (muscles). He concluded that any given stimulus appeared to be, by necessity, connected to a specific response (Pavlov, 1927).

There are at least three other meanings for the term "reflex" (Zuriff, 1985). First, the term may refer to the causal relationship between a stimulus and a response mediated by a reflex arc. A physical stimulus applied to a receptor cell results in glandular or muscular activity by means of reflexive response elicitation. The reflex is thus defined by the physiological (sensory-conduction-motor) structures and the stimulus events themselves. Second, a reflex may be defined by a stimulus-response pair, independent of the mediating physiology. The laws governing the relationship

between the stimulus and the response involve not only the characteristics of the response, such as latency and magnitude, but also the dimensions of the stimulus, including its intensity and frequency. A third, less restrictive definition is that a reflex is any behavior caused by and related to an antecedent sensory event.

Conditioned taste aversions, in which classical conditioning procedures are employed to pair a taste with a drug or other illness-inducing stimulus and the resultant physiological effect, can be described by aspects of all of these definitions of the term "reflex." Both first- and second-order conditioned taste aversions however, as will become evident, clearly do not fit well within the strict definitions of classically conditioned reflexive behavior encountered in the literature (Garcia, 1989).

Operant Behavior

In contrast to reflexive behavior, responses which have been conditioned and maintained by means of programmed environmental consequences that are made contingent upon their occurrence are termed operants (Skinner, 1937, 1938, 1953). Operant conditioning involves the arrangement of a specific contingency between a subject's behavior and a given consequence (presentation of a reinforcer), with a resultant change in probability of response.

Many observed and unobserved behaviors are the products of multiple interactions between stimuli and responses. First-order classical conditioning in the context of operant conditioning is a commonly observed phenomenon. The development of conditioned reinforcers is a good example of classical and operant conditioning occurring in conjunction. For example, during a reinforcement cycle, access by means of mechanical instrumentation to a food hopper in an operant experimental chamber may be immediately preceded by certain auditory stimuli. These previously neutral stimuli become conditioned stimuli (CSs) through the process of respondent conditioning, which is inherent in this preparation, and are capable of maintaining operant responding beyond the period normally observed during extinction trials (Bugeleski, 1938; Melching, 1954; Skinner, 1938). Hence, the stimuli function by definition, as reinforcers. The classification of any given behavior dichotomously as either operant (controlled by reinforcement contingencies) or respondent (classically conditioned or reflexive) is usually arbitrary and may be technically incorrect in many cases, as both operant and respondent procedures may be present in a single preparation. It may be the context in which the conditioning occurs that determines the classification of the response as an operant or respondent behavior.

First-Order Classical Conditioning

Classical conditioning involves the arrangement of a specific contingency between two stimuli (Pavlov, 1927; Rescorla, 1988). The term reinforcer, in respondent conditioning, refers to an unconditioned stimulus whose presentation increases (strengthens) the probability that the neutral stimulus will elicit a particular response. In a reinforced conditioning trial, a previously neutral stimulus (CS) is presented, followed by an overlapping unconditioned stimulus (US). The conditioned stimulus by itself initially has little or no effect upon the probability of the response. In contrast, the unconditioned stimulus reliably elicits the response reflexively, in other words, without the necessity of prior conditioning. Through a series of successive and overlapping temporally paired presentations of the CS and US, the conditioned stimulus will come to elicit a conditioned response (CR) which resembles the unconditioned response (UR) (Mackintosh, 1974).

Several variations in the order of stimulus presentation, or the temporal relationship between the CS and US, are recognized (Mackintosh, 1974; Pavlov, 1927). In simultaneous (the most common form), delayed, and trace conditioning, the CS temporally precedes the US, and each differs only in the degree of overlap or interval between presentation of stimuli. In backward

conditioning, the onset of the US precedes the CS. Such temporal arrangements have generally been reported to produce poor results (Davey, 1981), but some researchers have found them to be quite effective (Spetch, Wilkie, & Pinel, 1981). Temporal conditioning arrangements, in which the time interval since the last US acts as the CS, have also been reported. The most common classical conditioning procedure, simultaneous conditioning, is used in the present study.

Second-Order Classical Conditioning

In Pavlovian conditioning experiments, the US has and maintains its function in the absence of prior learning experiences. Second-order conditioning is distinguished from first-order by the manner in which the unconditioned stimulus exerts its control over the response; the second-order US becomes a US through past pairing by the experimenter (Rescorla, 1980).

Second-order conditioning in a classical conditioning preparation involves first the pairing of an initially neutral stimulus (S_1) with a stimulus (US) which, without prior conditioning, elicits a specific response (UR). Second, another initially neutral stimulus (S_2) is then paired with S_1. Upon presentation of S_2 alone in an extinction trial, the elicitation of a conditioned response (CR) is taken as an indicator that

second-order conditioning has occurred (Rescorla, 1980).

First-Order Conditioned Taste Aversion

Conditioned Taste Aversion (CTA) researchers have used both first and second-order classical conditioning techniques in attempts to produce suppression of drinking or eating behaviors with a variety of flavored solutions or pellets. Sweet, sour, bitter and salty tastes, as well as fruit juices, milk, coffee, natural prey and many other substances have been employed as CS flavor stimuli in CTA research (Garcia et al., 1974). Lithium chloride (LiCl), cyclophosphamide, X-irradiation and numerous other chemicals have been commonly used as illness producing stimuli to serve in the role of the unconditioned stimulus in CTA preparations (Gamzu, Vincent, & Boff, 1985; Riley & Tuck, 1985). The capacity of a given chemical US to result in a taste aversion is dependent upon the gastrointestinal illness effects produced, the intensity of which, are related to the dose, route of administration and the interval separating ingestion of the distinctively flavored CS and the onset of illness (Shumake, Sterner, Gaddis, & Crane, 1982).

Second-Order Conditioned Taste Aversion

Second-order classical conditioning procedures have

been applied to CTA research also. The methodology involves the pairing of two drugs, one serving a US function, the other a CS, then pairing a novel flavor with the CS-drug. Attempts at such conditioning have not been completely successful (Cunningham & Linakis, 1980; Revusky, Taukulis, & Peddle, 1979; Revusky, Taukulis, & Coombes, 1980).

In a second-order CTA preparation, the failure of one of the drugs to produce a first-order aversion would be highly desirable in order to facilitate the assessment of the contribution of the conditioning process to the development of a second-order aversion. In other words, if the drug used as a CS was capable of causing an aversion by itself, it would clearly be difficult to demonstrate an effect attributable to second-order conditioning.

In previous reports, strychnine, the principal toxin selected to serve as the CS-drug in this study, has been demonstrated to be at best a very weak CTA agent (Cheney, Vander Wall, & Poehlmann, 1987; Nachman & Hartley, 1975). Strychnine causes death at relatively low doses due to its potent analeptic effect. The injected strychnine dosages used in the present study were not successful in producing taste aversions in first-order conditioning procedures. That is, no taste aversion occurred with strychnine as the potential US,

probably because it does not induce gastrointestinal distress which is very important, if not essential, in CTA development. The site of action of strychnine is on the Renshaw cells in the spinal cord which motor neurons. One reason that strychnine may be ineffective in producing first-order aversions may be related to the nature of the physiological activity it causes. The behavioral expression of strychnine toxicosis, uncontrolled muscular contractions, is directly linked to the general activity level of the organism receiving it. An injection of strychnine, even at near lethal dosages, can be survived and the consequent convulsant activity minimized if the subject is in an environment in which sensory stimuli have been diminished (Goodman & Gilman, 1975). The inactivity induced by LiCl when pairing these two drugs only serves to further decrease the discriminable properties of strychnine as a CS-drug. That is, inactivity caused by the lithium induced sickness allows the strychnine to be metabolized without the production of discernible seizures. Thus, to enhance the discriminable stimulus properties of the CS-drug (strychnine), procedures were introduced in the present study which served to excite the geotactic behaviors (Carlson, 1977; Kelly, 1985) of the subjects involved. Such stimulation was hypothesized to be sufficient to cause some motor activity in the animals,

which, in turn, would lead to behavioral expression of the physiological effects of the strychnine.

A wide range of flavor stimuli are available to which aversions have been conditioned. Novelty, salience, and palatability are three important flavor-CS variables directly related to the probability of producing an aversion (Brackbill, Rosenbush, & Brookshire, 1971; Etscorn, 1973; Revusky & Bedarf, 1967; Vogel & Clody, 1972; Wilcoxon, Dragoin, & Kral, 1971). On the basis of preliminary studies with various solutions including sodium saccharin, aspartame, sucrose, and grape juice, the last of this list was selected for use in these experiments in an effort to maximize the salience of the flavor stimulus. Grape juice (unsweetened and sweetened with sucrose) has been successfully used in first-order CTA experiments (McCoy, Nallan, & Pace, 1980; Parker & Revusky, 1982). Grape juice artificially sweetened with aspartame, was used in this study and introduced (grape juice with aspartame) as another novel flavor stimulus in the field.

Overshadowing

The strength of conditioning to a particular stimulus depends upon the conditions surrounding its presentation, that is, as a single stimulus or within the context of a set of stimuli. The control of the response by a single component of a compound conditioned

stimulus appears to be related to the relative strengths or intensities of the components, or what has been called the predictive value of the components (Davey, 1981). Overshadowing occurs when the rate and level of response acquisition to a target stimulus is diminished through compound training with another CS that is capable of rapid response acquisition (Kehoe, 1987).

Pavlov (1927) originally found overshadowing effects with animals which were presented with compound multimodal stimuli. He suggested that this effect may have been due to different strengths of the respective stimulus components. The dependence of the overshadowing effect on the relative intensities of the component stimuli has been demonstrated in a number of studies (Kamin, 1969; Mackintosh, 1971).

Overshadowing of one stimulus by another is not only affected by the relative intensity but also by the relative validity of the stimuli (Wagner, 1969). It was concluded on the basis of their evidence (Wagner, Logan, Haberland, & Price, 1968) that a stimulus which better predicted the occurrence of reinforcement (a more valid stimulus) could overshadow a less valid one. A third factor in overshadowing is the extent of training which has taken place on the overshadowing stimulus; the greater the training, the more probable is an overshadowing effect (Kamin, 1968, 1969).

In conditioned taste aversion, Revusky (1971) has also found evidence of overshadowing. He observed that exposure to a second-flavor CS prior to administration of a chemical US interfered with the conditioning of an aversion to the first-flavor CS.

In conjunction with the presentation of what amounts to a compound stimulus (the overlapping and opposing effects of strychnine and lithium), it appears that an overshadowing-like effect (the action of strychnine on the Renshaw cells and the gastrointestinal effect of LiCl) has contributed to the failure of second-order aversions previously observed in first-order preparations in the laboratory and widely reported in the literature. In this particular case, geotactic excitation as a means of causing activation of the physiological and behavioral effects of strychnine may prove to be a solution to the problems associated with pairing two drugs which exert their effects in different physiological systems.

Rotational stimulation procedures have been used to condition aversions in first-order preparations (Fox & McKenna, 1988; Hutchison, 1973; McCoy et al., 1980). The procedures employed in the current study, however, do not fit within the parameters of studies conducted in the Motion Sickness CTA literature and, in and of themselves, were expected to have no effect on the

acquisition of conditioned aversions (Holder, Yirmiya, Garcia, & Raizer, 1989). In fact, the periodic angular orientation changes of the experimental chamber designed for this study resulted in minimal externally mediated agitation and in no way resembled agitation or motion sickness procedures. The resultant motor activity induced by varying the chamber orientation is a function of the rats' geotactic behaviors. Based on preliminary findings it was determined that this amount of motor activity would be sufficient to facilitate the behavioral expression of the toxic effects of the strychnine CS, thereby increasing it's discriminability.

Statement of the Problem

Previous research utilizing traditional drug pairings in an attempt to show second-order classical conditioning has failed to demonstrate conditioned aversions to novel flavor stimuli with a number of drug combinations (Cunningham & Linakis, 1980; Revusky & Coombes, 1982; Revusky et al., 1980; Revusky, Taukulis, Parker, & Coombes, 1979; Revusky, Taukulis, & Peddle, 1979).

Traditional conditioning procedures involve the application of second-order classical conditioning techniques (i.e., the presentation of a CS-drug (CS_1) followed by a US-drug for varying numbers of trials, and

then the presentation of a novel taste stimulus (CS_2) followed by CS_1). Testing for taste aversion occurs on subsequent days by means of presenting the taste stimulus alone and measuring the intake of that substance compared to the water consumption for the immediately preceding day (Shumake et al., 1982) or compared to the intake of the flavor upon its initial presentation (Nachman & Hartley, 1975). The present study used this procedure with the addition of the orientation manipulation to make the effects of the two drugs more salient.

A unique finding within taste aversion research is the failure to produce a second-order aversion with some chemical combinations and under certain experimental conditions. On the other hand, a variety of antidepressants, stimulants, anxiolytics, anesthetics and other drug classes are capable of producing aversions. In fact, it is possible that any chemical substance could function as a CTA agent given sufficient dosage and exposure (Gamzu, 1977; Gamzu et al., 1985). There is, however, a large body of research, which, using second-order classical conditioning procedures, has consistently resulted in aversion failure. First reported by Revusky, Taukulis, & Peddle (1979), this failure to produce a second-order conditioned aversion following drug pairings is called the Avfail Effect.

Research seems to have either neglected or ignored the potential problems involving overshadowing of the CS-drug by the US-drug during the antecedent classical conditioning procedure. The most frequently used US-drug in CTA is lithium chloride. The effect of LiCl upon the activity of the animal at moderate to high CTA dosages is to depress motor activity and induce gastrointestinal distress; the animal remains relatively motionless for a variable, dosage-dependent period following the injection. In the case of a CS-drug such as strychnine at the very low dosages that must be used to maximize survivability, motionlessness may effectively eliminate the perceptible stimulus properties of the drug. Thus, the failure to develop an aversion following second-order conditioning procedures (Avfail) may be due, at least in part, to an overshadowing-like effect by the US-drug.

No research has been located which examined whether second-order conditioned taste aversions could be produced by pairing two drugs, one a weak or neutral CTA agent such as strychnine as a CS, the other a premier CTA agent such as lithium as a US, in the presence of procedures which would enhance the discriminable stimulus properties of the CS-drug. The present study attempted to address this issue.

CHAPTER II

REVIEW OF THE LITERATURE

Conditioned Taste Aversion

When an olfactory or taste stimulus is followed by illness in the form of gastrointestinal distress, subsequent avoidance of that taste is exhibited by the animal in future presentations. If a rat consumes distinctively flavored poisoned bait and survives, it will develop a "shyness" for that bait (Rzoska, 1953). In the first report of experimentally produced "bait shyness" Rzoska (1953), rats were presented with saccharin flavored water and were then exposed to 30 roentgens of x-irradiation. Upon subsequent presentation of the flavored solution the rats exhibited aversions that persisted for weeks of continuous preference testing. This article appears to mark the beginning of the field of conditioned taste aversion research.

Conditioned taste aversion as long delay learning. In traditional classical conditioning studies, delays between the presentation of the CS and US (interstimulus intervals or ISIs) of only a few seconds can significantly reduce or eliminate conditioning (Bersh, 1951). Kimble (1961) went so far as to say that

the optimal ISI in classical conditioning preparations is in the 250 to 750 ms range. This is a gross oversimplification, as the optimal ISI is dependent upon the response, the organism and any number of other variables but is always less than minutes (Mackintosh, 1974).

Long delay learning is a peculiar characteristic of the taste aversion learning paradigm and one of the reasons that Bermudez-Rattoni, Sanchez, Perez, Forthman, & Garcia (1988) and Garcia (1989) have argued that CTA procedures do not resemble pure classical conditioning procedures. Conditioned taste aversions are unique for many reasons. They may be produced through a single conditioning trial (Garcia, Kimeldorf, & Hunt, 1961; Garcia & Koelling, 1966), when the interval between presentation of the CS and US is delayed by an hour or more (Deutsch, 1978; Domjan & Gregg, 1977; Garcia & Koelling, 1966; Nachman, 1970; Revusky & Bedarf, 1967; Riley & Mastropaolo, 1989; Rozin, 1969) and even when the subject is unconscious (Bermudez-Rattoni et al., 1988; Roll & Smith, 1972) or when cortical function has been depressed by potassium chloride (Buresova & Bures, 1973; Davis & Bures, 1972).

Novelty of the flavor used can influence the delay intervals which successfully result in taste aversions. The novelty of a flavor is defined by the animal's previous exposure to the substance. Franchina, Silber,

& May (1981) compared flavor novelty and temporal contiguity in the production of lithium chloride induced taste aversions and found that the relative novelty of the flavor stimulus was more important than temporal contiguity between flavor and toxicosis. Despite a 12 hr delay between presentation of a novel flavor and the administration of LiCl injection, the degree of aversion was found to be more pronounced for subjects exposed to the novel flavor.

Another unique aspect of long delay CTA learning is that testing procedures may be carried out days or even weeks following the last conditioning trial with positive results (Domjan & Gregg, 1977; Kalat & Rozin, 1973). The adaptive function of an animal which learns to avoid substances encountered in its environment that caused illness is clearly not easily extinguished (forgotten) and has obvious survival value.

Cue to consequence specificity. The vertebrate brain has apparently evolved two specialized defense systems in response to natural selection pressures inherent in the food chain. For example, to protect itself from external insult, such as predatory attack, the vertebrate organism selectively associates exteroceptive stimuli with peripheral insult. To protect itself from toxic or nonnutritional food, it selectively associates interoceptive taste stimuli with delayed

illness (Garcia et al., 1974; Garcia, Lasiter, Bermudez-Rattoni & Deems, 1985). This defense system doesn't easily intermingle with exteroceptive stimuli such as color or sound (Garcia & Koelling, 1966). Rats exposed to very small doses (1 roentgen) of x-rays can be aroused from sleep due to stimulatory effects upon the olfactory receptors. Larger doses, 100 roentgens, will cause illness, while doses in the range of 1,000 roentgens are lethal. Despite the illness-inducing effects of x-rays, rats will approach a clearly marked irradiated field in a free-choice environment and will demonstrate only a mild avoidance of this area following training (Garcia et al., 1961). The exteroceptive stimulus, in this case, the place in the chamber, is not associated with the internal malaise produced by the radiation.

In a now classic study, Garcia and Koelling (1966) presented audiovisual stimuli contingent upon rats licking at a water spout. "Bright-noisy" water (a 5 watt incandescent lamp and a clicking relay) as well as "tasty" water (0.1% sodium saccharin solution) was presented to rats in conjunction with 54 r of filtered 250 kv x-rays, 0.12 M LiCl solution and immediate or delayed foot shock consisting of 500 ms presentations of a 0.08 to 0.20 ma current. All consequences were effective in producing discrimination learning during the acquisition phase. Avoidance reactions produced by

radiation and LiCl were readily transferred to the gustatory stimulus but not to the audiovisual stimulus. Gustatory stimuli were successfully paired with illness inducing agents and apparently acquired secondary properties which the authors described as "conditioned nausea." When peripheral pain was the stimulus, conditioned avoidance was more readily acquired by auditory and visual stimuli than by gustatory stimuli. The environmental stimuli that controlled the rats' behavior appeared to be related to the consequences of the subsequent stimulus event (Garcia & Koelling, 1966), hence the phrase "cue to consequence conditioning."

Garcia, McGowan, Ervin, and Koelling (1968) investigated nongustatory attributes of food in the acquisition of conditioned aversions. Four groups of rats were trained with either a large or small pellet flavored with flour or powdered sugar, conditionally paired with radiation or peripheral shock. Aversions resulted when the flavor of the pellet was paired with radiation or when the size of the pellet was paired with shock. Aversions did not result from pairings in which flavor was followed by shock or when the size of the pellet was paired with radiation. Both radiation and shock disrupted consummatory behaviors, but avoidance learning occurred reliably only when the cue was "appropriate" to the consequence (Garcia et al., 1968).

Methodological parameters. The production of CTA is dependent upon a number of variables including the species, illness agent, dosages, routes of administration, flavor concentrations and exteroceptive stimulation coincident with experimental conditions. As the present study utilized Sprague-Dawley rats, emphasis is given to reviewing experiments involving this species.

Nachman and Hartley (1975) reported that intraperitoneal injection of 127.2 mg LiCl resulted in the most substantial aversions among the substances they tested as potential CTA agents. Warfarin, sodium cyanide and strychnine sulfate failed to produce aversions throughout the course of the study and the 15% sucrose solution intakes for these groups actually increased from treatment to test days. (Actually they should have as novelty diminishes.) A second experiment examined whether repeated trials of strychnine at a dosage twice that of the previous experiment and a single trial of red squill (another potent rodenticide) almost three times the dosage of the previous experiment would result in conditioned taste aversions. Rats in the LiCl and strychnine groups received a total of 5 pairings; the red squill group received only a single pairing. The LiCl and red squill groups exhibited strong aversions while the strychnine group

failed to show any aversion despite high dosages and repeated pairings.

Similar negative results utilizing ingested strychnine sulfate as a conditioned stimulus in a CTA paradigm have been obtained by other researchers as well (Cheney et al., 1987). In contrast, Howard, Palmateer, and Nachman (1968) reported that with strychnine concentrations of 0.01%, 0.05% or 0.5% in water presented in drinking bottles, Sprague-Dawley and Norway rats were able to effectively discriminate and avoid the flavor. Roof rats learned to avoid moderate and high concentrations of strychnine while pocket gophers failed to avert to any concentration of the flavor despite apparent illness related to its ingestion. Thus, the only report of strychnine which resulted in conditioned aversions was obtained through oral administration of the solution. This was probably due to the relatively high concentration of strychnine where the taste (bitter) of the solution played a major role in its palatability.

Nachman and Ashe (1973) established that 0.15 mEq/kg LiCl was the threshold dose for producing measurable aversion to a 15% sucrose solution and that the optimal aversion was produced at a dose of 3.0 mEq/kg. The concentration of the toxin was found to be irrelevant by itself and needs to be considered only

with regard to the practicality of the ml/kg volumes to be administered. Comparisons were also made of administration routes (i.e., intraperitoneal vs subcutaneous injection vs intubation). All routes of administration were found to be equally effective in producing learned aversions.

In another parametric study, Shumake et al. (1982) compared administration routes, dosages and solution concentrations using Philippine rice rats. Gavage, ip injection and ingestion were employed as administration routes for copper sulfate, cyclophosphamide, lithium chloride, red squill, sodium chloride and deionized water. Lithium chloride, at a dosage of 368 mg/kg, produced the strongest and most sustained aversions of all chemicals tested. Gavage administration at this dosage resulted in increased saccharin intake over this time period. Injection and ingestion administrations, however, resulted in sustained aversions across the same 28 day test period.

Stimulus equipotentiality and CTA. Pavlov's conclusions regarding the ability of any "natural phenomena" to become conditioned stimuli in respondent conditioning preparations are not supported by the majority of current classical conditioning or CTA research. The mere contiguous presentation of one stimulus as a CS and another as a US is neither

necessary nor sufficient to produce a classically conditioned response (Rescorla, 1988). Applied to CTA technology, simply administering a toxic agent subsequent to the presentation of some neutral substance will not necessarily result in an aversion. Characteristics of both the neutral substance and the toxin need to be considered. It appears that the CS can perhaps not be a truly neutral stimulus. Rather, it must result in some physiological activity that the animal can behaviorally discriminate or at least experience at the neurological level.

In the Garcia and Koelling (1966) study, all USs were effective in producing discrimination learning during the acquisition phases. Aversion to a flavor produced by x-rays or lithium chloride was easily transferred to a gustatory stimulus but not to an audiovisual stimulus. Electric shock following an audiovisual stimulus also resulted in avoidance behaviors but not if it had been paired with a gustatory stimulus. The point is, that in a CTA preparation, one cannot readily pair internal CSs with external USs and vice versa and obtain conditioning.

The context or environment in which taste aversions are conditioned does not seem to be a significant variable in this type of learning. Animals that sample a food substance and subsequently become ill will avoid

that substance in future instances, but they do not learn to avoid the environment in which the food was found (Barnett, 1963). Apparently, olfactory and gustatory stimuli are more salient than are other environmental events such as sound or light in poison avoidance learning in rats. This does not seem to be the case in quail (Wilcoxon et al., 1971). Furthermore, gustatory aversions have been empirically found to be difficult or impossible to establish using peripheral pain producing procedures (Garcia et al., 1967; Garcia et al., 1968).

Exteroceptive stimulation presented during conditioning trials has not been demonstrated to interfere with the development of CTA (Holder et al., 1989). This is an important finding in that it provides further evidence that taste aversions are learned by animals attending to interoceptive stimuli rather than external environmental stimuli. The implication is, to some extent, that independent of external environmental conditions, taste aversions are learned selectively by means of visceral cues.

Results consistent with these previous observations are reported by Holder et al. (1989). In this study, the effects of external excitation upon the acquisition of conditioned taste aversions were systematically evaluated. In a series of experiments, water restricted

rats were given access to 0.1% sodium saccharin solution followed 30 minutes later by sham intubation or intubation of 25-64 mg/kg of isotonic LiCl. Access to females, mild footshock, pain from intraperitoneal or intramuscular injections of hypertonic or isotonic saline and exposure to heat during the taste-illness delay failed to show disruptions in the acquisition of aversions for subjects exposed to LiCl following ingestion of the saccharin solution. Their conclusion was that CTA was not readily disrupted by these sources of externally-mediated stimulation.

Motion sickness effects. The present study employed a procedure to induce locomotor activity by simply changing the angular orientation of the experimental chamber. This resulted in excitation of geotactic behaviors consistent with the goal of producing self-initiated subject movement within the chambers. Rotational stimulation has been used as a US in many CTA studies and is reviewed here to demonstrate that these procedures in no way resemble those used in the present study.

The effects of rotation on locomotor activity (Eskin & Riccio, 1966), operant response rate (Riccio & Thach, 1968) and on the production of conditioned taste aversions (Elkins & Harrison, 1983; Green & Rachlin, 1973, 1976; Haroutunian & Riccio, 1975; Haroutunian,

Riccio, & Gans, 1976; Harrison & Elkins, 1987; Hutchison, 1973; McCoy at al., 1980) have been extensively researched. Rotation usually consists of placing the subject in a chamber mounted on a turntable and rotating it a number of revolutions over a specified time period (Green & Rachlin, 1973). The procedure is not accompanied by drug injection.

In the Green and Rachlin (1973) study, a two bottle 0.2% saccharin preference was established over a period of 4 days before pairing the 2 g/litre saccharin solution with rotation. The subject that received rotation after drinking, at a rate of 12 rpm, markedly reduced its saccharin intake by the fourth session and had completely ceased saccharin consumption by the fifth. For the rat receiving rotation at 23 rpm, nearly complete avoidance of the saccharin solution was evident by the third session. Even with a relatively low saccharin concentration, the rotational procedures successfully resulted in an aversion within the range of pairings typically found in chemically induced CTA. This study also showed that the speed of rotation was related to the efficiency of aversion conditioning in a similar manner to that expressed by dose-response relationships that exist with chemical CTA agents.

In an analysis of some parameters of flavor-rotation delay intervals, Haroutunian and Riccio

(1975) found that delays of 0.5 min, 15 min or 30 min were sufficient to establish conditioned taste aversions. A delay interval of 120 min did not result in an aversion to a 0.1% saccharin solution. Rats can, however, learn to avoid a flavor when it has been paired with even longer delay intervals between flavor consumption and rotation. Green and Rachlin (1976) also researched these parameters utilizing delays ranging from 0 to 9 hours. Their results showed that the shorter the delay, the greater the aversion to a 2 g/liter (a higher flavor concentration) saccharin solution. In a subsequent parametric experiment, the same authors reported results from 1 hour (duration) rotations at rotational rates of 5 rpm, 15 rpm, 30 rpm, 45 rpm or 60 rpm. Variable rotation durations of 10 min, 30 min, 60 min, 90 min or 120 min at a rotation rate of 30 rpm for 1 hour were also examined. Their results indicated that the degree of aversion exhibited to a specific taste stimulus paired with rotation was related to the duration and speed of rotation. Their results indicated that saccharin aversions were roughly equivalent for subjects rotated at high speeds for short durations compared to subjects rotated at low speeds for long durations.

In summary with regard to rotation induced CTA, the capacity of rotation to produce an aversion to a taste

stimulus in a first-order conditioned taste aversion paradigm is a function of the number of rotations (rpm x duration) and the delay interval between the presentation of a taste stimulus and the rotation. Generally speaking, the shorter the delay and the greater the number of actual rotations, the greater the probability of producing a rotation induced CTA.

The poisoned partner effect. Another tangential finding from conditioned taste aversion research worthy of review due to its significance to the understanding of the complexity of CTA, is the Poisoned Partner Effect (PPE). Rats housed in close proximity to animals made ill through CTA procedures may develop aversions for flavors presented at the time of exposure to the sick rat in its home cage as much as 6 hrs later (Coombes, Revusky, & Lett, 1980; Lavin, Freise, & Coombes, 1980). The poisoned rat is called a poisoned partner (PP) and the aversion exhibited by the unpoisoned rat is called the poisoned partner effect (Revusky, Coombes, & Pohl, 1982).

In an evaluation of the capacity of CTAs to be learned indirectly as in the PPE, adult wild rats were trained to avoid a distinct-tasting diet by lacing it with lithium chloride. They were then tested for aversions transferred to their progeny (Galef, 1977). The transmission of an aversion for the diet laced with

the toxin was successful despite the fact that the young had no direct conditioning experience with the diet or the toxin. Weanling rats avoided the diet associated with adult avoidance. Galef (1977) emphasized two factors which are important in this apparent social transmission of a dietary aversion. First, weanling rats tend to remain in proximity to the adults, thus being exposed to the foods available to and eaten by the adults. Second, the safe diet is approached more often and is therefore more familiar to the usually neophobic animals. Thus, the weanling rats would have been subject to neophobia with regard to the averted diet but not the safe diet. They could, therefore, have learned to avoid the "unsafe" diet by means of a combination of socially transmitted cues and neurologically based neophobic behaviors.

Another study of the influence of social factors upon the selection of diets is reported by Beck and Galef (1989). They examined the role of social influences of rats upon the selection of protein deficient and protein sufficient diets. Isolated rats choosing from among four foods, three protein deficient, one protein rich, failed to develop preferences for the protein rich diet. In contrast, rats that interacted with conspecifics trained to eat the protein rich food developed strong preferences for that diet. Thus, not

only can aversions for diets be socially conditioned but preferences for diets can also be conditioned through social contingencies.

Nonpoisoned rats will also develop a taste aversion to a novel gustatory stimulus consumed either in the presence of an ill rat or just prior to the presence of such a rat (Bond, 1984; Lavin et al., 1980; Stierhoff & Lavin, 1982). An apparently sufficient condition for the production of a transferred aversion (poisoned partner effect) occurs when the nonpoisoned partner (NPP) is present with the poisoned rat soon after it (the unpoisoned rat) has consumed the flavored solution (Coombes et al., 1980). It is not necessary for the PP to be present during the actual consumption by the NPP nor is it necessary for the PP to have any direct contact (intake) with the flavor (i.e., it could receive an injection of lithium without flavor pairing). The poisoning of the PP and its presence subsequent to flavor consumption by the unpoisoned rat result in an aversion as if the mere presence of the poisoned partner serves a US function.

Bond's (1984) series of parametric studies refined the necessary and sufficient conditions for the production of the poisoned partner effect. Not only is it necessary for the nonpoisoned partner to have contact with the poisoned partner as Coombes et al.

(1980) had found but that this contact has to be for a period of at least 30 min and it has to begin immediately following a poisoning episode. Partner pairing that commences even 40 min after the poisoning event results in failure to fully demonstrate the effect.

Stierhoff and Lavin (1982) have established that intact olfactory functioning is also a prerequisite for the production of the poisoned partner effect, whereas it is not for the production of CTA. The implication is that transferred flavor aversions of this type are accomplished by means of odors emitted by the poisoned rats which are of sufficient aversiveness to serve as unconditioned stimuli. The precise nature of the olfactory stimuli are unknown but it has been suggested that they may act in a manner similar to that of pheromones (Stierhoff & Lavin, 1982).

The medicinal effect. Pairing a distinct taste stimulus with illness results in an aversion for that taste upon subsequent presentation. Conversely, Green and Garcia (1971) have demonstrated that rats receiving multiple pairings of a taste stimulus with recovery (the diminishing effects) from an apomorphine-induced illness subsequently showed preferences for the flavor; they called this, the Medicinal Effect.

Hasegawa (1981) examined the medicinal effect using a 1.0% saccharin solution paired with recovery from

lithium chloride (15 ml/kg, 0.12 M) poisoning. Three groups of rats received intraperitoneal injections of LiCl at 30 min, 60 min or 90 min prior to saccharin presentation and a control group was given access to saccharin without LiCl injection. Hasegawa's results demonstrated all experimental groups had significantly different saccharin intakes compared to a matched control group. The groups that received injections either 60 min or 90 min prior to the presentation of the taste showed greater preference for the solution than either the 30 min postinjection or control groups. In this experiment, 4 pairings of recovery from LiCl injection and saccharin consumption resulted in a preference for the flavored solution if the lithium-saccharin interval was at least 60 min. This threshold time interval is probably related to the dose-response curves of the toxins used.

Interestingly, contrary to the medicinal effect, backward conditioning CTA effects of single LiCl-saccharin pairings have been obtained at postinjectional flavor presentation intervals of 60 min (Domjan & Gregg, 1977). In addition, other failures to obtain the medicinal effect are reported (Barker & Smith, 1974; Domjan, 1977). The backward conditioning effects may have been due to insufficient numbers of pairings of illness recovery and taste resulting in failure to

obtain habituation to the flavor (Hasegawa, 1981). The greater the number of exposures to the taste stimulus, the less likely is it that neophobic behaviors will detract from the effects of illness recuperation paired with a taste stimulus.

The avfail effect. The concept of the equipotentiality of stimuli (Pavlov, 1927) has run into a number of alternative findings, especially in the field of conditioned taste aversion. The Cue to Consequence Effect (Garcia et al., 1974) previously reviewed, clearly demonstrates that a given stimulus can serve a CS or US function only insofar as it is consistent with the type of learning involved. That is, external stimuli can successfully be paired with peripheral insult, and internal stimuli can be paired with visceral distress but cross system pairings are difficult or impossible to obtain.

This cue-to-consequence specificity extends even to the level of drug action. Revusky, Taukulis, and Peddle, (1979) discovered that second-order classical conditioning procedures in a taste aversion paradigm did not always result in the production of aversions; in fact they were difficult to establish. Rats injected (4x-8x) with pentobarbital 30 min prior to an identically injected lithium chloride dose failed to exhibit a saccharin aversion when later injected with pentobarbital

following exposure to a saccharin solution. Controls receiving equal experience with pentobarbital or lithium chloride alone did not exhibit aversion failure (Revusky, Taukulis, & Peddle, 1979; Revusky et al., 1980).

Similar effects have been obtained with drugs other than pentobarbital and LiCl (Revusky et al., 1982). Any drug given the role of the pentobarbital in the foregoing study is defined as a CS-drug and any drug given the role of LiCl is defined as a US-drug.

In a series of nine experiments involving over 700 rats, Revusky et al. (1982) investigated the pharmacological generality of the avfail effect using a variety of CS- and US-drug combinations. The following procedural groups were delineated: CS->US; US->CS; CS alone; US alone; and control. CS-drugs used in this study included chlordiazepoxide hydrochloride, d-amphetamine, morphine sulfate, apomorphine HCl, atropine sulfate, sodium pentobarbital and LiCl; US-drugs included LiCl and d-amphetamine. In all cases, to match the number of injections and the volumes injected, saline solution was used as a substitute for a CS- or US-drug as indicated by the protocol. Separate dosages for each animal were deemed unnecessary for experimental purposes. The weakening of the capacity of the CS-drug to produce an aversion due to its presentation in a number of initial pairings was

experimentally offset by the high (0.6% w/v) saccharin concentration. This highly concentrated solution resulted in increased evidence of neophobia in all subjects. While not all combinations of drugs resulted in statistically significant aversion failures, these results were obtained with a wide variety of drugs making it unlikely that the effect was due to a specific pharmacological interaction. Among the chemicals that did result in aversion failure, chlordiazepoxide HCl, d-amphetamine, morphine sulfate and sodium pentobarbital (paired with a LiCl or d-amphetamine US) resulted in complete or partial Avfail effects. As stated by the authors, the issue of discriminability of the drug state may have been a major factor in the Avfail studies (Revusky et al., 1982) and is the basis for the research presented in this dissertation.

Neural mechanisms. Neural control of the internal environment exercised by selectively associating taste stimuli with internal states may be independent of the control of the external environment achieved by associating external cues with cutaneous pain (Garcia et al, 1974; Garcia et al., 1985). Visual acuity, aiding in the identification of predators, mates and food, serves an important role in terms of guiding an animal's motor functions in avoidance or pursuit of these stimuli in the external environment. It serves little function

with regard to maintenance of its internal homeostatic environment. The milieu interne is better served by gustatory and olfactory systems which accommodate responses to demands or cues from internal receptors. The ability of an animal to initiate motor activity following ingestion of a toxic substance does little to facilitate its escape from such a state of affairs. The animal must be able to accept or reject food substances on the basis of previous experience with regard to the effects of ingestion upon its internal environment. It must be able to identify and consume nutritional substances and avoid those substances which have resulted in illness (Garcia et al., 1974).

Several neurological structures have been shown to be involved in the development of CTA. Bilateral lesions in the lateral septum have been demonstrated to affect auditory stimulus-peripheral pain learning but not to adversely affect conditioned taste aversion learning with radiation as an unconditioned stimulus (McGowan, Garcia, Ervin, & Schwartz, 1969). Rats with medial septal lesions showed little evidence of extinction over 9 unreinforced trials (27 days after the last exposure to radiation) in that experiment as compared to the lateral septal group that extinguished after 3 nonreinforced trials. This evidence indicated that septal lesions in general failed to result in

disruptions of taste aversion learning. Furthermore, the neural mechanisms mediating control of the internal environment are distinct from those that are involved with adaptation responses to the external environment.

Disruption of the neural control by features of the external environment has been demonstrated to be more readily accomplished than disruption of control by features of the internal environment (McGowan, Hankins, & Garcia, 1972). Rats lesioned in the lateral septum or the ventral hippocampus were found to be deficient in acquiring conditioned suppression of drinking behavior when a noise was paired with footshock but they were proficient in learning to avoid a flavor which had been followed by LiCl. Medial septal lesions produced similar results but the auditory-shock learning was not as affected. Lesions of the amygdala produced decrements in learning both types of avoidance behaviors while hippocampal lesions resulted in little effect on either mode of learning.

Ablation of the area postrema has been shown to block the acquisition of combined subthreshold radiation-amphetamine taste aversions but only resulted in diminished intensity of the aversion at higher doses (Rabin, Hunt, & Lee, 1987).

Smith (1980) examined the locus of action of LiCl-induced aversions to 0.2% saccharin solution by

administering intraperitoneal injections of 150 mmol/l LiCl or NaCl, and bilateral intracerebroventricular (ICV) injections of 150 mmol/l LiCl, NaCl or artificial cerebrospinal fluid. Subsequent saccharin intake decreased in rats that received the IP lithium injections but did not depend on the ICV injection given. Thus, CTA was found to be dependent upon the peripheral (not central nervous system) action of the lithium chloride US.

Garcia et al. (1985) persuasively argued that the convergence of gustatory, olfactory and visceral pathways is a requisite condition for normal taste-illness, odor-illness and flavor-illness learning. Manipulations that involve the disruption of olfactory-gustatory-visceral convergence within the ventral somatosensory and anterior insular neocortices will alter flavor-illness learning. The gustatory pathways in the thalamus and neocortex are integrally involved in taste aversion learning (Garcia et al., 1985).

Applications of CTA technology. CTA technology has been applied in a variety of areas including aversion therapy for alcohol abuse, as a means of estimating maximum drug dosages short of producing side effects, in immunosuppression research, oncology settings and in

the range sciences.

The most commonly recognized application of CTA technology is the use of emetine (antabuse) as an illness-inducing agent when combined with the ingestion of alcohol. Lemere & Voegtlin (1950) published a report of the efficacy of such aversion therapy with a select group of patients in their alcoholism treatment center. The procedures included the provision of counseling services by former patients of the program and the conditioning of aversions to the sight, taste, smell and thought of alcoholic beverages. In essence, the production of nausea and the vomiting of alcoholic drinks by the concurrent interaction effects of emetine and alcohol were the principal means of treatment. The authors reported that of the 4096 patients treated between 1935 and 1948 whose records were accessible, 51% had remained abstinent for the period covered by the survey.

Contrary to that impressive record, it has been suggested that familiarity with a particular flavor prior to conditioning, such as would occur with alcohol, has been found to significantly reduce the magnitude of conditioned taste aversions in rats (Domjan 1971; Elkins, 1973; Nachman, 1970; Vogel & Clody, 1972). Elkins (1973, 1974) found that as little as one day of pre-exposure to the flavor could partially disrupt the conditioning of an aversion.

Taste aversion technology has also been suggested as a means of safely and conveniently estimating the maximum dose of a therapeutic agent which can be administered without producing such side effects as malaise or nausea (Garcia et al., 1967). In a conditioning procedure that involved the pairing of a gustatory stimulus and a test drug, a test for toxicosis at varying dosages could be conducted with a very small number of subjects and with a high degree of reliability.

Conditioned taste aversion techniques have been successfully utilized in immunosuppression research. Immunological reactivity has been found to be conditionable through first-order procedures and a wide range of literature has been published during the past two decades (Ader, 1981; Ader & Cohen, 1984; Czajkowski, 1988).

The field of range sciences has been yet another source of studies involving the use of CTA technology. Such research typically involves the conditioning of aversions to nonnutritive or toxic foliage (du Toit, Provenza, & Nastis, in press; Provenza, Burritt, Clausen, Bryant, Reichardt, & Distel, in press).

Summary

The strength of learning in a classical conditioning experiment increases as the intensity of the CS and US components increases (Mackintosh, 1974).

This has also been found to be the case in conditioned taste aversion research where the production of an aversion has been demonstrated to be related to the CS-flavor novelty (Franchina et al., 1981; Vogel & Clody, 1972), salience (Kalat & Rozin, 1971), palatability (Brackbill et al., 1971; Etscorn, 1973), and intensity (Nowlis, 1974).

Parametric studies have also been conducted that examined lithium-US dosages (Nachman & Ashe, 1973) and comparisons of a variety of US-drugs (Nachman & Hartley, 1975). These studies have demonstrated that at sufficiently high dosages, most chemicals can serve as effective first-order CTA agents (Gamzu et al., 1985); injected strychnine appears to be one of the exceptions. Drugs that exhibit the capacity to serve effective functions as second-order CTA agents, however, are relatively rare and not widely reported. Strychnine is neither a good first or second-order CTA agent.

Given the previously reviewed literature, the design of the experiments in the present study endeavored to take into account and control for as many of the variables that account for the development of a conditioned taste aversion as would be practical in the available laboratory setting. This study attempted to integrate the findings from over 35 years of previous taste aversion research and 60-70 years of classical

conditioning research to test the capacity of stimulus control technology incorporated into second-order drug pairing procedures to result in conditioned taste aversions in animal subjects.

The present study also attempted to address some of the experimental issues raised in the literature with regard to second-order drug pairings such as the Avfail effect. The experimental protocol was also expected to facilitate comparisons of obtained results not only in relation to the state of locomotor excitation but also to the CS-drug type (strychnine vs. hypertonic saline).

CHAPTER III

METHOD

Purpose

The purpose of the present study was to investigate the proposition that a technique designed to promote locomotor activity in rats undergoing second-order conditioning procedures in a CTA paradigm would be effective in the development of an aversion to a distinctive flavor. Aversion failures reported with some drug pairings may have been due, at least in part, to the absence of a procedure which would overcome potential overshadowing effects encountered when using antagonistic drugs.

Overshadowing is likely to play a role in the failure to obtain aversions when using drug combinations such as strychnine and lithium chloride due to the sedative effects observed in rats given lithium injections. As noted previously, strychnine-induced seizures may be minimized at most nonlethal dosages by allowing the subject to remain motionless in a subdued environment such as a laboratory cage. The issue is further compounded by subsequent administration of lithium chloride, which by itself results in gastrointestinal distress, malaise and generally

decreased motor activity.

The first experiment was conducted to examine the effects of geotactic excitation upon the production of a second-order aversion with a strychnine CS-drug and a LiCl US-drug. No previous studies have been found in which similar stimulus enhancement procedures have been utilized in first- or second-order conditioned taste aversion preparations.

The second experiment was designed to serve as a control condition for the first experiment. In both excitation and control (non-excited) conditions hypertonic saline served as the CS-drug and LiCl, strychnine or hypertonic saline were utilized as US-drugs. Hypertonic saline as a CS-drug was tested for its capacity to serve as a CTA agent given the introduction of the independent variable (geotactic stimulation). The concentration of saline used in this study had been found to be ineffective in producing any aversions during preliminary first-order conditioning.

Subjects

Eight groups (n = 6 in each group, total = 48) of male Sprague-Dawley rats (Rattus norvegicus), approximately 100-180 days old at the beginning of the study, served as subjects. All animals were experimentally naive to conditioned taste aversion procedures. Group assignment was accomplished on a

random basis from pools of available subjects. All subjects were housed in individual laboratory cages maintained by the University Laboratory Animal Research Center (LARC) with the exception of the No Injection group, which was maintained at the Brigham Young University Psychology Department vivarium. Food was available on an ad libitum basis throughout with the exception of the immediately subsequent two-hour period following a conditioning or treatment trial. Water intake was regulated through a deprivation schedule which allowed access to drinking bottles at approximately the same time of day in the home cages for a period of 10 min daily. Animal colony rooms were monitored and regulated for stable temperature and humidity.

Adaptation to the 14-18 day baseline water deprivation schedule was monitored daily by means of pre- and post-drinking bottle weights using a Sartorius Type P-6 electronic balance with a resolution of one gram. Criteria for group baseline water intake stability consisted of: 1) absence of a new group mean high or low water intake (g); 2) no variation in group mean intake weight greater than 3 g for the immediately preceding three days; and 3) no upward or downward trend in group mean baseline water intake. Conditioning trials commenced following baseline water intake stabilization for all groups of subjects.

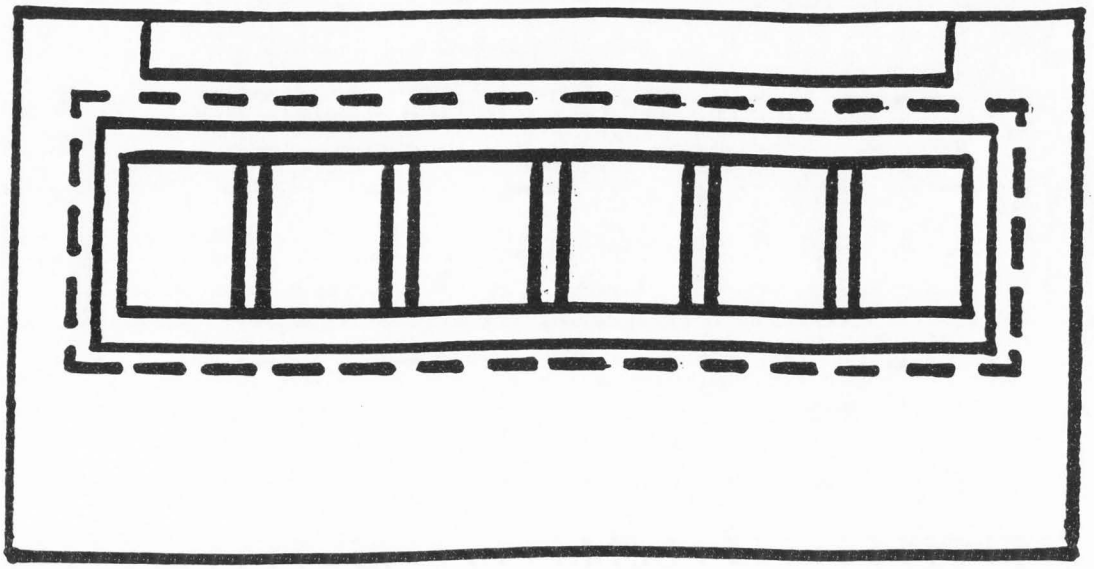
Apparatus

During interstimulus intervals (ISI's), subjects in the geotactic excitation conditions were placed into a six-compartment enclosure (see Figure 1) designed such that standard angular orientation changes, approximating forty-five degrees, could easily be made for a group of six subjects simultaneously. The experimental chambers were hinge mounted to a rectangular base measuring 42.5 cm x 61.7 cm, with each compartment having interior dimensions of approximately 7.8 cm x 15 cm x 7.8 cm. Perforated plexiglass covers were attached to the top of the compartments by velcro strips. Standard experiences for all subjects within an experimental condition were accomplished by means of this simultaneous tilting procedure.

Chemicals, Solution Concentrations and Dosages

Dosages for all injections were based upon group mean body weights taken immediately prior to injection on the first conditioning trial. As each subject's weight decreased during the experiment as a function of water deprivation and periodic (drug-induced) illness, relative equivalent dosages (mg of drug/kg of body weight) for CS-drugs and US-drugs were appropriately adjusted. However, it was not necessary to recalculate dosages from injection to injection as weight reductions

Top View:



Side View:

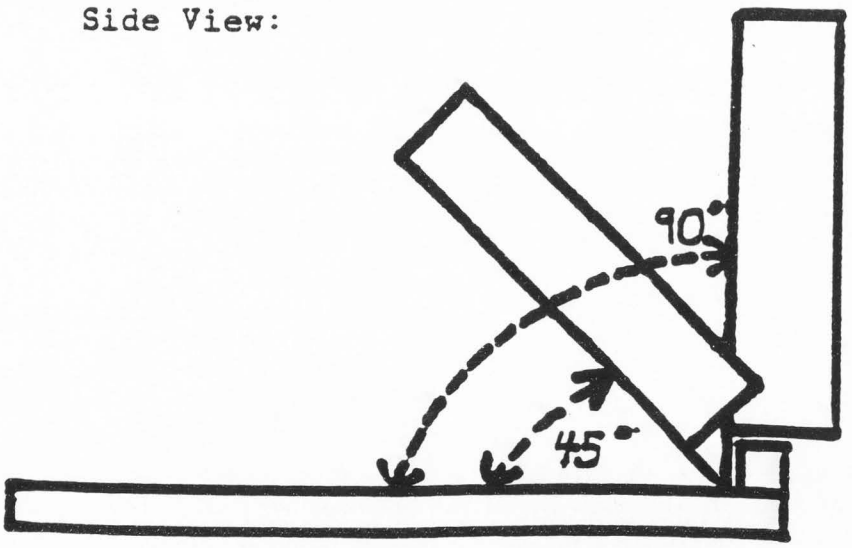


Figure 1. Apparatus designed for induction of geotactic behaviors.

were insignificant. The initial mg/kg ratios for all drugs and groups were determined to be low risk yet effective for purposes of the study. Mortality from apparent drug (strychnine) toxicity was minimal at a rate of approximately 9.5% across a total of 294 injections. All dosages used for lithium chloride have been demonstrated to be effective in parametric studies (Nachman & Ashe, 1973; Nachman & Hartley, 1975) and under personal observation in previous laboratory research. Strychnine dosages were derived from the results of previous experimental work in the experimenter's laboratory and were within the dosage ranges for this drug reported in the literature (Cheney et al., 1987). Distilled water was used as a vehicle in all cases and injections were delivered intraperitoneally via 3 cc syringes through a 25 gauge, 1/2 inch needle. Group mean body weights used for calculation of equivalent dosages are reported in Table 1 and specific dosages for each drug are listed by group in Table 2.

Strychnine. Strychnine is prepared from dried ripe seeds of Strychnos nux-vomica which contains 1.1 to 1.4 percent strychnine and about an equal amount of brucine (Gleason, Gosselin, Hodge, & Smith, 1969). It is a potent analeptic (convulsant) with no accepted therapeutic value. It has long been used as a vermicide

Table 1

Mean Body Weights by Experimental Group

	Group		Body Weight (g)
1.	Excitation Strychnine-LiCl	M	400.83
		SD	32.16
2.	Control Strychnine-LiCl	M	369.17
		SD	25.77
3.	Excitation NaCl-LiCl	M	404.17
		SD	38.78
4.	Excitation NaCl-Strychnine	M	426.67
		SD	31.88
5.	Control NaCl-LiCl	M	362.50
		SD	35.18
6.	Control NaCl-Strychnine	M	357.50
		SD	21.62
7.	Excitation NaCl-NaCl	M	271.00
		SD	11.26
8.	Excitation No Injection	M	260.00
		SD	18.17

Table 2

Mean Drug Dosages by Experimental Group

Group	Mean Equivalent Dosage[a]		
	Strychnine	LiCl	NaCl
1. Excitation Strychnine-LiCl	1.77	296.14	n.a
2. Control Strychnine-LiCl	1.92	321.54	n.a.
3. Excitation NaCl-LiCl	n.a.	293.70	404.88
4. Excitation NaCl-Strychnine	1.66	n.a.	383.53
5. Control NaCl-LiCl	n.a.	327.46	451.42
6. Control NaCl-Strychnine	1.99	n.a.	457.73
7. Excitation NaCl-NaCl	n.a.	n.a.	603.84
8. Excitation No Injection	n.a.	n.a.	n.a.

[a] mg drug/kg body weight

despite the fact that rats will typically refuse bait tainted with strychnine. The lethal dosage in man lies between 100 and 120 mg. It's actions upon the central nervous system are excitatory but not through direct synaptic excitation. Strychnine selectively blocks inhibition, consequently enhancing ongoing neuronal activity. Sensory stimuli, therefore, may produce exaggerated reflex effects. The analeptic effects following introduction of strychnine typically occur within 5 to 10 minutes and are characterized by tonic extension of the body and limbs. Tonic extension is preceded and followed during the phase of postictal depression by phasic symmetrical extensor thrusts that may be initiated by stimulation in any sensory modality. Approximately 20% of a sublethal dose escapes in the urine unchanged. Since detoxication and excretion are relatively rapid at sublethal dosages, survival rates are good and there is no significant cumulative toxicity (Goodman & Gilman, 1975).

Strychnine solutions were prepared for this study such that a 2 cc injection contained 0.71 mg of drug. Injection volumes were maintained at 2 cc to allow for delivery of a mean equivalent strychnine dose of 1.84 mg/kg.

Lithium chloride. Lithium is a monovalent cation that is the lightest of the alkali metals. It occurs in

trace amounts in the body and its salts are highly soluble in water. It was employed as a hypnotic in the 1920s, and, in 1940, with disastrous effects as a sodium substitute. It had been observed that the administration of lithium salts to experimental animals in an attempt to increase the solubility of urates resulted in the production of lethargy in guinea pigs. This led to its use in the treatment of manic human patients with encouraging results. Lithium ions are readily absorbed when given orally. Peak plasma levels are reached within one to three hours after ingestion. A steep drop in plasma level occurs for the first 5 to 6 hours, followed by a slower elimination over the next 24 hours or more. Toxic reactions may occur at plasma concentration levels of 2.0 mEq per litre while maintenance lithium levels range between 0.5 and 1.2 mEq per litre. Patients on therapeutic dosages of the carbonate form of lithium have reported fatigue, muscular weakness, slurred speech, ataxia and fine motor tremor in the hands. Nausea, vomiting, and diarrhea may also occur (Goodman & Gilman, 1975). It is this last group of side effects that has facilitated the usage of this chemical as a premier CTA agent.

LiCl solutions were prepared at a concentration of 1.4 Molar. Each 2 cc injection contained approximately 118.70 mg of Lithium Chloride. Injection volumes were

kept at a constant 2 cc as above. The mean equivalent lithium chloride dosage for all groups receiving this drug was 309.71 mg/kg. The established LD_{100} for this chemical is 800.0 mg/kg (Nachman & Hartley, 1975); thus, dosages used in this study were approximately 39% of this value.

Sodium chloride. NaCl solutions were prepared at a concentration of 1.4 Molar. Each 2 cc injection of hypertonic Saline solution contained 163.64 mg NaCl. The mean equivalent dosage for groups receiving Sodium Chloride solution injections was 460.28 mg/kg.

Test solution. Grape Juice (Welch's Grape Juice Cocktail concentrate, artificially sweetened with aspartame), was presented in approximately 200 cc volumes via 250 cc glass drinking bottles for a period of 10 min. The flavor solution was prepared such that tap water was combined with one 12 oz. can of concentrate to make one gallon of liquid.

Design and Procedure

Within each experiment, subjects were randomly assigned to drug combination and Excitation or Control conditions. Following baseline water intake stabilization, each subject was presented with the respective group experimental protocol outlined in Tables 3 and 4.

Table 3

Protocol for Experiment 1

	Treatment				
	Post Baseline Days				
Group[a]	1	8	13	18	23
1. Excitation Strychnine-LiCl	CS_1-US	CS_1-US	CS_1-US	CS_2-CS_1	Test
2. Control Strychnine-LiCl	CS_1-US	CS_1-US	CS_1-US	CS_2-CS_1	Test

Note. CS_1 = Strychnine; CS_2 = Flavored Test Solution; US = LiCl.

[a] n = 6 for each group.

Table 4

Protocol for Experiment 2

Group[a]	Treatment				
	Post Baseline Days				
	1	8	13	18	23
3. Excitation NaCl-LiCl	CS_1-US_1	CS_1-US_1	CS_1-US_1	CS_2-CS_1	Test
4. Excitation NaCl-Strychnine	CS_1-US_2	CS_1-US_2	CS_1-US_2	CS_2-CS_1	Test
5. Control NaCl-LiCl	CS_1-US_1	CS_1-US_1	CS_1-US_1	CS_2-CS_1	Test
6. Control NaCl-Strychnine	CS_1-US_2	CS_1-US_2	CS_1-US_2	CS_2-CS_1	Test
7. Excitation NaCl-NaCl	CS_1-CS_1	CS_1-CS_1	CS_1-CS_1	CS_2-CS_1	Test
8. Excitation No injection	n.a.	n.a.	n.a.	CS_2-Exc	Test

Note. CS_1 = Saline; CS_2 = Flavored Test Solution; US_1 = LiCl; US_2 = Strychnine; Exc = Excitation procedures only.

[a] $\underline{n}$ = 6 for each group.

Excitation conditions. Immediately subsequent to each injection during the conditioning trials, subjects in the Excitation conditions were placed into the compartments of the experimental apparatus head facing downward. The experimenter altered the angle of the experimental chamber by approximately 45 degrees at 30 s intervals by tilting the apparatus, thus changing the angular orientation of the animals. Angular orientation changes were repeated at the pre-determined intervals throughout each trial which included a paired injection. Approximately 15 min following a CS-drug injection, each subject received the US-drug injection and was then returned to the experimental chamber where excitation procedures were resumed. At the end of a total of 30 min from the beginning of a conditioning trial each subject was returned to his home cage to begin a four to six day water intake recovery period.

Control conditions. The same scheduling of CS and US injections was presented as in the excitation conditions with the omission of the angular orientation change procedures. During the period after each injection each subject was simply placed into the apparatus set at horizontal orientation for the same duration as in the Excitation conditions but received no other treatment.

Recovery. All conditioning and treatment sessions were separated by four to six day water intake recovery periods. Daily 10 min access to tap water resumed at the next regularly scheduled drinking time (i.e., the next day following injection). This recovery period helped to minimize toxicity and resultant mortality.

Treatment. When water intake had recovered following the third conditioning session, each subject was presented with the flavored test solution immediately followed by an injection of the CS-drug. This constituted the Treatment session for each subject.

Testing. Subjects were tested on the fifth day following the treatment session by presentation of the test solution (one bottle test procedure) in each subject's home cage for a period of 10 min.

Data Analysis

Statistical analysis of the data was conducted using a variety of tests including One-Way Analysis of Variance, Analysis of Covariance, Pearson Product Moment Correlation, the Kruskal-Wallis H-test and the Mann-Whitney U-test as appropriate. Nonparametric tests were utilized for comparisons between groups on Learned Aversion Ratios only, as the distributions obtained for all other data were consistent with the assumptions for parametric analysis. Tests for

homoscedasticity consisted of Cochran's C and Bartlett-Box F tests. If the probability exceeded $p>.01$ for either test, parametric analyses were utilized and reported. The Mann-Whitney U-tests and Kruskal-Wallis H-tests were two-tailed and in all cases alpha was set at .01. In addition, group mean data graphs were prepared, allowing visual inspection of obtained results for each phase of the experiment.

CHAPTER IV

RESULTS

All results were derived from raw data consisting of fluid intake measured in grams during daily 10 min access periods allowed each animal throughout the respective phases of the experimental protocols. In all figures the experimental group is designated by number on the abscissa and the dependent measure is indicated on the ordinate. Tables have been prepared to provide group means, standard deviations, standard errors of the mean and statistical significance matrices for parametric or nonparametric group comparisons.

Baseline Water Intake

There was considerable variation in the baseline intake across groups (see Figure 2). As enumerated in Table 5, mean intake during the five days immediately preceding the onset of the experiment for all groups ranged from a low of 9.93 g (Group 8) to a high of 16.37 g (Group 4). Analysis of variance tests indicated that significant differences existed between groups for tap water intake for the last five days of baseline, $F(7, 40) = 4.1281$, $p<.0017$.

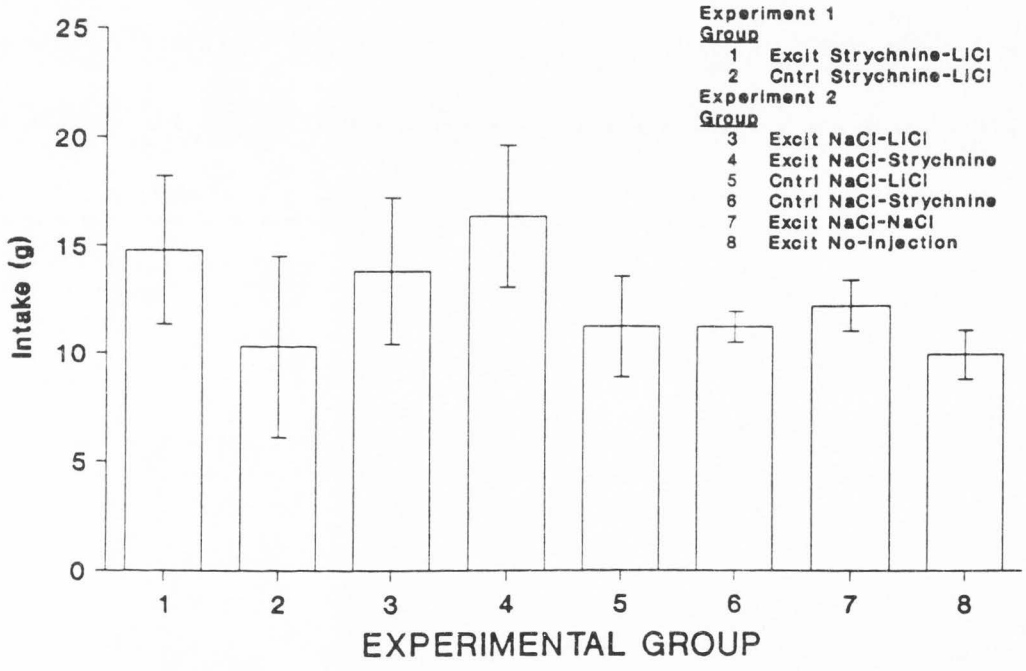


Figure 2. Mean water intake for the last five days of baseline.

Table 5

Means, Standard Deviations, and Standard Errors of the Mean for the Last Five Days of Baseline Water Intake (g)

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR
Grp 1	6	14.7667	3.4303	1.4004
Grp 2	6	10.3000	4.2100	1.7187
Grp 3	6	13.8333	3.4022	1.3889
Grp 4	6	16.3667	3.2971	1.3460
Grp 5	6	11.2333	2.3543	.9611
Grp 6	6	11.2333	.7312	.2985
Grp 7	6	12.2333	1.1961	.4883
Grp 8	6	9.9333	1.1431	.4667
TOTAL	48	12.4875	3.3364	.4816

Table 6 contains the probability matrix for all group comparisons during this phase of the experimental protocol. Statistically significant differences were found for water intake during the last 5 days of baseline in six pairs of comparisons. Variation within groups, however, was determined to be within acceptable limits for parametric assumptions about homogeneity. The results of tests for homogeneity attained nonsignificance on this variable, Cochran's C = .2917, $p<.222$.

Pretreatment Water Intake

As evidenced in Figure 3, water intake on the day immediately preceding treatment was also somewhat dissimilar despite precisely the same number of recovery days following the final conditioning trial. For groups receiving conditioning trials (all except Group 8) the mean intakes for this day ranged from a low of 13.33 g (Group 6) to a high of 17.33 g (Group 1). Table 7 details the descriptive statistics for this variable. Overall, water intake recorded on this day was equal to (Group 4) or greater than (all other Groups) their respective baseline mean intake. The mean percentages of water intake recovery relative to baseline are provided in Appendix A as Table 19.

Table 6

Statistical Significance Matrix for Water Intake (g) for the Last Five Days of Baseline

Mean	Group	Grp 8	Grp 2	Grp 5	Grp 6	Grp 7	Grp 3	Grp 1	Grp 4
9.9333	Grp 8								
10.3000	Grp 2								
11.2333	Grp 5								
11.2333	Grp 6								
12.2333	Grp 7								
13.8333	Grp 3								
14.7667	Grp 1	*	*						
16.3667	Grp 4	*	*	*	*				

Note. All significant differences presented were derived through parametric one-way analysis of variance tests.

* Denotes pairs of groups significantly different at the $p<.01$ level.

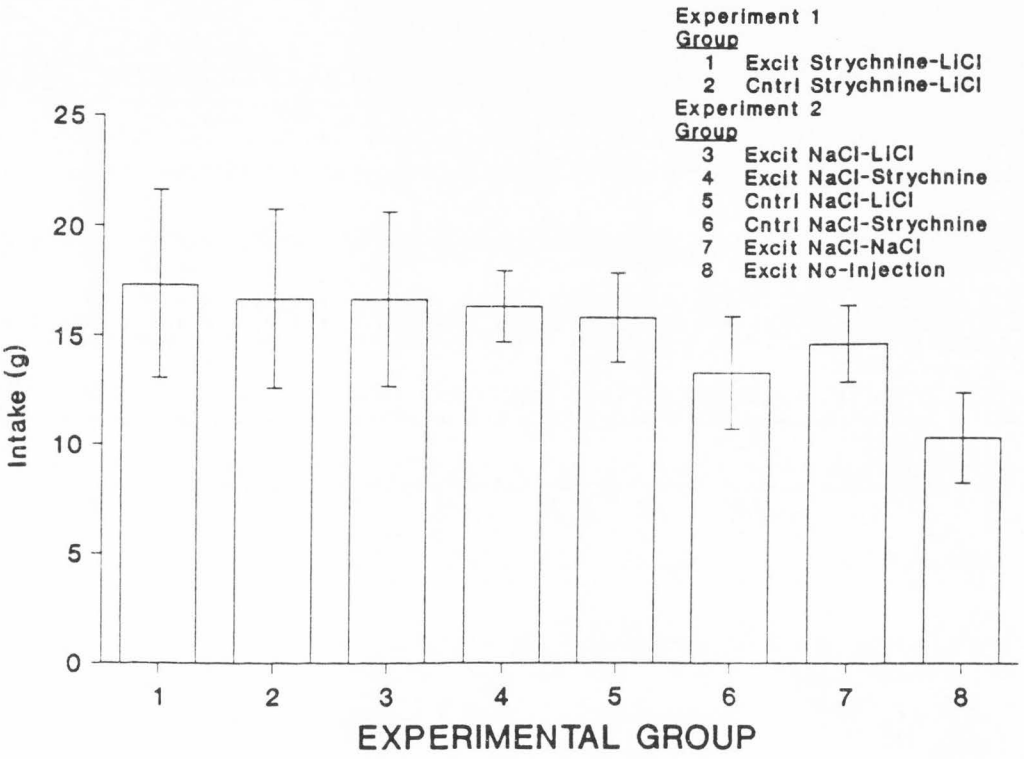


Figure 3. Mean pretreatment water intake recovery.

Table 7

Means, Standard Deviations, and Standard Errors of the Mean for Pretreatment Water Intake (g) Recovery

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR
Grp 1	6	17.3333	4.2740	1.7448
Grp 2	6	16.6667	4.0825	1.6667
Grp 3	6	16.6667	3.9833	1.6262
Grp 4	6	16.3333	1.6330	.6667
Grp 5	6	15.8333	2.0412	.8333
Grp 6	6	13.3333	2.5820	1.0541
Grp 7	6	14.6667	1.7512	.7149
Grp 8	6	10.3333	2.0656	.8433
TOTAL	48	15.1458	3.5310	.5096

Table 8 shows the pairs of groups with significant differences on this measure. Analysis of variance tests resulted in statistically significant differences across groups receiving conditioning trial injections, $F(7, 40) = 3.6346$, $p<.0040$. The only comparison pairs determined to be significantly different were between Groups 1-5 and Group 8. Again, within groups variation did not result in a violation of homogeneity, Cochran's C = .2550, $p<.457$.

Flavor Intake on Treatment Day

As shown in Figure 4, neophobic flavor intake on treatment day was dissimilar as well. Flavor intakes on this first exposure to the grape juice solution ranged from 5.17 g (Group 4) to 12.33 g (Group 3). Table 9 contains summarized descriptive data. As shown in Table 10, statistically significant differences were attained for One-Way ANOVA tests across groups on this variable for eight pairs of comparisons, $F(7, 40) = 6.2340$, $p<.0001$. Mean group flavor intake was found to be significantly different for Group 4 (Excitation Na-Strychnine) versus all other groups receiving conditioning trial injections. Groups 8 and 2 were also found to be significantly different from Group 3 (Excitation Na-LiCl). Homogeneity was not violated on this variable either, Cochran's C = .2600, $p<.416$.

Table 8

Statistical Significance Matrix for Pretreatment Water Intake (g) Recovery

Mean	Group	Grp 8	Grp 6	Grp 7	Grp 5	Grp 4	Grp 2	Grp 3	Grp 1
10.3333	Grp 8								
13.3333	Grp 6								
14.6667	Grp 7								
15.8333	Grp 5	*							
16.3333	Grp 4	*							
16.6667	Grp 2	*							
16.6667	Grp 3	*							
17.3333	Grp 1	*							

Note. All significant differences presented were derived through parametric one-way analysis of variance tests.

* Denotes pairs of groups significantly different at the $p<.01$ level.

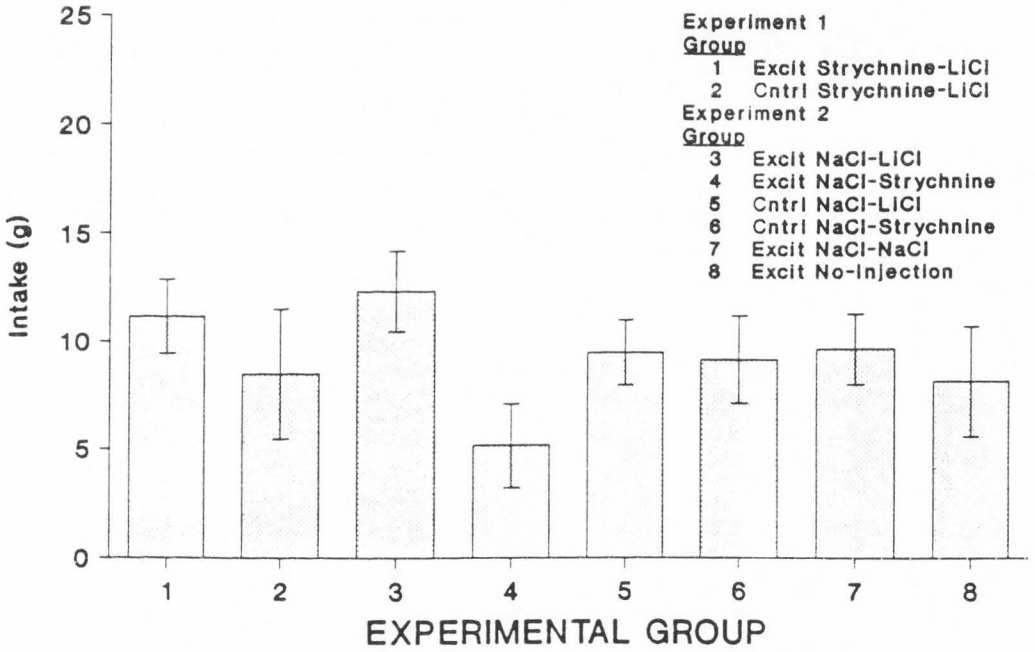


Figure 4. Mean neophobic flavor intake on treatment day.

Table 9

Means, Standard Deviations, and Standard Errors of the Mean for Flavor Intake (g) on Treatment Day

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR
Grp 1	6	11.1667	1.7224	.7032
Grp 2	6	8.5000	3.0166	1.2315
Grp 3	6	12.3333	1.8619	.7601
Grp 4	6	5.1667	1.9408	.7923
Grp 5	6	9.5000	1.5166	.6191
Grp 6	6	9.1667	2.0412	.8333
Grp 7	6	9.6667	1.6330	.6667
Grp 8	6	8.1667	2.5626	1.0462
TOTAL	48	9.2083	2.7902	.4027

Table 10

Statistical Significance Matrix for Flavor Intake (g) on Treatment Day

		Grp 4	Grp 8	Grp 2	Grp 6	Grp 5	Grp 7	Grp 1	Grp 3
Mean	Group								
5.1667	Grp 4								
8.1667	Grp 8								
8.5000	Grp 2	*							
9.1667	Grp 6	*							
9.5000	Grp 5	*							
9.6667	Grp 7	*							
11.1667	Grp 1	*							
12.3333	Grp 3	*	*	*					

Note. All significant differences presented were derived through parametric one-way analysis of variance tests.

* Denotes pairs of groups significantly different at the $p<.01$ level.

The mean percentages of flavor intake on treatment day compared to baseline water intake are provided in Appendix A as Table 20.

Pretest Water Intake

Figure 5 shows that tap water intakes on the day before aversion testing ranged from 12.67 g (Group 8) to 17.17 g (Group 4). Differences observed on this variable were not statistically significant with the alpha level chosen for these analyses, $F(7, 40) = 2.7481$, $p<.0199$. Table 11 shows means and standard deviations derived through analysis of these data. Table 12 indicates that by the end of all conditioning and treatment trial injections, the only significant differences in tap water intake were found to be between Group 8 and Groups 1 and 4. All other groups were determined to be not different from one another at this point. Again, as in the case of the pretreatment water intake recovery, all intakes recorded for this day were well over 100 percent relative to their respective baseline means (see Appendix A, Table 21). Violations of homogeneity assumptions did not occur, Cochran's $C = .3265$, $p<.106$.

Flavor Intake on Test Day

Test day flavor intakes were clearly different for Excitation Groups 1, 3, and 4 compared to all other

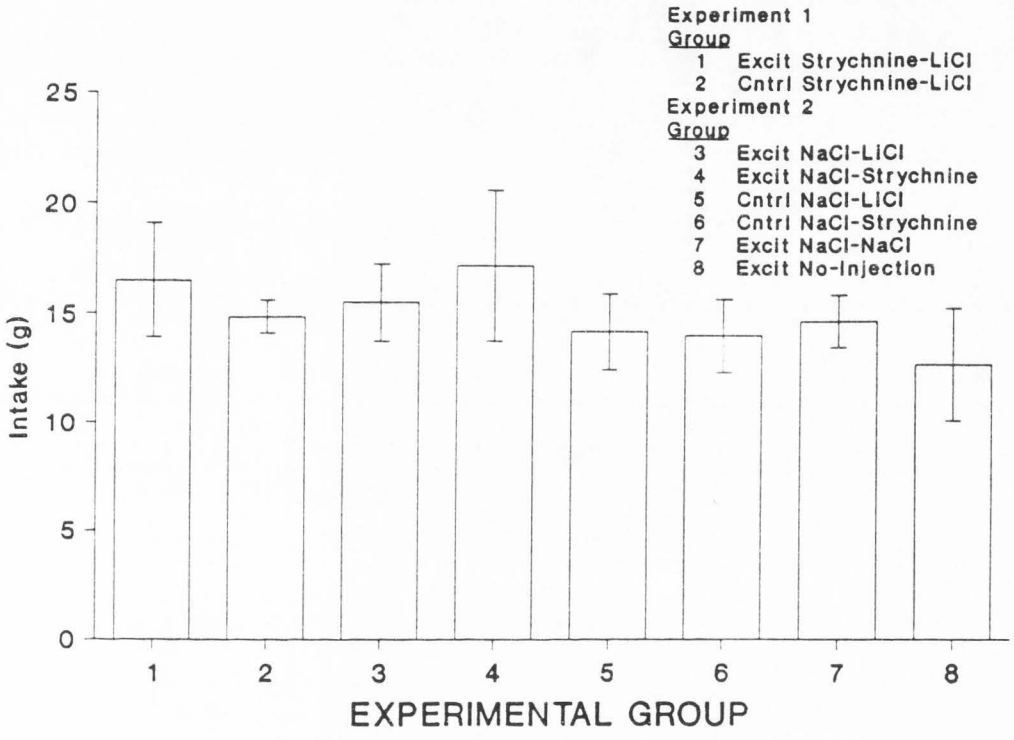


Figure 5. Mean pretest water intake recovery.

Table 11

Means, Standard Deviations, and Standard Errors of the Mean for Pretest Water Intake (g) Recovery

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR
Grp 1	6	16.5000	2.5884	1.0567
Grp 2	6	14.8333	.7528	.3073
Grp 3	6	15.5000	1.7607	.7188
Grp 4	6	17.1667	3.4303	1.4004
Grp 5	6	14.1667	1.7224	.7032
Grp 6	6	14.0000	1.6733	.6831
Grp 7	6	14.6667	1.2111	.4944
Grp 8	6	12.6667	2.5820	1.0541
TOTAL	48	14.9375	2.3826	.3439

Table 12

Statistical Significance Matrix for Pretest Water Intake (g) Recovery

Mean	Group	Grp 8	Grp 6	Grp 5	Grp 7	Grp 2	Grp 3	Grp 1	Grp 4
12.6667	Grp 8								
14.0000	Grp 6								
14.1667	Grp 5								
14.6667	Grp 7								
14.8333	Grp 2								
15.5000	Grp 3								
16.5000	Grp 1	*							
17.1667	Grp 4	*							

Note. All significant differences presented were derived through parametric one-way analysis of variance tests.

* Denotes pairs of groups significantly different at the $p<.01$ level.

groups (see Figure 6). Mean flavor intakes ranged from 4.5 g (Group 4) to 15.67 g (Group 2). Table 13 provides means and standard deviations for all groups. Statistical significance comparing intakes across groups was attained through an analysis of variance, $F(7, 40) = 28.5932$, $p<.00005$ (see Table 14). Significant differences in flavor intake were found between 16 pairs of comparisons. In each case the principal treatment groups (1, 3, and 4) were demonstrated to drink significantly less upon testing than their respective controls and other comparison groups. Homogeneity was not violated on this variable either, Cochran's $C = .2172$, $p<.897$. Mean percentages for flavor intake on test relative to baseline water intake and flavor intake on treatment day are provided in Appendix A, Table 22.

CTA Suppression Ratio

The first transformation of the raw intake data was the calculation of a suppression ratio. This ratio is not only common in the conditioned taste aversion literature but in classical conditioning in general (Rescorla, 1980). The result of dividing the test day flavor intake (g) by the sum of this flavor intake plus the tap water intake (g) from the immediately preceding day is a proportion in which higher degrees of relative aversion are indicated by lower values. These values

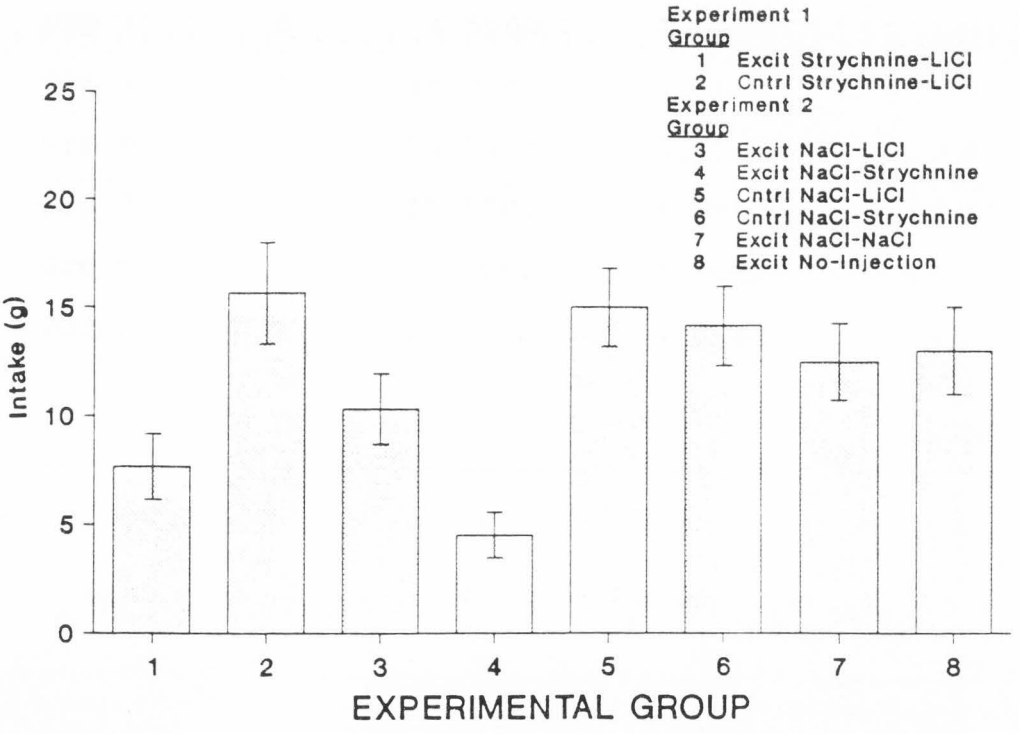


Figure 6. Mean flavor intake on test day.

Table 13

Means, Standard Deviations, and Standard Errors of the Mean for Flavor Intake (g) on Test Day

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR
Grp 1	6	7.6667	1.5055	.6146
Grp 2	6	15.6667	2.3381	.9545
Grp 3	6	10.3333	1.6330	.6667
Grp 4	6	4.5000	1.0488	.4282
Grp 5	6	15.0000	1.7889	.7303
Grp 6	6	14.1667	1.8348	.7491
Grp 7	6	12.5000	1.7607	.7188
Grp 8	6	13.0000	2.0000	.8165
TOTAL	48	11.6042	4.0092	.5787

Table 14

Statistical Significance Matrix for Flavor Intake (g) on Test Day

Mean	Group	Grp 4	Grp 1	Grp 3	Grp 7	Grp 8	Grp 6	Grp 5	Grp 2
4.5000	Grp 4								
7.6667	Grp 1	*							
10.3333	Grp 3	*							
12.5000	Grp 7	*	*						
13.0000	Grp 8	*	*						
14.1667	Grp 6	*	*	*					
15.0000	Grp 5	*	*	*					
15.6667	Grp 2	*	*	*	*				

Note. All significant differences presented were derived through parametric one-way analysis of variance tests.

* Denotes pairs of groups significantly different at the $p<.01$ level.

can theoretically range from 0 (complete aversion to the test solution) to 1.0 (exclusive preference for the test solution). Typically, ratios above .4 or .5 are considered nonsignificant by most researchers. Exclusive preference is probably not possible in actuality.

As can be seen in Figure 7, ratios ranging from .2112 (Group 4) to .5142 (Group 5) were obtained (see Table 15). Highly significant differences between groups were attained by means of One-Way ANOVA tests, $F(7, 40) = 49.3304$, $p<.00005$. All statistically significant differences were found between Excitation Groups 1, 3 and 4 in comparison to other groups (see Table 16). CTA suppression ratios for these groups were significantly lower than their respective controls and other comparison groups. Again, homogeneity was not violated, Cochran's $C = .2321$, $p<.693$.

Learned Aversion Ratio

The second ratio comparison of raw intake data to be analyzed and presented is what Nachman and Hartley (1975) referred to as a "Learned Aversion Ratio." This is calculated by dividing the test day flavor intake (g) by the treatment day flavor intake (g). The resulting ratio expresses a proportion of flavor ingested after presentation of CS_2 to that ingested on a different day prior to training. Such a ratio by itself expresses a

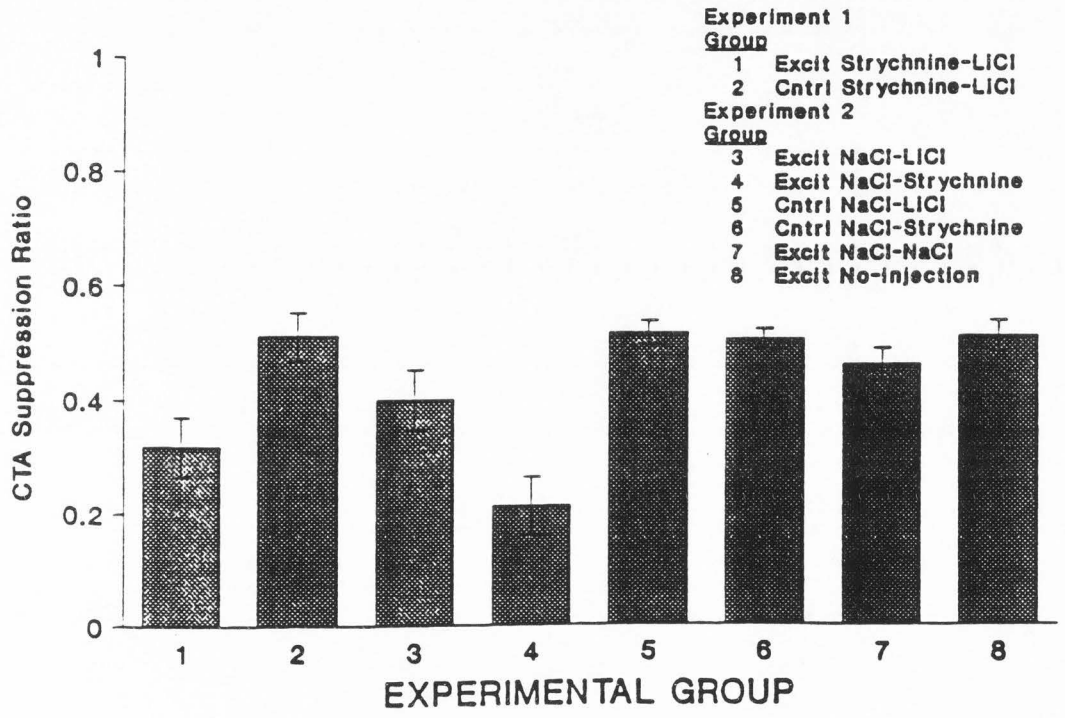


Figure 7. Mean CTA suppression ratios.

Table 15

Means, Standard Deviations, and Standard Errors of the Mean for CTA Suppression Ratios

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR
Grp 1	6	.3180	.0531	.0217
Grp 2	6	.5115	.0413	.0169
Grp 3	6	.3995	.0524	.0214
Grp 4	6	.2112	.0515	.0210
Grp 5	6	.5142	.0205	.0084
Grp 6	6	.5030	.0178	.0073
Grp 7	6	.4590	.0283	.0116
Grp 8	6	.5087	.0263	.0107
TOTAL	48	.4281	.1116	.0161

Table 16

Statistical Significance Matrix for CTA Suppression Ratios

Mean	Group	Grp 4	Grp 1	Grp 3	Grp 7	Grp 6	Grp 8	Grp 2	Grp 5
.2112	Grp 4								
.3180	Grp 1	*							
.3995	Grp 3	*	*						
.4590	Grp 7	*	*						
.5030	Grp 6	*	*	*					
.5087	Grp 8	*	*	*					
.5115	Grp 2	*	*	*					
.5142	Grp 5	*	*	*					

Note. All significant differences presented were derived through parametric one-way analysis of variance tests.

* Denotes pairs of groups significantly different at the $p<.01$ level.

meaningful relationship between two common intake measures (i.e., a ratio of 1.50 means that the subject consumed 150% of the amount of flavor solution on test compared to its neophobic intake of this same substance prior to exposure to the second-order contingencies). Another advantage is that the range of the ratio is not constrained.

Figure 8 clearly shows that in all cases excitation groups (the principal treatment groups) were superior to controls in terms of the relative aversions displayed to the flavor solution upon testing. Table 17 shows specific group descriptive statistics and further confirms that the introduction of the geotactic excitation procedure in pairing the drugs strychnine and lithium chloride resulted in an apparently strong second order conditioned taste aversion. While analysis of variance tests initially revealed statistically significant differences between means, a nonparametric alternative was deemed necessary due to a statistically significant violation of homogeneity; Cochran's C = 4824, $p<.002$.

The Kruskal-Wallis H-test has been referred to as an excellent nonparametric alternative to the standard One-Way ANOVA test (Hays, 1973) and was employed as such an alternative. The results of these tests were highly statistically significant, H = 36.2846;

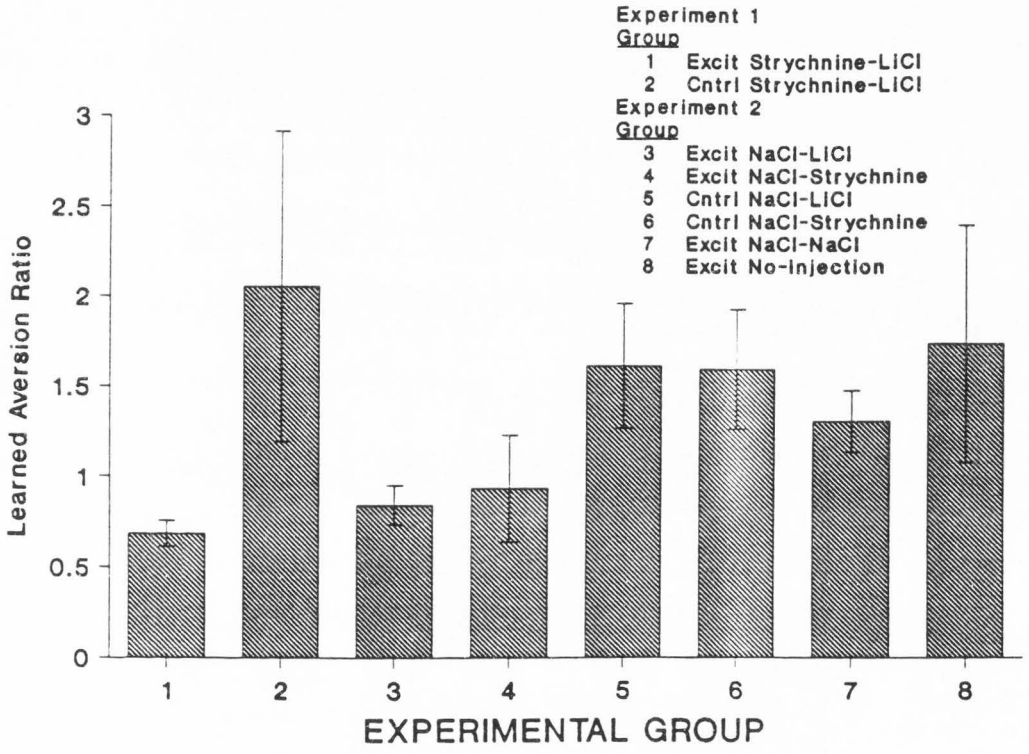


Figure 8. Mean learned aversion ratios.

Table 17

Means, Standard Deviations, and Standard Errors of the Mean for Learned Aversion Ratios

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR
Grp 1	6	.6857	.0717	.0293
Grp 2	6	2.0533	.8591	.3507
Grp 3	6	.8430	.1088	.0444
Grp 4	6	.9343	.2945	.1202
Grp 5	6	1.6117	.3443	.1406
Grp 6	6	1.5950	.3288	.1342
Grp 7	6	1.3067	.1711	.0698
Grp 8	6	1.7383	.6574	.2684
TOTAL	48	1.3460	.6107	.0882

df = 7; $p<.00005$. Table 18 provides the probability matrix for this variable.

Mann-Whitney comparisons on a group by group basis revealed statistically significant differences between Groups 1 and 3 and Groups 2, and 5 through 7. Group 4 was also found to be superior in aversion compared to Groups 2, 5, 6, and 8.

Summary

Groups receiving excitation showed greater relative aversion following second-order conditioning procedures than groups not treated. Specifically, Excitation Groups 1 (Strychnine-LiCl), 3 (Na-LiCl) and 4 (Na-Strychnine) were found to be significantly different compared to other groups on the amount of flavor consumed upon testing, CTA suppression ratios, taking into account the previous day's water intake and in terms of a learned aversion ratio, which was free of absolute water intake bias.

Additional statistical analyses for all groups were conducted to determine whether there were systematic relationships between baseline water intake and subsequent water and flavor intake data. Pearson product-moment correlation analysis revealed nonsignificant correlations between baseline water intake and treatment (neophobic) flavor intake,

Table 18

Probability Matrix for Learned Aversion Ratios

Mean	Group	Grp 1	Grp 3	Grp 4	Grp 7	Grp 6	Grp 5	Grp 8	Grp 2
.6857	Grp 1								
.8430	Grp 3								
.9343	Grp 4								
1.3067	Grp 7	*	*						
1.5950	Grp 6	*	*	*					
1.6117	Grp 5	*	*	*					
1.7383	Grp 8	*	*	*					
2.0533	Grp 2	*	*	*	*				

Note. All probabilities presented were derived from nonparametric two-tailed corrected Mann-Whitney U-tests. * Denotes pairs of groups significantly different at the $p<.01$ level.

r =0.355, p>.01, as well as between pretest water intake and test flavor intake, r = -.3212, p>.01 (see Appendix Table 23 for correlation matrix). In spite of the lack of statistically significant correlations found, Analysis of Covariance was conducted with a finding of nonsignificance.

CHAPTER V

DISCUSSION

The purpose of the study was to test the premise that locomotor activity induced through angular orientation changes of the experimental apparatus would result in enhancing the discriminable properties of a CS-drug. In that respect this study provided data upon which to base subsequent research. This study was not intended as a parametric analysis of the use of geotactic excitation in the production of conditioned taste aversion, as this effect by itself had not been previously reported. With the substantial body of literature on the Avfail Effect, it is anticipated that the results of this research may lead to future trials in which similarly antagonistic drug pairing combinations may be attempted in the context of stimulation that delimits overshadowing.

The particular CS-drug used in this study, strychnine, can only have a discernible effect upon an organism if that organism is maintained in an environment in which external stimulation is present. External stimulation of the organism is necessary in order to produce tremors or major convulsant activity in a subject receiving strychnine. Any drug which has no

discernible effect probably cannot become a CS in much the same way that any other stimulus used in behavioral research (operant or respondent) probably can't serve a stimulus control function unless it is perceptible.

The test results and observations by the experimenter confirmed that indeed locomotor activity did occur as a result of the introduction of the independent variable. In addition, aversions were selectively produced for those groups receiving exposure to the procedure. It can be speculated that the salience of the drug was increased as a result of the excitation of locomotor behaviors. That is not to say that strychnine injections cause completely undetectable effects upon an organism. Rather, these effects are diminished with low drug doses without environmental stimulation such as that produced in this study and are of insufficient intensity to facilitate second-order aversions.

Some of the problems associated with conducting research in this area involve the specificity of the results, the methodology used and the selection of a seemingly appropriate dependent measure. An attempt to address these issues is made in this section.

Compared to baseline, data for the pretest tap water recovery day for all groups indicated that intake recovery had occurred and ranged from 105% to 144% of

baseline (see Appendix Table 21). These data demonstrate that after three conditioning trials (drug-drug pairings) and the introduction of second-order pairing procedures, fluid intake had nonetheless sufficiently recovered to allow for comparisons of test flavor to tap water intake used in the calculation of CTA suppression ratios. Despite apparently sufficient recovery to make this comparison, however, the problem of differential intake of tap water and CS flavor upon initial presentation (treatment) is still present. Treatment day flavor intakes (Table 9) were substantially lower than tap water intakes recorded on the day immediately preceding treatment (Table 7) and the day immediately preceding testing (Table 11). It was shown through statistical analysis, however, that the relationship between prior water intake and subsequent flavor intake was nonsignificant.

Initial intake depression is characteristic of the neophobic feeding behavior of rats in general (Archer, 1989; Garcia et al., 1974) and is heightened if the animal experiences illness, even if the illness is not contingent upon ingestion of a food or liquid. In fact, literature does exist which supports the speculation that neophobic behavior is accentuated following toxin administration (du Toit et al., in press).

Test flavor intake as both a percentage of baseline

tap water intake and as a percentage of the respective treatment flavor intake for the three main treatment groups was well below percentages calculated for other groups (see Appendix Table 22). Upon initial presentation, water deprived rats will characteristically consume a certain amount of a novel substance at a lower rate than upon subsequent exposures. In later exposures to the same substance, intake is likely to either increase, approaching the intake level for more familiar substances or decrease as a function of prior illness experience (Garcia et al., 1974). A comparison of test intake to treatment intake of the CS flavor stimulus is not confounded by this differential fluid intake for tap water versus flavor and may therefore constitute a more valid index of the extent of conditioning obtained. The calculation of a learned aversion ratio in a single bottle test is an indicator of the extent of relative aversion or acceptance of the substance upon subsequent exposure (Nachman & Hartley, 1975).

Geotactic Excitation as an Independent Variable

The introduction of procedures to elicit behavioral excitation was successful in facilitating the differential conditioning of aversions for all treatment groups with the exception of the saline-saline group.

On the basis of a substantial review of the literature, it was discovered that geotactic excitation procedures have not been utilized either in first or second-order conditioned taste aversion preparations. The relative simplicity of the procedures and apparatus devised for this study and their novelty might lead to further testing of second order drug pairings involving chemicals previously shown to result in aversion failure (Revusky et al., 1982).

First-order studies utilizing rotation as a US have been demonstrated to be effective as a means of conditioning aversions to flavor stimuli but have little relationship to procedures or the rationale employed in the current study. It has also been demonstrated that external stimulation does not affect the production of conditioned taste aversions (Holder et al., 1989). In fact, it was found that the administration of hypertonic saline intraperitoneally, inducing peripheral pain, slightly increased the strength of LiCl induced aversions (Holder et al., 1989).

Altering the angular orientation of an experimental chamber by 45 degrees at thirty second intervals and thereby inducing struggling and righting behaviors is a quite different stimulus compared to the rotational stimulation used in the motion sickness studies. In addition, none of the rotational studies utilized any injections. Furthermore, the excitation procedure by

itself was shown to be ineffective as a US in this study as evidenced by the failure to avert for the Excitation No Injection and Excitation Saline-Saline groups. These groups showed no evidence of aversion on either ratio or gram intake measures. The point is, that excitation did not serve as a US in this study but rather as an independent variable whose introduction facilitated the development of second-order aversions and whose absence was demonstrated to be associated with the failure to produce aversions.

The Dependent Variable in Conditioned Taste Aversion

The relevant dependent variable for the conditioned taste aversion research involved in this study, as in other CTA studies, is fluid intake. Water intake during baseline conditions may vary within and across groups by virtue of a myriad of variables including body weights, ages, temperature and humidity changes within the laboratory environment, individual subject activity levels, food intake or individual differences in adaptations to the deprivation schedule. While water intake is an important factor in research in this area, it is in and of itself not the principal dependent variable. Although it is correlated to some extent with subsequent intakes of the flavor stimulus, at least in terms of a certain intake range, it has been shown to

differ across groups to an extent that renders it less useful in determining relative preference or aversion when used in a ratio calculation such as that commonly reported in the literature (for example, Nachman & Hartley, 1975; Shumake et al., 1982). A comparison of a subject's intake upon testing (the second presentation of the flavor stimulus) to its water intake the day immediately preceding testing may well not be an optimal means of gauging the extent of conditioning which has taken place with the animal. Such a ratio is overly dependent upon the stability of water intake in general and to an intake value for the immediately preceding day in particular. As demonstrated in this study, water intake is highly variable and cannot be fully controlled through deprivation procedures which allow for limited free ingestion of fluid.

A comparison between flavor intake measured either by mass (g) or volume (ml) across groups is subject to the same criticisms as the transformed suppression ratio previously mentioned. Just as differences between groups on water intake were observed before, during, and after conditioning, differences were observed between groups upon presentation of the flavor on treatment and test days. Some animals ingested amounts of grape juice upon initial presentation approximating their mean daily water intake while others drank more or less. The same

can be said for intake of the flavor stimulus upon testing; it may not necessarily be related to the animal's normal daily intake of tap water due to the presence or absence of neophobia or aversion. Subjects who averted to the flavor drank less, those who failed to avert drank nearly as much or more upon testing.

A more appropriate and relevant measure of aversion may be the relative amount of an initially novel flavor stimulus ingested upon presentation on the treatment day, and later upon testing. A comparison between intakes on these separate occasions is mostly independent of water intake on any given day. The data obtained in terms of aversion ratio were found to be consistent with the expected results. The introduction of excitation with lithium chloride US groups resulted in statistically significant aversions compared to their respective control groups, and compared to the Excitation Saline-Saline and No Injection groups (see Table 18).

Alternatives to single-bottle testing are reported in the literature. The use of two-bottle preference testing (Shumake et al., 1982), in which simultaneous presentation of tap water and a flavor stimulus, is one such alternative. The determination of conditioning is made on the basis of rejection of the flavor in favor of tap water. A criticism of this procedure includes the

possible problems involved in insuring exposure to the flavor during the test. It would seem necessary to have observed that rejection of the flavor occurred on the basis of contact with the flavor and not merely to have been related to some other factor such as lateral preference by the animal. In the present study, a 1-bottle test was conducted to avoid methodological problems associated with insuring that equal exposures to water and flavor occurred.

The Taste Reactivity Test (Grill & Norgren, 1978a, 1978b) is another alternative to single bottle testing. In this procedure, a taste stimulus is injected into the oral cavity of an animal and the immediate behavioral response is videotaped for later frame by frame analysis of lingual, facial and masticatory muscle movements. This procedure was primarily designed to be used with neurologically impaired animals (i.e., those unable to maintain normal drinking behaviors) and requires fairly sophisticated videotaping equipment and rater training. This procedure has some merit in that uniform exposure to the CS occurs not only during conditioning trials, but also on test days. This uniformity of stimulus presentation allows for excellent control of individual drinking differences between subjects.

Overall, the primary methodology used to assess acceptance or rejection of flavors in animal subjects

has been the use of one- or two-bottle preference tests (Grill & Norgren, 1978a). The most frequently encountered means of assessing conditioned taste aversion has been the single-bottle procedure employed in this study.

Limitations of the Current Study

Conditioned taste aversion research designs do not closely resemble any other experimental designs. The measurement that takes place occurs following the implementation of the conditioning procedures and a rather long delay interval between treatment and testing. As such, the analysis of resultant data is restricted to two or three key data points upon which conclusions must be drawn. Any number of intervening stimulus events, which cannot easily be controlled, can impinge upon the subjects after conditioning procedures have been implemented. Variations in laboratory environment such as the introduction of new animals to the colony room, changes in temperature and humidity, increased or decreased traffic in the lab or electrical failures resulting in alteration of the light-dark cycle, etc. are, for the most part, uncontrollable but must be at least minimized. One means of controlling for differential water intake would be to match subjects across groups on baseline intake levels. The concern

with such a solution would be the necessity for pseudorandom assignment of subjects to groups after baseline measures have been taken. Another potential means of minimizing baseline variability, though less precise than matching subjects, would be to utilize subjects within a tighter weight and age range, thus indirectly controlling for expected intake differences. Regardless of the experimental control decisions made, there are trade-offs which must be taken into consideration.

It is expected that the results presented in this study will lead to further testing of the pairing of pharmacological agents in the production of second order conditioned taste aversions. The results also lend suggestion to a number of other studies that could be performed to examine the effects of similar geotactic excitation procedures on the facilitation of strychnine and other drugs as effective USs.

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APPENDICES

Appendix A

Table 19

Mean Percentage Water Intake (g) Recovery for Pretreatment Day Relative to Baseline

GROUP	COUNT	BASELINE WATER	PRETREATMENT WATER	PERCENT OF BASELINE
Grp 1	6	14.7667	17.3333	117.38
Grp 2	6	10.3000	16.6667	161.81
Grp 3	6	13.8333	16.6667	120.48
Grp 4	6	16.3667	16.3333	99.80
Grp 5	6	11.2333	15.8333	140.95
Grp 6	6	11.2333	13.3333	118.69
Grp 7	6	12.2333	14.6667	119.89
Grp 8	6	9.9333	10.3333	104.03
TOTAL	48	12.4875	15.1458	121.29

Table 20

Mean Percentage Flavor Intake (g) on Treatment Day Relative to Baseline Water Intake

GROUP	COUNT	BASELINE WATER	TREATMENT FLAVOR	PERCENT OF BASELINE
Grp 1	6	14.7667	11.1667	75.62
Grp 2	6	10.3000	8.5000	82.52
Grp 3	6	13.8333	12.3333	89.16
Grp 4	6	16.3667	5.1667	31.57
Grp 5	6	11.2333	9.5000	84.57
Grp 6	6	11.2333	9.1667	81.60
Grp 7	6	12.2333	9.6667	79.02
Grp 8	6	9.9333	8.1667	82.22
TOTAL	48	12.4875	9.2083	73.74

Table 21

Mean Percentage Pretest Water Intake (g) Recovery Relative to Baseline Water Intake

GROUP	COUNT	BASELINE WATER	PRETEST WATER	PERCENT OF BASELINE
Grp 1	6	14.7667	16.5000	111.74
Grp 2	6	10.3000	14.8333	144.01
Grp 3	6	13.8333	15.5000	112.05
Grp 4	6	16.3667	17.1667	104.89
Grp 5	6	11.2333	14.1667	126.11
Grp 6	6	11.2333	14.0000	124.63
Grp 7	6	12.2333	14.6667	119.89
Grp 8	6	9.9333	12.6667	127.52
TOTAL	48	12.4875	14.9375	119.62

Table 22

Mean Percentage Test Flavor Intake (g) Relative to Baseline Water Intake and Treatment Flavor Intake

GROUP	n	BASELINE WATER	TREATMENT FLAVOR	TEST FLAVOR	%BASE LINE	%TREAT MENT
Grp 1	6	14.7667	11.1667	7.6667	51.92	68.66
Grp 2	6	10.3000	8.5000	15.6667	152.10	184.31
Grp 3	6	13.8333	12.3333	10.3333	74.70	83.78
Grp 4	6	16.3667	5.1667	4.5000	27.50	87.10
Grp 5	6	11.2333	9.5000	15.0000	133.53	157.90
Grp 6	6	11.2333	9.1667	14.1667	126.11	154.54
Grp 7	6	12.2333	9.6667	12.5000	102.18	129.31
Grp 8	6	9.9333	8.1667	13.0000	130.87	159.18
TOTAL	48	12.4875	9.2083	11.6042	92.93	126.02

Appendix B

Table 23

Pearson Product Moment Correlation Matrix for Significant Phases of the Experiments

	BL	PRETX	TX	PRETST	TST	CTA
BL	1.0000	.5324**	.0355	.6602**	-.5121**	-.6527**
PRETX	.5324**	1.0000	.3078	.5019**	-.0575	-.2590
TX	.0355	.3078	1.0000	-.0140	.3194	.2922
PRETST	.6602**	.5019**	-.0140	1.0000	-.3212	-.6318**
TST	-.5121**	-.0575	.3194	-.3212	1.0000	.9230**
CTA	-.6527**	-.2590	.2922	-.6318**	.9230**	1.0000
LAR	-.5672**	-.2401	-.4758**	-.2942	.5848**	.5729**

N of cases: 48 2-tailed Signif: * .01 ** .001

VITA

John H. Gatling

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Birth date: September 14, 1956
Birth place: Hackensack, New Jersey

PROFESSIONAL AFFILIATIONS

American Psychological Association (student affiliate)
Association for Behavior Analysis
International Association for the Right to Effective Treatment
International Society for Human Ethology
Rocky Mountain Psychological Association (student affiliate)
Society for the Advancement of Behavior Analysis

EDUCATION

Ph.D. 1990
Major: Psychology, Analysis of Behavior Specialty
Utah State University
Logan, Utah 84322-2810

M.S. 1982
Major: Psychology
New Mexico Highlands University
Las Vegas, New Mexico 87701

B.S. 1979
Major: Psychology
Arizona State University
Tempe, Arizona 85281

CLINICAL EXPERIENCE

Psychologist, Forensic Treatment Unit, Las Vegas Medical Center, Las Vegas, NM (1989-present)

* Serve as Program Director and Chief of Psychology for the treatment unit of the Hospital's Forensic Division

* Develop and supervise the implementation of behavioral treatment programs within the Forensic Division

* Provide clinical psychology services to residents of Forensic "D" Wing in compliance with their court commitments for treatment until competent to stand trial

* Prepare treatment plans for all patients on caseload

* Serve as the treatment coordinator for all patients on caseload

* Consult with psychiatry to determine the appropriate psychopharmacological treatment regimen, and monitor progress of patients

* Perform psychological, neuropsychological, adaptive behavior, and intelligence assessments of all patients as deemed appropriate, with resultant DSM-III R diagnosis

* Serve as an expert behavioral consultant within the hospital

* Provide expert witness court testimony regarding patients' competency to stand trial in all of the judicial districts within the state of New Mexico

* Serve as a member of the institution's Medical Staff

* Serve as a member of the institution's Pharmacy and Therapeutics Committee, Continuing Medical Education Committee, as well as other committee duties periodically assigned

* Develop behavioral programs for the maximum security emergency seclusion unit

* Supervise the provision of services by the treatment team staff including psychology, social work, nursing and psych tech staff assigned to the unit

Staff Psychologist, San Miguel/Mora County Mental Health Services, Las Vegas, NM (1989-present)

* Provide psychological services to individuals in an outpatient setting

* Perform psychological, and neuropsychological evaluations of patients from the community for the purpose of diagnosis and formulation of appropriate treatment

* Supervise the development of treatment plans for all patients assigned to my treatment team

* Assist staff in the organization of day treatment program

Associate Psychologist, Utah State Training School, American Fork, UT (1987-1989)

* Responsible for the psychological services being provided to mentally retarded clients residing in an institutional environment; this includes the research and development of individual behavioral interventions, and annual psychological evaluations. [all activities were conducted under the supervision of a Psychologist licensed in the State of Utah]

* Provided in-service training to a varied staff ranging from aid-level to professionals on topics relating to the application of behavioral technology

* Responsible for the development of a training program for staff members which includes the use of nonhuman subjects, lecture/film presentations, and role play interactions at a competency based level

* Supervised the ongoing data collection and monthly behavioral data analysis

* Supervised the paraprofessional staff members assigned to the building

* Served as a member of the institution's research committee

* Performed on-call duties as scheduled

* Evaluation and authorization of emergency restraint procedures requested by line staff for control of the aggressive and self-injurious behaviors exhibited by clients

* Responsible for compliance with human rights committee and institutional policies pertaining to the application of behavioral treatments, and the overall provision of psychological services in a manner which satisfied state and federal surveyors, and as was consistent with the ethical practice of Psychology

* Established the behavioral "House Rules" for the organizational unit to which I was assigned

* Established building policy for the use of behavioral restraint, thus substantially reducing the overall usage of mechanical restraint

* Served as an informal technical advisor to the institution's psychology staff

* Participated in research group activities and independently conducted research in pertinent areas. The results of these activities have culminated in the production of a paper presentation at RMPA, a funded Developmental Disabilities Council Grant, a major paper in preparation for journal submission, and other treatment case studies which will likely be prepared for presentation or journal submission in the future

Behavioral Consultant, Private consulting contracts within the state of Utah (1988-1989)

* Provided psychological/behavioral consulting services to a variety of group homes, ICF/MR, and other facilities under supervision of a Psychologist licensed in the State of Utah

Clinical Psychologist, Geropsychiatric Unit, Las Vegas Medical Center, Las Vegas, NM (1981-1985)

* Provided general clinical psychological services to elderly residential patients in a 66 bed geriatric treatment unit. [all activities were conducted

under the supervision of a Psychologist licensed in the State of New Mexico]

* Performed psychological testing, intelligence and behavioral assessments, and general diagnostics for all patients under my charge

* Developed and implemented individualized treatment plans for patients under my care

* Prepared legal commitment proceedings paperwork and testified as an expert witness during court hearings

* Developed and implemented a formal transitional treatment program for geriatric patients utilizing a 16 bed open cottage

* Provided in-service training to a variety of staff members in areas of concern relating to the treatment of our patients

* Provided supervision to professional and paraprofessional subordinates

* Engaged in research activities relating to the provision of psychological services to the geropsychiatric population resulting in several paper presentations and a Master's Thesis

* Received extensive opportunities for exposure to the State and Community Mental Health system including personal site visits of such facilities and a week at the Neurology Ward of the Albuquerque VAMC

Adolescent Counselor, Arizona Baptist Children's Services, Phoenix, AZ (1980)

* Provided counseling to adolescent residential clients in a residential/school setting

* Provided input into disposition planning for clients

* Monitored client progress through behavioral observation and point-level contingency system

Clinical Research Assistant, (undergraduate student position), Department of Psychology, Arizona State University, Tempe, AZ (1974-1978)

* Provided prescribed therapeutic regimen in smokers'

clinic to decrease or eliminate the behavior through various levels of aversive conditioning

* Served as a behavioral observer/rater for a clinical self-disclosure project designed to determine the efficacy of several means of increasing patients' self-disclosure during clinical interviews

* Participated in a rape crisis counseling center project to evaluate and improve counselors' skills to deal effectively with clients

TEACHING EXPERIENCE

Psychology Instructor, Department of Psychology, Extension Division, Utah State University, Logan, Utah (1987-1988)

* Provided complete instruction to undergraduate students enrolled in an introductory course in behavior analysis

* Developed syllabus, quizzes, and examinations

* Developed lectures, assigned and supervised laboratory experiences, and assessed student performance

Teaching Assistant, Department of Psychology, Utah State University, Logan, UT (1985-1986)

* Provided administrative support for Introductory Psychology course with class sizes ranging from 80-210 students

* Supervised student proctors

* Prepared and delivered lectures within the scope of the course content

* Assisted students with individual self-management projects

Teaching Assistant, Department of Psychology, New Mexico Highlands University, Las Vegas, NM (1980-1981)

* Provided general administrative support for Sophomore level psychology course

* Maintained student grade records

* Prepared and delivered lectures

* Provided tutoring to undergraduate students

RESEARCH EXPERIENCE

Research Assistant, Early Intervention Research Institute, Utah State University, Logan, UT (1986-1987)

* Evaluated the effectiveness of early intervention procedures employed with handicapped children from birth to six years of age

* Conducted research relating to parental involvement in early intervention

* Received training from the interdisciplinary training facilities of the UAF regarding developmental disabilities

Research Assistant, Department of Psychology, New Mexico Highlands University, Las Vegas, NM (1980-1981)

* Performed experimental surgical and pharmacological procedures in a laboratory setting with nonhuman subjects

* Participated in research design development

* Conducted research utilizing an animal model of tardive dyskinesia

PAPERS, PRESENTATIONS

Gatling, J. H., & Cheney, C. D. (1990, May). Geotactic excitation in the development of second order conditioned taste aversion. Paper presented at the 16th Annual Convention of the Association for Behavior Analysis, Nashville, TN.

Gatling, J. H., & Cheney, C. D. (1990). The occurrence of single subject methodologies in the developmental disabilities literature. Unpublished manuscript.

Bonem, E. J., Gatling, J. H., & Crossman, E. K. (1990). The role of the brief blackout stimulus in post-reinforcement pause shaping. Manuscript submitted for publication.

Wells, J. P., Gatling, J. H., & Osborne, J. G. (1990). Sampling methodologies for the classification and measurement of clients who drool. Unpublished manuscript.

American Association on Mental Retardation. (June, 1989). Behavior Management and Psychotropic Medication. Panel presentation at the annual meeting of the State Chapter of AAMR, Park City, UT.

Gatling, J. H. (1988, April). Staff reinforcement styles in an institution for the mentally retarded. Paper presented at the annual meeting of the Rocky Mountain Psychological Association, Salt Lake City, UT.

White, K. R., & Gatling, J. H. (1987, April). Using research for formulating public policy about early intervention. Paper presented at the biennial meeting of the Society for Research in Child Development, Baltimore, MD.

Gatling, J. H. (1987, March). Admission and discharge rates in a geropsychiatric treatment unit. Paper presented at the conference of the American Society on Aging, Salt Lake City, UT.

Gatling, J. H. (1985, March). Reality orientation with institutionalized elderly clients. Paper presented at the conference of the American Society on Aging, Denver, CO.

Gatling, J. H. (1985, March). Prevalence of tardive dyskinesia in a geropsychiatric treatment unit. Paper presented at the conference of the American Society on Aging, Denver, CO.

Schreiber, H. L., Larson, C., McGahie, F., & Gatling, J. (1983). Effect of early stress and sex on the sensitization induced by methylphenidate and haloperidol. Unpublished manuscript, New Mexico Highlands University, Department of Psychology.

Gatling, J. H. (1982). Intensive individual reality orientation therapy for geropsychiatric patients. Unpublished master's thesis, New Mexico Highlands University, Las Vegas, NM.

Larson, C., McGahie, F., Gatling, J., Gabaldon, M., & Schreiber, H. (1981). Effect of ovariectomy and adrenalectomy on REM sleep deprivation. Paper presented at the annual meeting of the Rocky Mountain Psychological Association, Denver, CO.

PROFESSIONAL REFERENCES

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