5-1981

Inter- and Intra-sensory Modality Stimulus Scaling: A Method for the Determination of the Relative Salience of Stimuli in Poison-based Aversion Learning by Pigeons

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INTER- AND INTRA-SENSORY MODALITY STIMULUS SCALING: A METHOD FOR THE DETERMINATION OF THE RELATIVE SALIENCE OF STIMULI IN POISON-BASED AVERSION LEARNING BY PIGEONS

by

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

of

DOCTOR OF PHILOSOPHY

in

Psychology

Approved:

UTAH STATE UNIVERSITY
Logan, Utah

1981

ACKNOWLEDGEMENTS

I especially thank my chairman, Dr. Carl Cheney, for his support, guidance, and friendship over the years. His insight and sense of humor are very much appreciated.

I express my appreciation to Dr. J. Grayson Osborne for his interest, academic advice, and nonacademic diversions at Daniels.

My appreciation is extended to Dr. Frank Ascione, Dr. Edward Crossman, and Dr. Arthur Mahoney for their helpful suggestions during the course of this study.

In addition, I thank Ralph Evans and Susan Nittrouer for their research assistance.

I am greatly indebted to my wife and best friend, Ginny, for her support, encouragement, and active participation. Her contribution to my progress at Utah State University cannot be overestimated.

David L. Pounds

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ABSTRACT

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by

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Utah State University, 1981

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One of the most rapidly expanding areas of research in psychology has been poison-based aversion learning (PBAL). The PBAL paradigm typically involves: exposing an animal to a novel substance; inducing illness following ingestion of that substance; and then providing access to the substance at a later time. The initial reaction to the novel substance is generally to reduce consumption, a finding labeled neophobia. The reduction of substance intake on test day is called learned aversion.

Following demonstrations of cue-to-consequence specificity (i.e., the differential associability of some stimuli with certain consequences) in PBAL research with rats, recent research has focused on PBAL by avians. Such research has been instigated by speculation

that avians might be specially adapted to better associate visual rather than flavor stimuli with illness. Studies to determine the relative salience of visual or flavor cues in avian PBAL have reported contradictory findings. A number of methodological differences exist between these studies including differences in stimulus intensity and type, duration between conditioning and assessment, and method of assessment. The current series of experiments made several methodological improvements to clarify the issue of cue to consequence specificity in PBAL with avians. Three experiments with pigeons as subjects are reported.

The first experiment equated (scaled) stimulus intensity across different sense modalities by equating neophobic responses to various concentrations of salt, sour, and red water.

The second experiment determined the extended effects of the illness-inducing stimulus alone on fluid consumption by pigeons in a restricted access to water environment.

The third experiment was based upon results from the first two experiments and assessed aversion, at two different post-injection times, to one of two concentrations of either salt, sour, or red water CSs. In addition, a compound (flavor plus color) conditioning group was employed.

Aversion was a function of flavor or color stimulus intensity. No differences were observed in degree of aversion demonstrated by groups receiving stimuli equated for initial suppression. Evidence for overshadowing or potentiation was not found.

The results support the position that neither flavor or color stimuli are necessarily the most salient in avian PBAL.

(123 pages)

CHAPTER I

INTRODUCTION

Since Garcia and Koelling's (1966) classic experiment demonstrating the relationship of cue to consequence, taste aversion learning has been one of the most rapidly expanding areas of research in psychology (Riley & Clark, 1977). Such interest has not been generated solely by intrinsic interest in the phenomenon per se, but by interest in whether the mechanisms of taste aversion learning are unique or can be subsumed under general process views of learning and conditioning (Logue, 1979).

The basic taste aversion conditioning paradigm consists of exposing an animal to a flavored food substance and then inducing illness at some time following ingestion of the substance. Aversion is assessed by providing access to the substance only at some later time, and contrasting the consumption of the substance either to pre-treatment levels or to the consumption of animals receiving control procedures. Conditioning in the form of substance avoidance typically takes place in one trial, is very resistant to extinction, can take place with interstimulus intervals up to 12 hours, and appears to be constrained by the nature of the conditional stimulus (Garcia, Ervin & Koelling, 1966; Garcia & Koelling, 1966; Smith & Roll, 1967).

An issue has been the question of whether such findings are sufficiently anomalous to require the revision of general laws of

learning in favor of alternative proposals. While a number of investigators have called for the inclusion of species and task specific constraints on the general laws of learning (Bolles, 1970; 1973; Breland & Breland, 1961; Hinde, 1973; Shettleworth, 1972), it is Seligman's (1970) and Rozin and Kalat's (1971) use of the taste aversion literature as support for their respective views that necessitates discussion of their theoretical positions.

The commonality between Seligman's (1970) concept of "preparedness" and Rozin and Kalat's (1971) concept of "adaptive specializations for learning" is the emphasis they share on species specific evolutionarily determined predispositions to associate certain cues in their respective environments with certain consequences. That is, animals are considered to be built to relate some stimuli better than others. Both approaches cite the early work of Garcia and associates (Garcia, Ervin & Koelling, 1966; Garcia & Koelling, 1966) with respect to two findings: 1) that conditioned taste aversions are obtained with long delays between the ingestion of a novel substance and subsequent illness; and b) that noise and light are associated with shock and flavor is not, while flavor is associated with illness and noise and shock are not. Both results were obtained with rats and both contradict what had been presumed to be general laws of arbitrary stimulus learning. The observation of associations formed over long delays violates the assumption that optimal conditioning takes place only when there is close (less than one sec) temporal contiguity between stimulus events (Kimble, 1961). Furthermore, the observation of differential conditioning between specific cues and consequences

violates assumptions concerning the "equipotentiality" of stimuli (Seligman & Hager, 1972), that is, for example, that any type of stimulus could be conditioned to any particular unconditioned stimulus. Both of these "anomalous" findings are employed as justification for recommending the revision of the general laws of learning (Kalat, 1977; Rozin & Kalat, 1971; Seligman, 1970; Seligman & Hager, 1972).

While initial experimentation appeared to suggest that many substantial differences existed between taste aversion learning and the learning observed under more traditional conditions, later research has indicated that such differences do not exist, at least to the extent that radical revision of existing general views is required (Logue, 1979; Revusky 1977; Revusky & Garcia, 1970; Testa & Ternes, 1977).

Taste Aversion as Traditional Conditioning

Testa and Ternes (1977) cite numerous similarities between the effects observed in taste aversion learning and those found in other forms of laboratory conditioning, specifically classical conditioning. Such effects include: extinction; generalization; novelty; sensitization; conditioned and latent inhibition; overshadowing; delay of reinforcement; as well as conditioned stimulus (CS) and unconditioned stimulus (UCS) intensity effects. Rather than describing each in detail, several of these findings will be discussed below.

The effect of stimulus novelty is well documented in the classical conditioning literature and has been called the orienting response or orientation reaction (Lynn, 1966; Sokolov, 1963). The response in this case is accompanied by a number of physiological changes as well as suppression of ongoing behavior and the avoidance of or withdrawal from

the novel stimulus. Such changes typically habituate with repeated presentations of the novel stimulus (i.e., it ceases to be novel). Similar effects occur in taste aversion conditioning. When a novel substance is presented to an animal the animal may hesitate to approach and usually suppresses its consumption of the substance relative to consumption of a familiar substance. Such a suppression, or reduction, is labeled a neophobic response and has been detected in a variety of species (Domjan, 1977). Domjan (1977) reports that such neophobic responses habituate following repeated exposure and in fact are sensitive to a number of experimental manipulations to which the orientation reaction responses are sensitive in other settings.

Sensitization refers to a procedure whereby the presentation of a UCS increases or "sensitizes," the response of interest to some other novel stimulus presented later in the same situation. Such a response occurs in animals that hve been slightly poisoned prior to exposure to a novel substance and is referred to as enhanced neophobia. This effect is demonstrated by an even greater suppression of consumption than that produced by normal neophobia (Testa & Ternes, 1977).

While associations with a long delay between the presentation of the CS and the UCS have been noted in taste aversion learning (Smith & Roll, 1967) it has also been reported that such increases in the interstimulus interval decrease the strength of the CS-UCS association (Garcia, Ervin & Koelling, 1966; Nachman, 1970). A similar inverse relationship between the length of the interstimulus interval and the strength of association between a CS and UCS has been observed in other

classical conditioning experiments dealing with a variety of different responses (Mackintosh, 1974).

Since Pavlov (1927) demonstrated that the degree conditioning which occurred to a stimulus depended upon whether the stimulus was presented alone or as an element of a compound, the phenomenon of "overshadowing" has been observed in a number of experimental settings (Mackintosh, 1974). Originally, Pavlov suggested that the basis for one element overshadowing conditioning to the other element of a compound was the difference in relative intensity of the component stimuli. Since then, other investigators have demonstrated the dependence of overshadowing upon the relative intensities of the component stimuli (Kamin, 1969), but have also reported, in instrumental discrimination learning studies (Wagner, Logan, Haberlandt & Price, 1968) and in conditioned suppression studies (Kamin, 1969; Wagner, 1969), that: a) the degree to which a cue predicts reinforcement or occurrence of the UCS; and b) the amount of previous elemental training, are other variables which affect the overshadowing of one cue by another. Wagner and Rescorla (1972) and Rescorla and Wagner (1972) have proposed a "summative" theory to account for the apparent variables involved in overshadowing. The theory proposes that a finite amount of conditioning can accrue to a particular UCS and thus to a stimulus compound and its components. Manipulating intensities, predictiveness, or adding components are postulated as being constrained by the total finite amount of conditioning possible for the particular UCS. Thus, if one element is associated with a UCS in such a manner that the maximum amount of conditioning is involved, then the addition of another stimulus element to the situation will result in

no evidence of association between that stimulus element and the UCS. Revusky (1971; 1977) has proposed a somewhat similar account called associative or concurrent interference, which also postulates competition between stimuli for association with a given reinforcer. Importantly, Revusky's account, while not based solely upon, does draw upon taste aversion learning where overshadowing has been observed both within a single stimulus modality (Revusky, 1971) and between stimulus modalities (Wilcoxin, Dragoin & Kral, 1971).

Mackintosh (1974) and Testa and Ternes (1977) point out that in more traditional classical conditioning paradigms as well as in taste aversion learning, the degree of conditioning obtained is a positive function of CS intensity (Dragoin, 1971; Rozin & Kalat, 1971) and of UCS intensity (Dragoin, 1971; Revusky, 1968).

Taste Aversion Theory and Constraints on Learning

Logue (1979), in a review paper, proposed that the adoption of a qualitative/quantitative distinction can be applied not only to differences in learning between different species (Bitterman, 1975) but also to within-species differences under varied conditions. Based upon this analysis, Logue concluded that while some real quantitative differences exist between the findings of the taste aversion paradigm and that of more traditional paradigms, essentially the mechanisms involved are not qualitatively dissimilar. However, Logue qualified his conclusions by emphasizing that what constitute the general laws of learning and what constitute qualitative or quantitative differences are both subject to debate. The comparisons were made between taste

aversion learning and diverse examples of traditional learning which included examples of "prepared" and "contraprepared" learning (Seligman & Hager, 1972) as well as many examples where feeding behavior and/or interoceptive stimuli were involved. He suggests that such similarities in experimental methodology should be taken into account. In addition, he indicates that a full understanding of each species' feeding behavior under natural conditions is necessary in order to describe and predict accurately what occurs in taste aversion learning. This latter statement seems to be somewhat in opposition to his earlier conclusion that "In virtually all cases the same principles are sufficient for describing taste aversion and traditional learning data" (p. 289). The two apparently different views can be reconciled if it is assumed that feeding behavior is a variable that operates in both standard and taste aversion conditioning. Such a view is compatible with Kalat's (1977) emphasis on the adaptive specializations involved in learning as well as with Seligman and Hager's (1972) emphasis on preparedness, although feeding behavior represents a limited application of their respective concepts. The utility of concepts (actually just names) such as "preparedness" (Seligman & Hager, 1972) or "adaptive specializations" (Kalat, 1977) is not due merely to their use as heuristics but includes the predictions that such concepts should allow. To explain behavior post hoc, while of interest, is not nearly as valuable a goal as that of predicting the occurrences of phenomena under certain conditions. For example, to suggest that an association is "prepared" or "contraprepared" based upon the rapidity or difficulty with which the association was formed is needless and

circular. However, if the nature of the acquisition of an association can be predicted in advance based upon an assumpton of what produces or is correlated with "preparedness," then the concept has utility. Similarly, if "adaptive specializations" are posited to account for species specific abilities to form associations between events, and such specializations are based upon evolutionarily determined physiology in interaction with the organism's naturally occurring environment, then knowledge of such factors should enable the prediction of the relative ease with which a particular association is made by a particular species.

As mentioned earlier, both the concepts of "preparedness" (Seligman, 1970; Seligman & Hager, 1972) and "adaptive specializations" (Kalat, 1977; Rozin & Kalat, 1971) have utilized experimental findings from taste aversion research as partial support. If the criterion of predictability developed above is applied to these concepts in the context of taste aversion learning it may be possible to judge the utility of such concepts. For example, both concepts should allow for the prediction of the relative associability of various stimuli. That is, if it can be assumed that the rat is biologically prepared or specially adapted for making associations between flavors and subsequent gastrointestinal illness because of its evolutionarily determined physiology, then predictions about the relative associability of various stimuli with such illness should be possible based upon similar knowledge of other species, for example avians.

Avian Taste Aversion Research

Wilcoxin et al., (1971) hypothesized that since avians have rather highly developed visual systems and relatively less well developed gustatory receptors, especially when contrasted with the same systems in the rat, that differential associations might be formed for each species when exposed to visual, flavor, or compound visual-flavor stimuli. Wilcoxin et al. (1971) exposed different groups of rats and quail to hydrochloric acid (HCl) flavored (sour) water, blue colored water, or blue sour flavored water. They subsequently injected the experimental animals with cyclophosphamide (an immunosuppressive compound that causes gastrointestinal distress) within a half hour of consumption. The assumption was that the rats would avert to the flavor (and not the color) and the quail to the color (and not the flavor).

Rats demonstrated aversions to the flavor only. The quail formed strong aversions to the blue water element and relatively weak aversions to the HCl flavor element. In addition, evidence of overshadowing of flavor by color was found for the group of quail exposed to the compound and tested only on the flavor element. These results were consistent with expectations that avians are prepared to associate visual stimuli with subsequent illness or that avians have evolved with special mechanisms for associating visual with interoceptive stimulation. As such, these data have been widely cited as additional examples of CS-UCS specificity (Garcia & Hankins, 1977; Mackintosh, 1974), as well as support for the view that the class of

effective CSs in any conditioning should vary from species to species (Rozin & Kalat, 1972).

However, the results from studies with predatory avians are different from those obtained by Wilcoxin et al. (1971) with seed-eating quail. Brower (1969) and Brower and Glazier (1975) have reported that bluejays avoided toxic insects (butterflies) based on visual information, but as food deprivation was increased, the bluejays seized the insects releasing the toxic ones and eating the non-toxic ones, with flavor apparently controlling consumption. In research with Buteo hawks, Brett, Hankins, and Garcia (1976) paired the consumption of either black mice, quinine-flavored mice, or black quinine-flavored mice with lithium chloride (LiCl) induced illness and observed stronger flavor based aversion than visual aversion. In addition, they reported that the flavor potentiated aversion to the color component when the color component was tested separately following compound training. This resulted in fewer trials (CS-US pairings) to acquisition than when the color component was conditioned separately. These apparent differences within avian species were cited by Garcia and Hankins (1977) when they suggested that at the time quail and ". . . perhaps its seed eating relatives are the only species which appear to prefer visual signals over taste in tests of food-aversion learning" (p. 14).

The data from other avian research have not resolved the issue of whether visual or flavor stimuli are more readily associated with illness and hence are more salient in the formation of poison based aversion learning (PBAL). Indeed, the contradictory reports from studies of flavor and color aversion conditioning with chicks (Gaston,

1977; 1980; Gillette, Martin & Bellingham, 1980), quail (Lett, 1980), and pigeons (Clarke, Westbrook & Irwin, 1970; Lett, 1980; Pounds, Williamson & Cheney, 1980; Westbrook, Clarke & Provost, 1980, Lett, Note 2; Pounds & Cheney, Note 3) appear to have further complicated the issue.

A limited review of these studies reveals striking differences in their respective methodologies which may be responsible for some or all of the contradictory findings. Such differences include dramatic differences in CS and UCS types and intensities, procedural differences, and differences in assessment techniques. More specific discussions of these methodological differences as well as conceptual issues follow in the section reviewing the avian aversion learning literature and in the introductions to the experiments.

CHAPTER II

REVIEW OF AVIAN AVERSION LEARNING LITERATURE

A number of investigators have reported strong color aversions (Czaplicki, Borrebach & Wilcoxon, 1976; Wilcoxon, et al., 1971; Wilcoxon, 1977), relatively weak flavor aversions, and overshadowing of flavor by color (Wilcoxon, et al., 1971) in research with quail. Lett (1980), on the other hand, reported strong flavor aversions, weak color aversions, and potentiation or enhancement of a weak color cue by a strong flavor cue, in her work with quail. In addition, although visually mediated aversions have been reported in chicks (Capretta, 1961; Gaston, 1977; 1980), Gillette et al. (1980) reported the differential use of taste and flavor cues with both food and water aversions while Gaston (1980) reported evidence of taste aversion learning with chicks only under special conditions. To further complicate the situation, the findings from some PBAL research with pigeons are also contradictory. A number of researchers have reported finding weak color aversion, strong flavor aversion, and potentiation of weak color cues by strong flavor cues (Clarke, et al., 1979; Lett, 1980; Westbrook, et al., 1980; Lett, Note 2). Others have reported finding evidence of strong color aversions in pigeons (Pounds, et al., 1980) as well as enhancement of a color aversion by a weak flavor cue (Pounds & Cheney, Note 3).

As mentioned earlier, real differences exist between most of the above studies which report divergent findings with respect to: a) UCS intensity; b) the nature of the CSs and their respective intensities;

c) the nature of the test for aversion, that is, whether one- or two-bottle tests are employed; and d) the duration between treatment and testing. Also, considerable variability exists in the literature with respect to reporting the dosage levels administered to subjects (i.e., mg/kg of body weight; mEq/kg body wt.; ml/kg; etc.) as well as reporting the concentrations employed as conditional stimuli (i.e., drops; ml; etc.). Such lack of convention in reporting methodological variables is nontrivial and adds to the difficulty of contrasting the respective findings.

Unconditional Stimuli

Studies employing cyclophosphamide as the illness inducing agent have detected strong color aversions in quail (Wilcoxon et al., 1971) and in pigeons (Pounds et al., 1980). Studies using lithium chloride (a salt used in the treatment of manic/depression with adverse gastrointestinal side effects) as the illness inducing agent have reported weak color aversions in buteo hawks (Brett et al., 1976), pigeons (Clarke et al., 1979; Lett, 1980) and quail (Lett, 1980). However, other studies using LiCl have reported strong aversions in quail to color (Czaplicki et al., 1976; Wilcoxon, 1977) and strong aversions in chicks to color (Gaston 1977; 1980).

A general conclusion about the relative contribution of the specific illness inducing agent used in the above studies is not possible since both absolute dosage levels (mg/kg of body weight) as well as concentrations of the respective drugs (molarity) have varied among nearly all the studies cited. The relative contribution of UCS

intensity and its two determinants: dosage level and concentration, to the differential conditioning of taste or visual cues has not been adequately assessed. To illustrate the problem that such differences in UCS intensity present when interpreting the results of the studies cited above, those studies employing quail and pigeons as subjects and LiCl as the drug can be contrasted within groups. Wilcoxon (1977) employed 0.15M LiCl with a dosage level of 127 mg/kg. Czaplicki et al. (1976) used the same concentration of LiCl (0.15M) but increased the dosage level to approximately 190 mg/kg. Both of these studies reported strong color aversions. Lett (1980) using quail, administered a much more intense dose of the UCS. She injected quail with a 0.3M concentration of LiCl at a dosage level of approximately 254 mg/kg and reported finding little evidence of color aversion. Unfortunately, other aspects of the experiments varied concomitantly making comparative interpretation of the data difficult, if not impossible.

The methodologies of pigeon studies have also differed from one another with respect to UCS intensity. Clarke et al. (1979) and Westbrook et al. (1980) used a 0.3M concentration of LiCl at a dosage level of approximately 127 mg/kg of body weight and reported no evidence of color aversion. The same concentration at a higher dosage level (approximately 254 mg/kg) was used by Lett (1980) who reported evidence of a color aversion. These two reports indicate the possibility that UCS intensity alone can account for the differential reports of the ability of pigeons to demonstrate aversions to color-mediated substances. However, Pounds and Cheney (Note 3) used both a lower concentration (0.25M) and dosage level (120 mg/kg) of LiCl

and still obtained aversion to colored water with pigeons. Again, differences in the respective methodologies preclude any specific conclusions about the existence of a relationship between UCS intensity and the differential demonstration of conditioning between induced illness and visual or flavor cues.

Conditional Stimuli

A number of different flavors and colors as well as compounds of both have served as potential CSs in examinations of avian PBAL. Blue commercial food coloring added to tap water has been used as a conditional stimulus in many studies, but the concentrations have varied widely. Wilcoxon et al. (1971) used 3 drops of food coloring per 100 milliliters of water and reported strong color aversions with quail. Czaplicki et al. (1976) also found substantial aversions to two concentrations of blue water: 5 milliliters (ml) of dye in 1 liter of water (0.5% v/v); and 0.5 ml of dye in 1 liter of water (0.05% v/v). Clarke et al. (1979) and Westbrook, Hardy & Faulks (1979) observed no aversion to a relatively weak concentration (0.1% v/v) of blue water in pigeons. Lett (1980) reported finding an aversion to the same stimulus concentration as was used in the two preceeding studies when she assessed PBAL in pigeons, but she, as noted earlier, used a much higher dosage level of the UCS than was used by Clarke et al. (1979) or Westbrook et al. (1979). Pounds et al. (1980) assessed aversion with a much higher concentration of blue water (1% v/v), which was approximately ten times as great a concentration as that used in the previously described reports, and found a strong association between color and subsequent illness.

Both red and green colored stimuli have also been employed. The usual medium for color has been fluid, but food has also been used (Gillette et al., 1980). As with the color blue, concentrations have varied considerably between studies for both red and green. Concentrations of green have ranged from four drops in 100 ml of fluid (Gaston, 1977; 1980) to one ml in one liter (Lett, 1980). Gaston (1977; 1980) detected significant aversions to green in chicks but Lett (1980) reported quail did not avert to the color green. Red has also been used with mixed results. A relatively weak concentration (0.5% v/v) was avoided by chicks following pairing with illness (Gillette et al., 1980). Two additional studies (Pounds et al., 1980; Pounds & Cheney Note 3) paired a more concentrated red solution and found that pigeons associated the ingestion of the colored water with subsequent illness even though the UCS in one of the studies was substantially weaker than that employed by Lett (1980). Evans, Pounds & Cheney (Note 4) reported an aversion to red water by pigeons lasting over 3 months and 13 extinction test trials.

Review of those studies employing visual stimuli allows several observations. First, the successes in producing visual aversions in quail have come from studies using the color blue. The use of green colored stimuli has met with mixed success. Second, some failures to detect an aversion to color in pigeons may be due to the use of a weak UCS, a weak color stimulus, or a combination of those conditions. Finally, a disproportionate number of successful studies have used blue food coloring added to water, as the conditional stimulus. The possible significance of this observation will be addressed further in Experiment I.

Flavors and Compounds

The differential evidence of aversion found in studies employing a variety of flavors as conditional stimuli also makes it difficult to conclude about the effectiveness of such stimuli with respect to their relative salience in PBAL in avians. Wilcoxon et al. (1971) and Gillette et al. (1980) both reported flavor aversions to dilute hydrochloric acid. The former study reported a relatively weak aversion in quail and the latter reported that the HCl stimulus was an adequate cue for water but not food. Gaston (1977) initially failed to detect an aversion to a sucrose solution, but subsequently found evidence of a learned aversion to sucrose in an interocular transfer study (Gaston, 1980). Pounds and Cheney (Note 3) failed to detect an aversion to saccharin although the addition of that flavor in compound with color did enhance the aversion to the color element. Hickis (Note 1) does report a relatively weak aversion to a very strong concentration of saccharin. Frome, Pounds and Cheney (Note 5) reported very little evidence of detectability of saccharin by pigeons. Other reports of strong aversions to flavor have come from studies using salt water as a CS with pigeons (Clarke et al., 1979; Lett, 1980; Westbrook et al., 1980), and studies using vinegar water with pigeons and quail (Lett, 1980) with the degree of aversion in pigeons apparently less to vinegar than to salt. Such limited and inconsistent results coupled with reports from studies with other species such as ducks and geese (Lett, Note 2) indicate the possibility that some flavors may not be as effectively associated with illness as others, although differences in stimulus intensity may be a factor.

Assessment

The method of assessment has also varied among studies as has the duration between conditioning and time of test. Forced consumption procedures (one-bottle) (Wilcoxon et al., 1971; Gillette et al., 1980; Lett, 1980; Pounds & Cheney, Note 3) or preference procedures (two-bottle) Clarke et al., 1979; Czaplicki et al., 1976; Gaston, 1977; 1980; Genovese & Browne, 1978; Westbrook et al., 1980) have been employed with quail, chicks, and pigeons. A forced consumption procedure provides the subject with no alternative to the CS substances at time of test. A preference procedure provides the subject with a choice between the CS substance and some alternative substance (usually plain water). The use of either method has apparently been influenced by reports that preference procedures (two-bottle) are more sensitive in demonstrating aversion (Dragoin, McCleary & McCleary, 1971; Grote & Brown, 1971).

Gaston (1977) has assessed aversion in chicks 24 hours after injection with LiCl, at a time when increased fluid consumption is expected (Westbrook, Hardy & Faulks, 1979) with a preference procedure. Clarke et al. (1979) have also used a preference procedure but assessed aversion after 12 and 14 days had elapsed, a time when consumption was expected to have returned to baseline. Lett (1980) assessed aversion with a modified forced consumption procedure (birds were given access to plain water following a one-bottle test) after 7 or 8 days had elapsed since training. Pounds and Cheney (Note 3) used a forced consumption procedure (one-bottle), but tested 48 hours following conditioning. Implicit in many of these studies using different

procedures are the assumptions that two-bottle tests may be superior to one-bottle tests, at least with a short duration between training and assessment, and that the illness itself may obscure early assessment of the degree of aversion obtained. An argument for the efficacy of the forced consumption procedure with short durations between conditioning and testing is made in Experiment II.

The problem observed in the preceding review of avian PBAL can be stated as follows: First, it has not been determined that if visual or flavor cues which were of equal intensity were paired with illness, that demonstrations of different degrees of aversion would result. Second, the effects of LiCl administration alone on fluid consumption by pigeons in a restricted access to water environment have not been determined. Finally, it is not clear that if stimuli which were equated on some basis for intensity were mixed together and paired with illness, that flavor would potentiate or be overshadowed by color. In brief, the effects reported in the literature to date may have been specific to the intensities used in those studies and not reflect the full realm of possible outcomes if other stimulus intensities were used. Therefore, these issues are addressed in the following study.

Three experiments investigating flavor and color aversion processes in pigeons are conducted. Several new conceptual and methodological approaches are undertaken. Rationales for the conduct of each experiment as well as the methodology for each experiment follow.

CHAPTER III

GENERAL METHODS AND PROCEDURES

This section describes the housing conditions and treatments which were common to all experiments. In addition, general descriptions of the flavors, colors, illness inducing drugs, as well as deprivation procedures which were used throughout the three experiments are noted. Exceptions to the General Methods and Procedures are described in the appropriate sections.

Subjects

Subjects were naive feral pigeons of undetermined breed, age, and sex. They were housed individually throughout the actual experiment under conditions of standard lighting and temperature. Temperature was maintained at approximately 65°F ($\pm$10°). Lighting was provided by standard overhead fluorescent units which were on between 0600 and 2000 hours daily.

Apparatus

Individual cages measured 30cm x 30cm x 30cm. Fluids and food were offered inside the home cage on the front panel in clear glass four-ounce baby food jars. Food, when provided, was a mixture of chicken scratch and Purina pigeon checkers. The color CSs consisted of red Schillings commercial food coloring added to tapwater. One, two, five, ten, or fifteen ml of coloring were mixed in one liter of water yielding 0.1%, 0.2%, 0.5%, 1.0%, and 1.5% v/v solutions respectively.

The flavor CSs consisted of salt water or sour water. Salt water was obtained by mixing 3.5, 7.0, 8.0, 9.0, 9.5, 10.5, or 14 gm of NaCl in one liter of tapwater each yielding 0.06M, 0.12M, 0.137M, 0.154M, 0.163M, 0.18M, and 0.24M (or 0.06N, 0.12N, 0.137N, 0.154N, 0.163N, 0.18N, and 0.24N) solutions respectively. Sour water consisted of 1, 2, or 3 ml of 36% HCl in 3 liters of tapwater or 3 ml of 36% HCl in 1 liter of tapwater yielding 0.012%, 0.024%, 0.036%, and 0.054% (an alternative designation allowing for the specification of the number of molecules present would be 0.0036N, 0.0073N, 0.011N, 0.033N approximately) solutions respectively. Compound solutions consisted of the same concentrations as used for the elements alone.

The illness-inducing agent was lithium chloride. The neotoxic effects of lithium dosages in humans include gastric discomfort, diarrhea, vomiting, and thirst (Gershon, 1975). Similar observable symptoms are obtained when animals, and specifically pigeons, are injected interperitonially (IP) with lithium chloride resulting in dehydration due to fluid loss associated with vomiting and diarrhea. As such, lithium chloride has been commonly used in PBAL studies. Injections were always either 120 mg/kg of 0.25M LiCl or equivalent volumes of distilled water which served as the vehicle control. Injections were given IP using 10 cc syringes and 1/4 inch 26 gauge needles. The amount of drinking fluid offered daily was 100 ml of either room temperature tapwater or test substance, in a single glass jar.

Procedure

Birds were habituated to the laboratory and housed in pairs for seven days with food and water available ad lib and freshened daily. Birds were then individually housed and given limited access to food and water for seven days (baseline). Food was removed from the cage about 3.5 hours (±.5 hr.) before a limited 15-minute access to water or test fluid in a single glass jar, and was replaced approximately 3.5 hours later. Birds were weighed daily by the experimenter and one of two research assistants. Consumption was measured by the experimenter with a 100 ml graduated cylinder on all days of interest. The two research assistants recorded consumption, aided in food and water presentation as well as the injection process. This regimen was designed to reduce the possibility of adventitious conditioning of an aversion to food. Birds were quasi-randomly assigned to treatment conditions with the restriction that total group consumption was approximately equated across groups. All injections were given by the experimenter within 15 minutes after fluid had been removed from the cage. The 15-minute per day access to fluids was continued throughout the experiment with test fluids substituted for tapwater on test days.

Statistical Analyses

All birds in all experiments were quasi-randomly assigned to the various groups. Such assignments had the restrictions that: 1) a range of intakes were included; and 2) total consumption was closely equated across groups. A consumption ratio was calculated to assess the effects of experimental manipulations upon consumption. The consumption ratio was obtained by dividing the consumption on the day

in question by the average of the fluid intakes on the last three days of baseline. A ratio of 1.0 indicated no change in consumption while those greater or less than 1.0 indicated enhanced or suppressed intake respectively with the distance from 1.0 in either direction indicating the relative strength of the enhancement or suppression. Such ratios have been used to detect aversion or preference and possess the advantage of correcting for individual differences in fluid intake by relating post-treatment fluid intake to pretreatment fluid intake for individual subjects (Hickis, Note 1). Mean group consumption ratios were the data for statistical comparisons. Kruskal-Wallis tests for differences between groups (Siegel, 1956), protected rank sums tests for subsequent comparisons (Welkowitz, Ewen, & Cohen, 1976), and Wilcoxon matched pairs signed ranks tests for repeated measures (Siegel, 1956) were used for statistical comparisons. Differences were considered significant only if the probability of obtaining the difference by chance alone was less than .05 (two-tailed).

CHAPTER IV

EXPERIMENT I

In reviewing the avian poison based aversion literature, a deficiency seemed apparent. No procedures have been included in any previous study known which scaled stimuli across sense modalities. Indeed almost no effort has been made to ascertain whether the failure to obtain conditioning to a specific stimulus at a specific intensity is the result of a failure to associate that class of stimuli with a specific class of consequences or merely the result of a failure to discriminate the addition of that stimulus to the environment. On logical grounds alone, one would not expect an aversion to be conditioned to a stimulus which the organism does not discriminate from its familiar environment. For example, if the organism is unable to discriminate that the water is sweet or blue, it is unlikely that the organism would associate sweet or blue water with subsequent illness. Such an effort seems necessary before a general conclusion about the relative saliency of cues is offered.

While no common physical scale exists for tastes and colors (Mackintosh, 1974), the importance of some manner of scaling stimuli from these two modalities remains for a number of reasons. It may be the case that a particular class of stimuli is not associable with induced illness regardless of the intensity levels of members of that class (ultra-high sound for example). Furthermore, it may also be the case that when stimuli for different sense modalities are presented in

compound, a particular class always overshadows or potentiates stimuli from the other class with relative intensity levels having little or no effect. Such possibilities seem somewhat unlikely given the contradictory nature of the literature reviewed earlier where CS and UCS intensity appeared to have an effect on the detection of differential conditioning to flavor and color cues. Yet, a number of authors have tended to overstate (my observation) the positions that flavor cues are more strongly associated with induced illness than color (Clarke et al., 1979; Westbrook et al., 1980) and that flavor cues potentiate weak aversions to color cues when conditioned in compound (Clarke et al., 1979; Lett, 1980, Note 2). While the observation of potentiation or enhancement eliminates the possibility that the bird did not discriminate the weaker stimulus, it should not be concluded that the same relationship would exist if the stimuli were initially equated for stimulus intensity or if other stimulus parameters were employed. Claims for the relative salience of visual or flavor cues in the formation of conditioned aversions in avians have been based for the most part upon reports of failure to detect aversion to an unscaled stimulus when compared to another unscaled stimulus. Additional support comes from reports of overshadowing (Wilcoxon et al., 1971) and potentiation (Clarke et al., 1979; Lett, 1980) in which relative intensities have apparently been unscaled or unequated. Such claims seem open to challenge. The point being that one should not conclude that color overshadows flavor, for example, when in fact the two stimuli, color and flavor, may not have had equal salience to begin with.

Neophobic Scaling

A means for scaling across stimulus modalities by scaling neophobic responses is a plausible approach for a number of reasons. First, in most instances the stimuli to be conditioned are novel. Studies report much stronger conditioning to novel than to familiar stimuli (e.g., Cheney & Eldred, 1980). Second, neophobia has been widely studied as a response to novelty (Domjan, 1977) and has been viewed as an analogue of the orienting reaction (Testa & Ternes, 1977). Third, orienting reactions can be considered a measure of discrimination. Fourth, considerable literature exists with other conditioning procedures indicating that a positive relationship exists between stimulus intensity and the strength of the orientation reaction (Sokolov, 1963). Fifth, Nachman, Rauschenberger and Ashe (1977) reported a high correlation (0.88) between the degree of neophobia to a novel substance and the subsequent degree of aversion to that same substance when they exposed rats to nine different flavors. Furthermore, they observed that if the substances were made familiar, following initial presentation and before they were then paired with illness, that the correlation between the degree of initial neophobia and subsequent degree of aversion rose to 0.91. While Nachman et al. (1977) contrasted neophobic responses with later aversion within a single stimulus modality, contrasts across modalities seem clearly possible.

If it can be assumed that: a) within a stimulus such as flavored water (varying in intensity) the degree of neophobia (as measured by a reduction in consumption) is highly correlated with the subsequent demonstration of aversion; and b) neophobia can be scaled and even

equated among sense modalities in terms of the organism's reduction in consumption of the novel substance, then the difference in the degree of aversion observed should be related to the relative associability of those stimuli with drug-induced illness rather than to initial differences in discriminability.

Such a scaling procedure possesses obvious advantages in compound conditioning studies investigating overshadowing, potentiation, or blocking. Separate elements could be scaled (and equated) initially and then conditioned in compound with subsequent assessment revealing additional information about the relative salience of each stimulus.

In light of the above discussion, the first experiment was designed to scale two different flavor stimuli and one color stimulus for subsequent use in Experiments III. At least four concentrations of each stimulus were examined. The flavor stimuli and color stimuli which were employed for scaling were stimuli which have been used in a number of PBAL studies with avians. Salt water has been used in several studies (Clarke et al., 1979; Lett, 1980) which have reported somewhat contradictory results. Rozin and Kalat (1971) have suggested that sodium appears to have some property to which rats, at least, are differentially sensitive. Perhaps avians in general, and pigeons specifically, also respond in a unique manner to NaCl. Diluted hydrochloric acid has also been employed by Wilcoxon et al. (1971) and Gillette et al. (1980) with mixed findings. By equating concentrations of NaCl in water and HCl in water in terms of neophobic responses to each, information may be gained concerning the relative salience of each with respect to taste aversion conditioning.

Red colored water has been used extensively with mixed success. The investigation of several concentrations of these stimuli should explicate the nature of such contradictory results. As mentioned earlier, the color blue has been frequently used. Delius (1968) reported differential color preferences in hungry and thirsty pigeons with greater numbers of thirsty pigeons responding to a blue colored key. This is a very important finding with reference to color aversion in pigeons. It indicates that blue is not an arbitrary stimulus but in fact, has some clear species survival value. Unfortunately, most studies contrasting the relative salience of different colors have employed equal concentrations without determining that the solutions in fact do not differ on any other critical dimension such as translucence. For example, 0.1% v/v blue water passes less light than similar red water. Thus previous research does not appear capable of resolving the question of whether some colors are more readily associable than others with drug induced illness. Since water occurring in the natural environment may have a blue appearance (from below or above) and feral pigeons may thus have a prior history with blue and, in light of the widespread use of blue color in previous research, using several concentrations of a different color, red, were employed.

Subjects

One hundred twenty-eight pigeons housed under conditions previously described were employed.

Procedure

Initially, ninety-six pigeons were assigned to one of twelve different groups each of which received either: 0.012%, 0.024%, 0.036% or 0.054% HCl; 0.1%, 0.5%, 1.0%, or 1.5% red water (RW); or 0.06M, 0.12M, 0.18M, or 0.24M NaCl solutions on day eight (the first day following seven days of baseline on limited access to food and water). Consumption was recorded after 15 minutes access to the fluid.

Following visual inspection of the day eight consumption data, 32 pigeons were assigned to one of four different groups each of which received either 0.2% RW, 0.137M NaCl, 0.154M NaCl, or 0.163M NaCl solutions on day eight. Consumption was recorded in a manner similar to that employed for the previous twelve groups. The additional experimentation with the latter four groups was conducted to: yield additional information concerning the relationship between red water concentration and consumption; and to attempt to find a salt water solution to which pigeons would respond in a manner similar to that demonstrated to the 0.1% RW and 0.012 HCl solutions.

Results and Discussion

Day eight consumption ratios (novel fluid consumption/average of consumption on the last three days of baseline) were calculated for all birds in all groups (Appendix A). Figure 1 shows the mean consumption ratios for these 16 groups. Non-parametric analysis of variance (Kruskal-Wallis H test) of the consumption ratios for all groups indicates that the groups differed in their consumption of novel fluids ($H = 51.26$; $p < .001$).

Six solutions were selected for further analysis from the sixteen groups based upon mean neophobic consumption ratio data. Two concentrations each of red, salt, and sour water were included. One of every two concentrations was associated with enhanced novel fluid consumption while the other concentration was associated with suppressed consumption. The six solutions and corresponding mean consumption ratio data are presented in Table 1.

Table 1

Equated Stimuli and Corresponding Consumption Ratios

Group	N	Mean Consumption Ratio (novel fluid consumption/ average baseline consumption)
0.1% RW	8	1.14
1.5% RW	8	0.73
0.012% HCl	8	1.15
0.036% HCl	8	0.75
0.163M NaCl	8	1.27
0.24M NaCl	8	0.67

Further analysis revealed that the six groups chosen also differed with respect to their consumption of novel fluids ($H = 20.75$, $p < .001$). However, the consumption ratios of the three groups evidencing enhancement, 0.1% RW, .012% HCl, and 0.163M NaCl, did not differ ($H = 1.25$) from one another, nor did the consumption ratios of the three remaining groups, 1.5% RW, 0.036% HCl, and 0.24M NaCl, which evidenced

suppression (H = 0.04). These results suggest that novel stimulus consumption was very close to equal among the two subgroups categorized for enhanced or suppressed novel fluid consumption.

Subsequent statistical analyses of the consumption ratios with protected rank sums tests reveals that: 0.163M and 0.24M NaCl groups differed significantly, Z = 2.52; 0.012% and 0.036 HCl groups also differed, Z = 2.42; while, the 0.1% and 1.5% RW groups did not differ significantly, Z = 1.58. The latter finding was somewhat surprising given the results shown for these two RW groups in Figure 1 and presented in Table 1. A non-parametric analysis of variance of the consumption ratios of the five groups that received red water was performed. No differences were detected, H = 3.31 (df = 4) suggesting that within-group variability may have obscured the between-group differences in mean day eight consumption ratios of the groups that received red water on day eight.

Table 2 presents the results of Wilcoxon signed rank tests for repeated measures performed to determine whether consumption on day eight differed significantly for each of the six groups from its corresponding average baseline consumption. The three groups which demonstrated initial suppression, 0.036 HCl, 0.24M NaCl, and 1.5% RW, were each found also to have demonstrated significant suppression on day eight. However, only the 0.163M NaCl group demonstrated significant enhancement.

Based upon the results obtained, the six groups presented in Table 1 were selected for further research. While the consumption ratios of the two red water groups, 0.1% and 1.5% RW, did not differ, inspection

Table 2

Results of Test for Significance of Neophobia

Group	Average Baseline Consumption	Day 8 Consumption	Z Score
0.1% RW	12.63	13.75	0.42
1.5% RW	14.33	9.88	1.96*
0.012% HCl	12.83	14.75	1.05
0.036% HCl	14.75	9.75	2.02**
0.163M NaCl	14.79	18.13	1.96*
0.24M NaCl	12.83	8.75	2.10**

*$p \leq .05$

**$p < .05$

of Figure 1 shows little difference in consumption between the 0.5%, 1%, and 1.5% groups and the Kruskal-Wallis analyses demonstrated that both the 0.1% and 1.5% group consumptions equated favorably with the consumptions of the other groups demonstrating enhancement and suppression of consumption respectively.

Several aspects of the data were unanticipated. As can be seen in Figures 2, 3, and 4, as novel stimulus intensity increased, in general, consumption decreased relative to average baseline consumption. However, as shown in Figure 2, the rate of change between the groups receiving the three highest concentrations of red water is slight suggesting that perhaps an asymptotic value may have been reached. Somewhat puzzling are the data presented in Figure 4 which show that five of the seven groups given salt water demonstrated enhanced

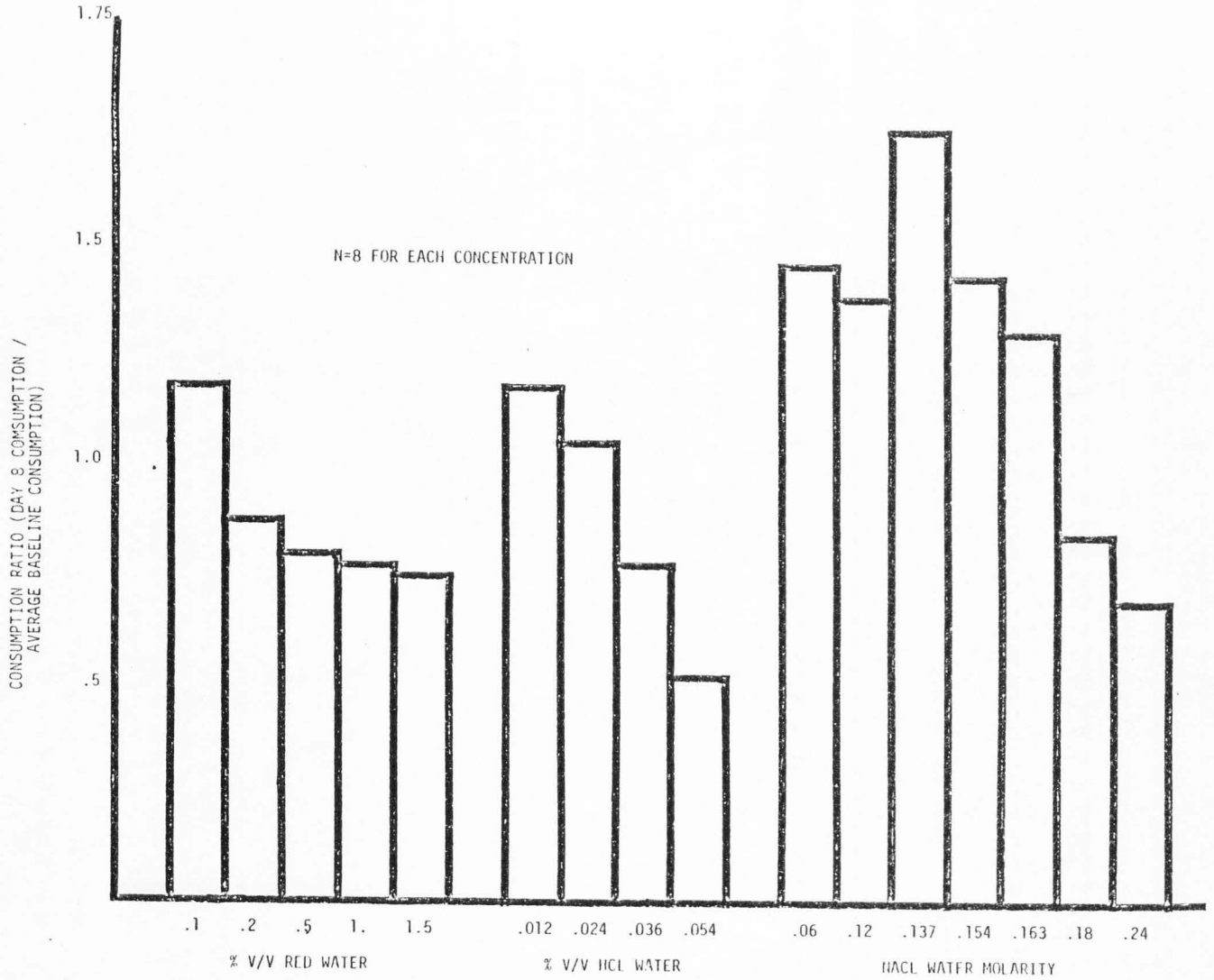

Figure 1: Mean consumption of novel fluids at various concentrations.

consumption. The relatively slight difference in molarity between the solutions received by the 0.163M and 0.18M NaCl groups resulted in observation of either enhancement or suppression of consumption respectively. Apparently, pigeons subjected to a limited access to food and water regimen show preference for a variety of concentrations of salt water but will demonstrate suppression if the concentration increases to some level. The effects that such preferences may have upon the detection of evidence of PBAL are addressed in Experiment III.

In summary, six solutions were selected. Three of the solutions were associated with intake enhancement and did not differ in the degree of enhancement. The remaining three solutions were associated approximately equally with intake suppression. In addition, red, salt, and sour water concentrations were each represented in the two subgroups of solutions associated with consumption enhancement and suppression. Thus the six novel solutions were scaled on the basis of initial consumption. Since neophobia, as defined by a reduction in consumption of a novel stimulus, was not demonstrated to all the stimulus concentrations employed, the use of the term is modified here to include instances of both suppressed and enhanced consumption. Experiment II began immediately with subjects from Experiment I.

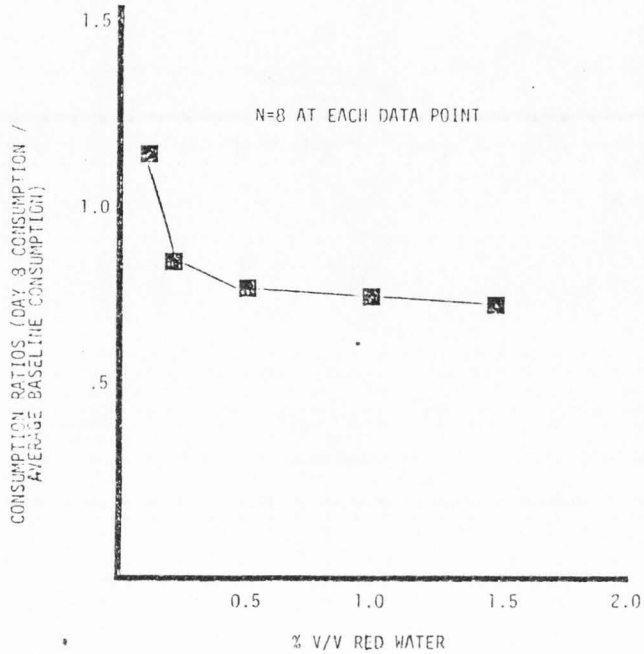

Figure 2: Red water intake as a function of concentration.

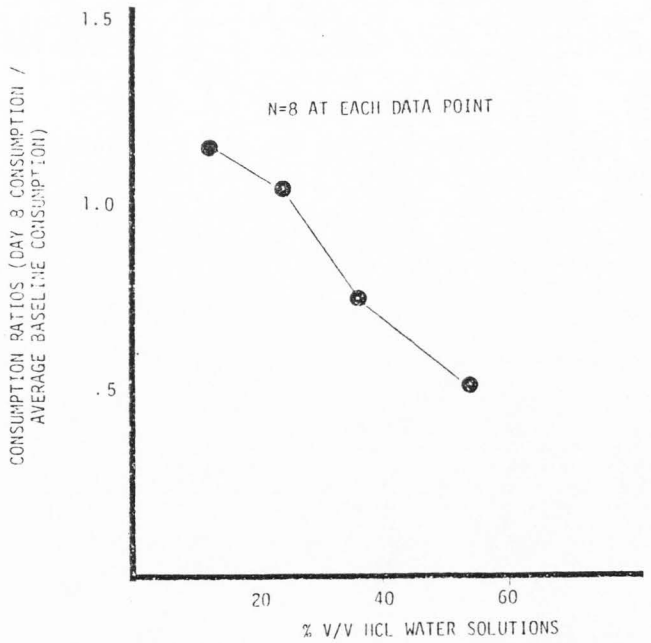

Figure 3: HCL water intake as a function of concentration.

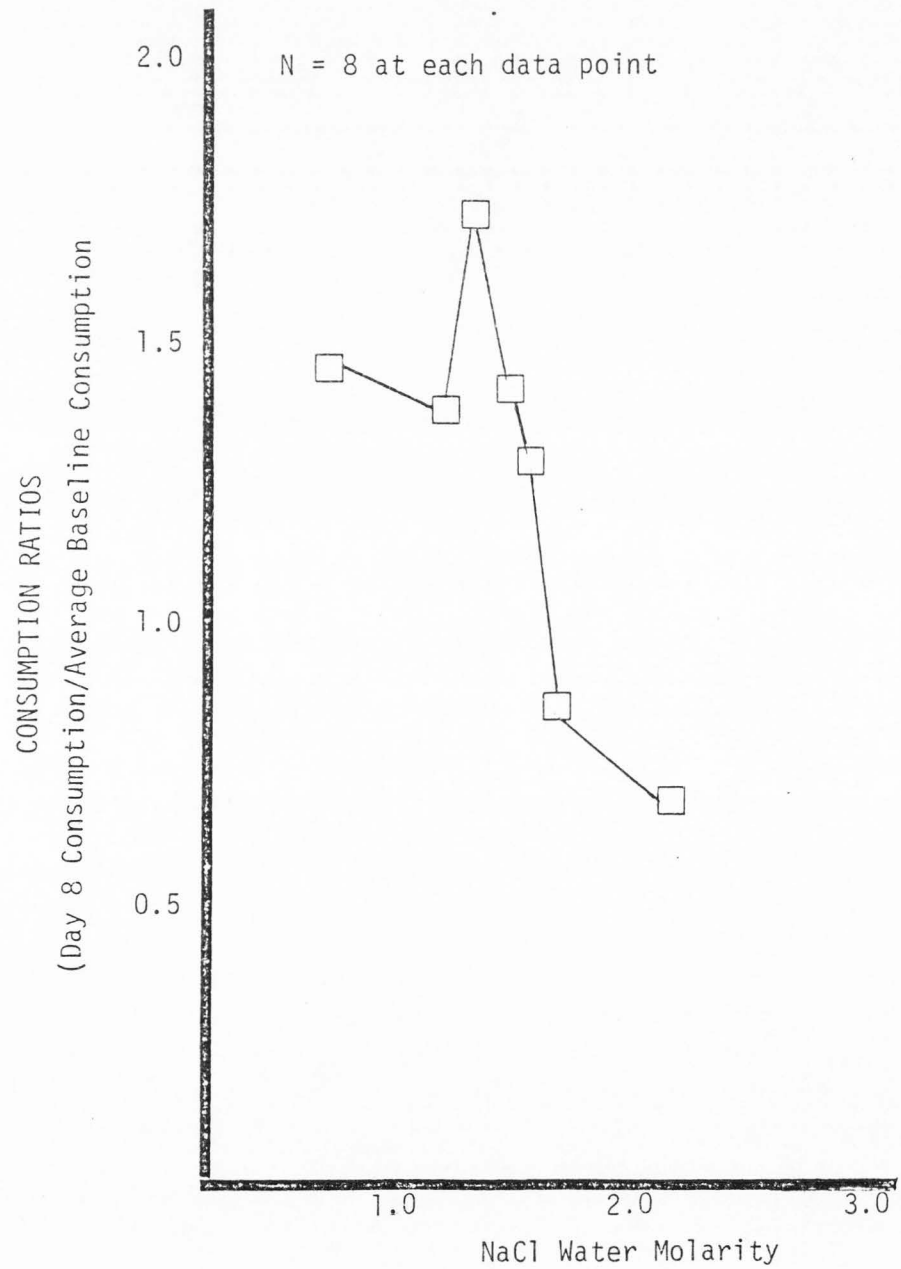

Figure 4: NaCL intake as a function of concentration.

CHAPTER V

EXPERIMENT II

The first experiment employed a forced consumption or one-bottle procedure to determine neophobic responses to a variety of different flavors and colors. Neophobia is a transient phenomenon. Consequently, a preference procedure (two-bottle) appeared inappropriate since a preference procedure requires that the position of the test stimulus be alternated in order to average-out (real) side preference (Frome et al., Note 5). Since neophobia may be nonexistent or greatly diminished even by the second trial, the one-bottle test is a preferable procedure.

In addition, objections can also be raised against the use of a two-bottle test in tests for aversion. My own unpublished research as well as reported work (Frome et al., Note 5) show that side preferences are very prevalent in pigeons. Such biases dictate that the position of the test substances be alternated with the result that at least two trials are necessary to generate a single data point.

An argument against the use of the one-bottle procedure may be linked to the observation of increased fluid consumption in the pigeon following administration of LiCl. Such an increase might therefore obscure any evidence of aversion. Reduction in intake might not be detected if comparisons are made between training-day consumption and test-day consumption if the test-day follows closely upon the training-day. Indeed, consumption might appear as enhancement on a

test-day occurring within two or three days after the training treatment-day. For this reason, it is proposed that the appropriate comparisons, for the demonstration of a learned aversion in studies with avians using LiCl, should be between test-day consumption and what consumption would have been in the absence of the presentation of the CS. For example, a group of birds (Group A) normally consumes an average of 20 ml of water but they consume an average of 40 ml of water (no CS present) on the third day following injection of LiCl. Another group of birds (Group B) also consumes an average of 20 ml before injection but consumes 25 ml on the third day, following LiCl injection, in the presence of the CS. A comparison between test day consumption and baseline consumption for Group B appears to demonstrate enhancement (up 5 ml). A comparison between Group B's consumption on test day and the same day consumption for Group A suggests an actual reduction of 15 ml, in other words, a clear aversion.

Such an approach would allow for early assessment of aversion using a one-bottle procedure. However, the results to date on fluid consumption in the pigeon following a single administration of LiCl, have come from a study where food and water were provided ad lib (Westbrook et al., 1979). Collection of data from an environment where access to food and water is limited is necessary to determine whether the general shape of the function of increased fluid consumption remains the same and to provide a data base for assessment of aversion in Experiment III.

Subjects

Subjects were 112 pigeons that had been used in Experiment I.

Procedure

Following the test for color or flavor neophobia in Experiment I, the birds were quasi-randomly assigned to one of two groups. One group received an injection of LiCl (immediately after the neophobia test) and the other group an injection of distilled water according to the specifications described in the General Methods and Procedures section. All birds remained on the normal limited access to food and water regimen for the subsequent ten days. Water consumption was tracked across time for both groups (Appendices B for LiCl birds and C for distilled water birds).

Results and Discussion

Figure 5 shows the mean fluid intake (on the right) and mean consumption ratios (on the left) for both the distilled water and lithium chloride treated groups for the ten post-treatment days. The data from 17 birds with incomplete data (days on which fluid was spilled in the cage) were not analyzed and the data from one randomly selected subject, bird #41, was not included for the statistical purpose of equating the number of subjects in both groups. Thus, the data from 94 pigeons were treated by an analysis of variance procedure for repeated measures (Keppel, 1973).

Inspection of Figure 5 reveals that: the consumption by the lithium chloride treated birds increased immediately on the day follow-ing treatment; the water consumption of the lithium chloride birds reached an asymptotic value on the second day post injection; and the water consumption of the LiCl treated birds decreased over time (successive periods of access) following the second post-treatment day.

The results of statistical analyses confirmed these observations. Comparisons between mean consumption ratios for both groups at each post-treatment day are presented in Table 3.

The lithium chloride treated birds consumed significantly more water on all days except the 7th, 8th, and 10th.

Day five appears to be the first day following treatment on which consumption by the lithium chloride treated birds approached their average baseline consumption level (a consumption ratio of 1.0). A Wilcoxon matched-pairs signed ranks test comparing the day five consumption to average baseline consumption for the lithium chloride birds was calculated and no significant difference was detected ($Z = 1.23$, $p < .30$).

Lithium chloride treated birds demonstrated signs of illness such as diarrhea and vomiting for a few days but remained viable despite the limited access to food and water regimen. In fact, the shape of the consumption function obtained in the current experiment closely approximated the shape of the function obtained by Westbrook et al. (1979) using a free access to food and water environment.

Findings from this experiment clearly indicate that: 1) birds may be maintained on a limited access to fluids regimen following lithium chloride treatment, and 2) assessment of aversion closely following treatment may be possible by making comparisons to drug-enhanced consumption levels (or control groups) on the day in question rather than to pretreatment baseline levels. This procedure might not be necessary for robust associations. Perhaps strength of association may be accurately inferred from the degree to which increased consumption

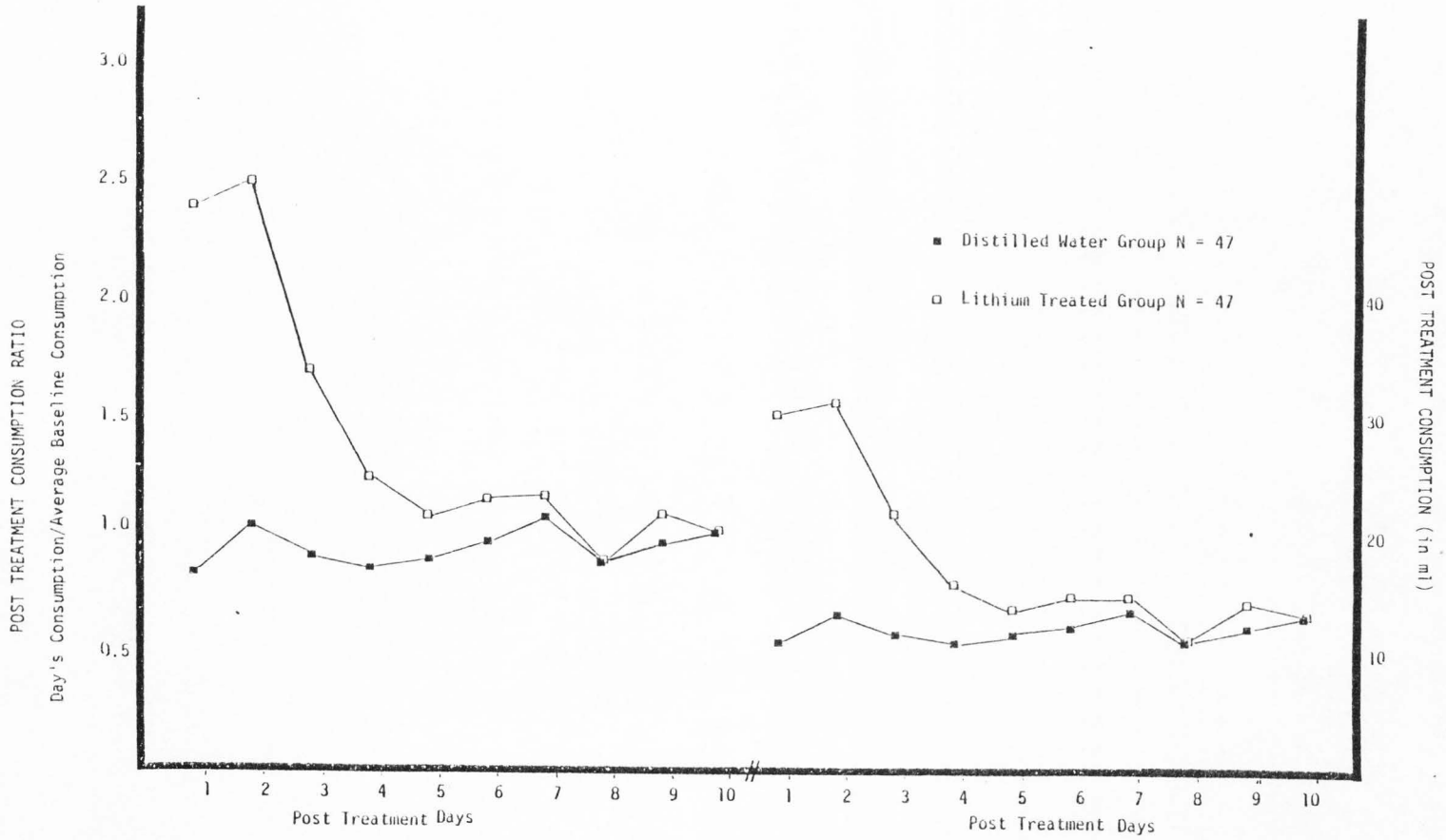

Figure 5: Post treatment consumption as a function of treatment alone. The ratio is shown on the 10-day curve to the left. The absolute consumption is shown on the same 10-day curve to the right.

Table 3

Effects of Type of Treatment on Repeated Consumption Measures

Day	F	df	Significance
1	163.23	*	$p < .001$
2	79.25	*	$p < .001$
3	63.87	*	$p < .001$
4	24.50	*	$p < .001$
5	14.00	*	$p < .001$
6	6.68	*	$p < .025$
7	1.67	*	$p < .25$
8	0.14	*	$p > .25$
9	5.29	*	$p < .05$
10	0.14	*	$p > .25$

* The degrees of freedom for all of the comparisons listed above were (1, 92)

following LiCl treatment is diminished in the presence of a conditional stimulus. These possibilities are explored in the following experiment.

CHAPTER VI

EXPERIMENT III

Experiment III combines the data from the first two experiments and extends their use. The third experiment combines the stimuli, which were scaled on the basis of neophobia, with the use of the assessment criteria developed in Study II of increased consumption of fluids following administration of LiCl. By inducing illness following consumption of the scaled substances, it was possible to demonstrate: the degree to which neophobia was related to the subsequent aversion within a stimulus category. This procedure also allowed for the assessment of the degree to which stimuli, which had been cross-modality scaled, differed in the amount of aversion following pairing with illness. In other words, it was possible, because of Experiments I and II, to present different types of CSs of known equality and to determine aversion shortly after treatment.

Subjects

Subjects were 227 experimentally naive pigeons with the same characteristics as described in the General Methods and Procedures.

Apparatus

Two different concentrations of each of three different stimulus solutions: NaCl water; HCl water; and red water, as well as a compound of red-HCl water were employed. Concentrations of the single element solutions to be used were determined in Experiment I and are listed in

Table 4 with a simplified notational system for identifying the groups and stimuli used in the following sections. For example, the notation N_H means high (H) sodium (N); R_L means red (R), low concentration (L).

Table 4

Stimulus Notation and Neophobic Effect

Stimulus Notation	New Notation	Neophobic Effect in Experiment I
0.24M NaCl	N_H	suppressed consumption
0.163M NaCl	N_L	enhanced consumption
0.036% HCl	H_H	suppressed consumption
0.012% HCl	H_L	enhanced consumption
1.5% Red Water	R_H	suppressed consumption
0.1% Red Water	R_L	enhanced consumption
Plain Water	W	none
1.5% Red Water + 0.036% HCl	R_HH_H	compound not run in Experiment I

Procedures

On the eighth day of baseline which was the limited access regimen, pigeons were semi-randomly assigned to one of several experimental or control groups such that average total consumption was closely equated between groups with eight birds per group. Birds in experimental groups received one of the novel stimulus elements, or the novel stimulus compound, on day eight followed by the appropriate injection of LiCl. Control birds received plain tapwater on day eight followed by the appropriate dose of LiCl. Experimental birds were

given tests for aversion on one of two post-treatment days. Sensitization effects were assessed for the control birds on one of the same two post-treatment days. The spacing of the two post-treatment days was determined from the results of Experiment II. These test days were: day ten (the second post-treatment day), the day when water consumption following injection was at its asymptote; and day thirteen (the fifth post-treatment day), the earliest day following evidence of return to baseline levels of consumption (Experiment II, Figure 5). A more detailed delineation of the various groups and their respective treatments is outlined in Appendices D and G. The standard maintenance procedures described in the General Methods and Procedures were followed.

Results and Discussion

Data were obtained pertaining to the demonstration of differential conditioning to: a) the different concentrations within a stimulus solution such as NaCl water; b) between stimulus solutions; and c) the component elements and the compound following compound conditioning. The correlation between degree of neophobia (defined in this study, page 36 as enhancement or suppression) and the subsequent degree of aversion for each of the six groups at each of the two test times was calculated. Data from the two different times of test were contrasted with respect to the differential demonstration of aversion depending upon whether a standard data analysis method or the new proposed methodology was employed. In addition, the consumption ratios for Day eight were contrasted both within and across experiments in determining whether the degree of neophobia to the stimuli differed from the levels

observed in Experiment I and if the various groups continue to demonstrate stimulus equality with respect to novel stimulus fluid intake. That is, part of Experiment III was analyzed as a replication attempt of Experiment I.

Two separate analyses of the first phase of Experiment III were conducted. The first and more traditional approach consisted of an overall non-parametric analysis of variance (Kruskal-Wallis H) for the 24 groups and then conducting subsequent Kruskal-Wallis and protected rank sum tests. Experimental and sensitization control groups consumption ratios were compared with one another to determine whether aversion had occurred and whether it was evidenced differentially.

The second approach consisted of making comparisons between the Day ten group's and Day thirteen group's consumption data and that of the LiCl treated group in Experiment II (Group LiCl) for those comparable days. To that end, two separate Kruskal-Wallis tests were conducted with the Experiment II consumption data for Day ten included in the analysis with the data of the 12 groups tested on Day ten. The second Kruskal-Wallis test was conducted including the 12 groups tested on day thirteen and the intake data from the LiCl treated group from Experiment II. The results of the first approach follow.

After finding significant differences in test day consumption between the 24 groups ($H = 129.53$, $p < 0.001$), subsequent analyses were conducted and are listed in Tables 5 and 6. Data are presented graphically in Figures 6 and 7.

Fluid intake of the six experimental groups tested at Day ten was significantly different ($H = 24.79$, $p < 0.001$) from one another. Those three groups which were given stimuli associated with enhanced

Table 5

Contrasts of Consumption Ratios

on Test Day Ten

	Contrast	Mean Ratios	Results	Significance
A.	11 vs. 9 vs. 3 vs. 1 vs. 7 vs. 5	1.46 vs. 0.26 vs. 0.42 vs. 0.15 vs. 1.56 vs. 0.63	H = 24.79*	$p < 0.001$
B.	11 vs. 3 vs. 7	1.46 vs. 0.42 vs. 1.56	H = 8.82	$p < 0.02$
C.	3 vs. 11	0.42 vs. 1.46	Z = 2.52	$p < 0.02$
D.	3 vs. 7	0.42 vs. 1.56	Z = 2.52	$p < 0.02$
E.	11 vs. 7	1.46 vs. 1.56	Z = 0.63*	$p > 0.40$
F.	9 vs. 1 vs. 5	0.26 vs. 0.15 vs. 0.63	H = 5.06*	$p < 0.10$
G.	11 vs. 9 vs. 3 vs. 1 vs. 7 vs. 5a	1.46 vs. 0.26 vs. 0.42 vs. 0.15 vs. 1.56 vs. 0.25	H = 28.96*	$p < 0.001$
H.	9 vs. 1 vs. 5a	0.26 vs. 0.15 vs. 0.25	H = 1.92*	$p > 0.20$
I.	1 vs. 3	0.15 vs. 0.42	Z = 0.85*	$p < 0.40$
J.	5 vs. 7	0.63 vs. 1.56	Z = 2.21	$p < 0.05$
K.	9 vs. 11	0.26 vs. 1.46	Z = 3.28*	$p < 0.001$

* Values corrected for tied ranks (Ferguson, 1981).

H = Kruskal-Wallis Test

Z = Protected Rank Sum Test

Table 5, Continued

Contrasts of Consumption Ratios

on Test Day Ten

Contrast	Mean Ratios	Results	Significance
L. 5a vs. 7	0.25 vs. 1.56	$Z = 3.36$	$p < 0.001$
M. 1 vs. 2	0.15 vs. 1.93	$Z = 3.25^*$	$p < 0.001$
N. 3 vs. 4	0.42 vs. 1.66	$Z = 2.71^*$	$p < 0.001$
O. 5 vs. 6	0.63 vs. 1.33	$Z = 1.79$	$p < 0.10$
P. 7 vs. 8	1.56 vs. 1.70	$Z = 0.73^*$	$p < 0.50$
Q. 9 vs. 10	0.26 vs. 1.43	$Z = 3.18^*$	$p < 0.001$
R. 11 vs. 12	1.46 vs. 1.97	$Z = 2.21$	$p < 0.05$

Table 6

Contrasts of Consumption Ratios on

Test Day Thirteen

Contrast	Mean Ratios	Results	Significance
AA. 23 vs. 21 vs. 15 vs. 13 vs. 19 vs. 17	0.72 vs. 0.13 vs. 0.36 vs. 0.04 vs. 0.98 vs. 0.10	H = 27.64*	$p < 0.001$
BB. 23 vs. 19 vs. 15	0.72 vs. 0.98 vs. 0.36	H = 6.15*	$p < 0.05$
CC. 15 vs. 19	0.36 vs. 0.98	Z = 2.49*	$p < 0.02$
DD. 15 vs. 23	0.36 vs. 0.72	Z = 1.68	$p < 0.10$
EE. 19 vs. 23	0.98 vs. 0.72	Z = 0.83*	$p < 0.50$
FF. 13 vs. 17 vs. 21	0.04 vs. 0.10 vs. 0.13	H = 1.99*	$p > 0.20$
GG. 13 vs. 15	0.04 vs. 0.36	Z = 2.87*	$p < 0.005$
HH. 17 vs 19	0.10 vs. 0.98	Z = 3.56*	$p < 0.001$
II. 21 vs. 23	0.13 vs. 0.72	Z = 2.54*	$p < 0.02$
JJ. 13 vs. 14	0.04 vs. 1.05	Z = 3.60*	$p < 0.001$
KK. 15 vs. 16	0.36 vs. 0.70	Z = 2.16*	$p < 0.05$
LL. 17 vs. 18	0.10 vs. 0.54	Z = 3.80*	$p < 0.001$
MM. 19 vs. 20	0.98 vs. 0.94	Z = 0.06*	$p > 0.95$

* Values corrected for tied ranks.

H = Kruskal-Wallis Test

Z = Protected Rank Sum Test

Table 6

Contrasts of Consumption Ratios on

Test Day Thirteen

Contrast	Mean Ratios	Results	Significance
NN. 21 vs. 22	0.13 vs. 0.90	$Z = 3.12^*$	$p < 0.001$
OO. 23 vs. 24	0.72 vs. 0.87	$Z = 1.00^*$	$p < 0.40$

novel fluid intake in Experiment I also differed in the degree of aversion demonstrated at Day ten (Table 5, Contrast B: $H = 8.82$, $p < 0.02$), with the 0.136M salt water group showing a greater degree of aversion compared to both 0.1% red water (Contrast C: $z = 2.52$, $p < 0.02$) and 0.012 HCl water (Contrast D: $Z = 2.52$, $p < 0.02$). The 0.1% red water and 0.012 HCl water groups did not differ (Contrast E).

The three groups which received the stimuli equated for suppression did not consume different amounts of fluid (Contrast F: $H = 5.06$, $p > 0.10$) on the test day.

Since inspection of the data (Appendix E) for Group 5 (0.036 HCl water) revealed that the consumption of two birds (166 and 168) was deviant, three additional birds were used, two of which were selected for replacement (322 and 324). Group 5a consisted of the six birds from Group 5 plus the two replacement birds. Contrasts G and A, including Group 5a, did not differ from those obtained with Group 5. However, the mean consumption ratio decreased from 0.63 for Group 5 to 0.25 for the revised group.

Contrasts M through R compared experimental group performance with the corresponding sensitization control groups. All comparisons were

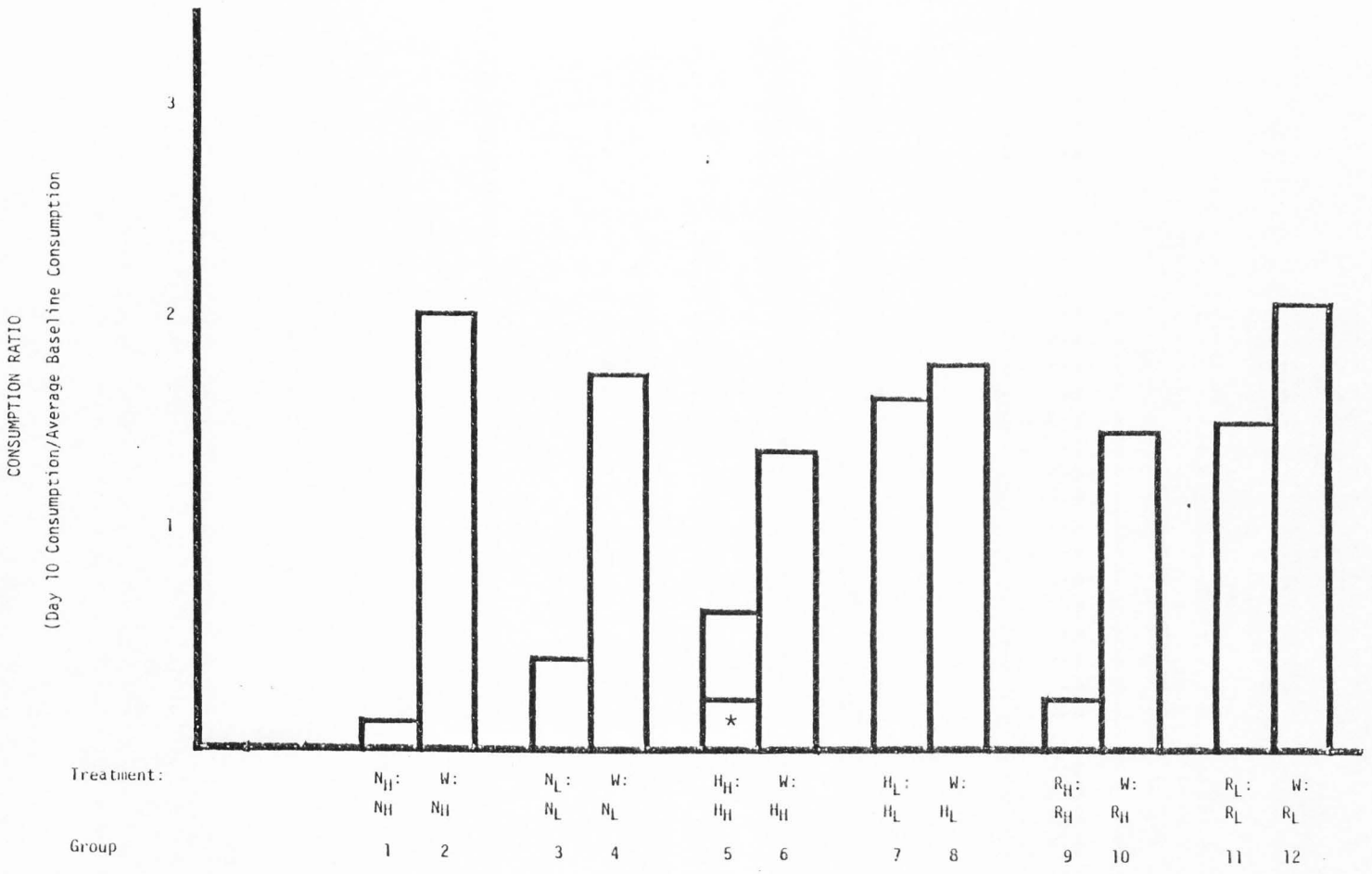

Figure 6: Day 10 test consumption contrasts between experimental and control groups.

*Consumption of group 5A

significant except those between the two HCl water groups and their controls (Contrast 7 vs. 8 and 5 vs. 6).

Comparisons of Day ten consumption ratios for the two concentrations of red water, NaCl water, and HCl water were significant for all the comparisons (Contrasts 5 vs. 7, 9 vs. 11, and 5a vs. 7) except that between 0.163M NaCl and 0.24M NaCl (Contrast 1 vs. 3). The differences obtained were in the expected direction with the stimuli equated for suppression in Experiment I associated with a greater aversion (reduction in Day ten consumption) than the contrasted groups which were equated for enhanced novel stimulus consumption.

Similar sets of statistical comparisons were conducted on Day 13 test data and are presented in Table 6. The exceptions are that Day 10, Contrasts G, H, and L were not conducted since no group analogous to Group 5a was tested at Day 13.

Figure 7 shows the mean Day 13 consumption ratios for the 12 groups. Groups 13, 17, and 21 which received stimuli equated for novel fluid intake suppression did not differ with respect to their demonstrations of aversion (Contrast FF). The Day 13 consumption of each of the aforementioned groups differed from their respective controls (Contrasts JJ, LL, and NN; all $p < 0.001$).

The three groups which received stimuli equated for novel fluid intake enhancement, Groups 15, 19, and 23, differed with regard to their demonstrations of aversion (Contrast BB; $H = 6.15$, $p < 0.05$). Group 15, which received 0.163M NaCl water, consumed significantly less test fluid on Day 13 than Group 19 (Contrast CC; $Z = 2.49$, $p < 0.02$). Comparisons between the Day 13 consumption ratios of Group 15 and 23 as well as 19 and 23 were not significant (Contrasts DD and EE). As

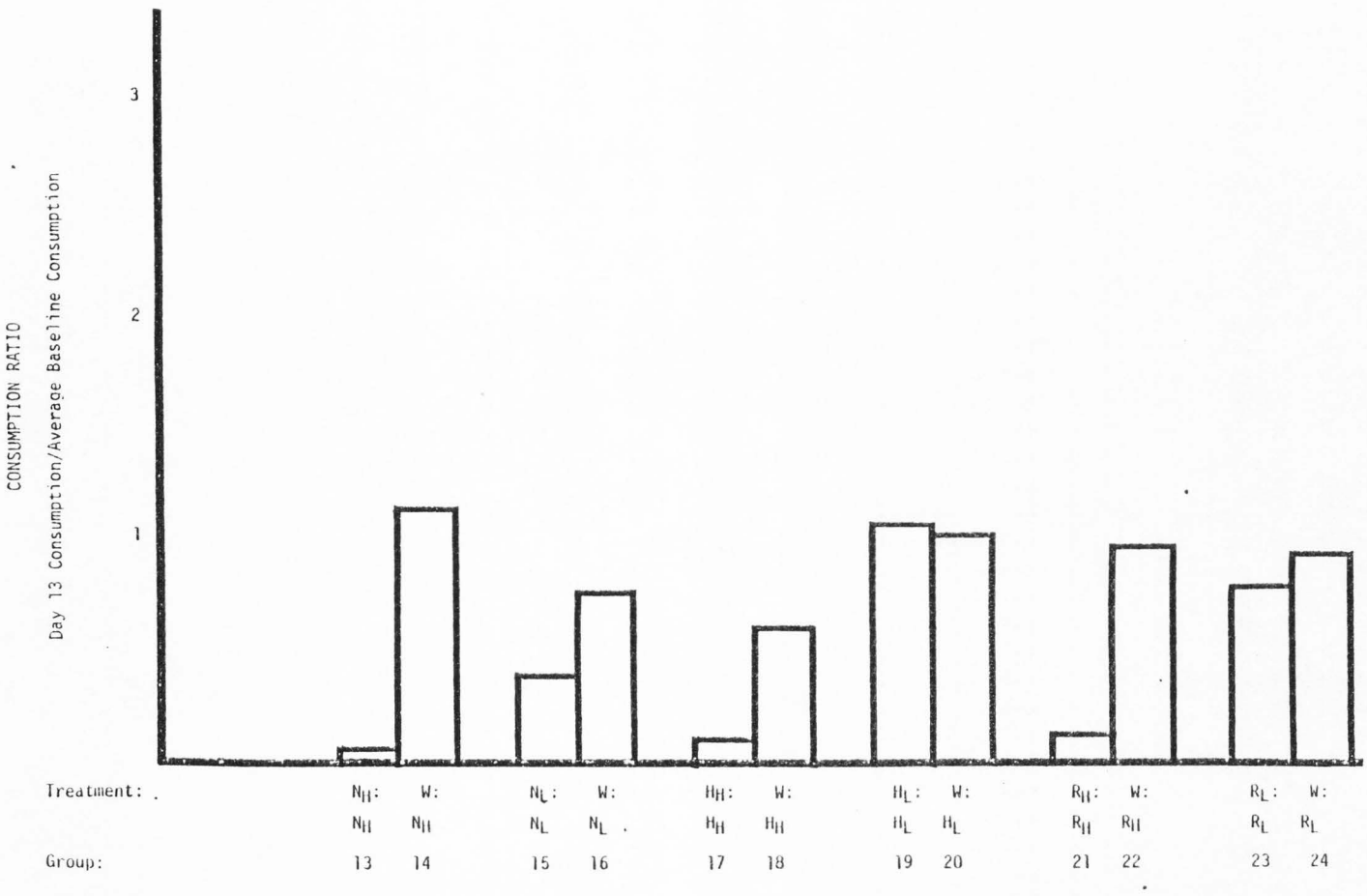

Figure 7: Day 13 test consumption contrasts between experimental and control groups.

observed in the tests on Day 10, the group which received the 0.163M NaCl water differed from the other two groups which were initially equated for novel fluid intake enhancement in Experiment I. However, the other two groups did not differ from one another with respect to their fluid intake whether tested at Day 10 or Day 13. Such results suggest that the pigeons' consummatory responses to NaCl stimuli may have been unique. This issue is addressed in greater detail in subsequent passages.

Statistical analyses were conducted to assess the relationship between stimulus concentration and degree of aversion. All three groups which received the higher of the two concentrations of NaCl water, HCl water, and red water, showed greater aversion to the test stimuli than the corresponding groups receiving the lower concentration (Contrasts GG, HH, and II; $p < 0.001$, 0.02, 0.001 respectively). These results are consistent with the results obtained for the same comparisons at Day ten.

Protected rank sums tests between experimental groups and corresponding sensitization control groups were also made. All contrasts were significant (JJ, KK, LL, and NN) with two exceptions (Contrasts MM and OO). The experimental groups which received the lower concentrations of HCl water, Group 21, and red water, Group 23, did not differ in Day 13 consumption from their corresponding sensitization control groups. This absence of differentiation between the Day 13 fluid consumption of experimental and sensitization controls militates against concluding that aversions were demonstrated for these groups.

Comparisons were also made between Day 10 and Day 13 fluid consumption for the twelve experimental groups in an effort to ascertain whether the aversions demonstrated on the two test days differed in degree. Table 7 lists these comparisons. Only the contrasts between Groups 7 and 19 and Group 11 and 23 were found to be

Table 7

Contrasts of Consumption Ratios on Test Day 13 and 10 for Experimental Group

Contrast	Mean Ratios	Results	Significance
S. 1 vs. 13	0.15 vs. 0.04	Z = 1.67	$p < 0.10$
T. 3 vs. 15	0.42 vs. 0.36	Z = 0.00	----
U. 5 vs. 17	0.25 vs. 0.10	Z = 0.84	$p < 0.50$
V. 7 vs. 19	1.56 vs. 0.98	Z = 2.40	$p < 0.02$
W. 9 vs. 21	0.26 vs. 0.13	Z = 0.89	$p < 0.40$
X. 11 vs. 23	1.46 vs. 6.72	Z = 2.94	$p < 0.01$

Z = Protected Rank Sum Test

significant with consumption levels of Groups 19 and 23 greater than those of Groups 7 and 11 respectively. However, these differences should not be construed to be evidence of aversion formation.

Comparison of the data shown on Figure 6 and Figure 7 reveals that the greatest proportion of the differences in consumption ratios between Day 10 and Day 13 can be accounted for by the proportion of consumption above average baseline consumption. This is shown on

Figure 6 as that area above the ratio value of 1.0 for both Group 7 and Group 11.

For those groups administered stimuli equated for novel fluid intake suppression, consumption levels on test day did not differ among groups nor between test days but did differ from the consumption levels of their corresponding sensitization control groups.

For those groups administered stimuli which were associated with fluid intake enhancement, consumption levels on test day did differ. Specifically, the groups administered 0.163M NaCl water showed aversion at Day 10 and Day 13 while the consumption levels of those groups given 0.1% red water and 0.012% HCl water did not differ from each other at Day 10 or Day 13. Considering the data at Test Day 10 and Day 13 for both experimental groups and control groups, neither the 0.1% red water or 0.012% HCl groups demonstrated aversions.

A proposal was advanced that suggested that the appropriate comparisons in PBAL studies should be between test day consumption and what consumption would have been in the absence of CS presentation following LiCl treatment. Experiment II provided information regarding the effects of LiCl administration on consumption in a restricted water access environment. The current experiment investigated the relative PBAL associated with various stimuli at two different post-treatment times when, according to the results of Experiment II, the enhancement effects upon consumption due to LiCl administration should have had either maximum (Day 10) or negligible (Day 13) influence. Figures 8 and 9 show the mean consumption ratios of the 24 groups tested on either Day 10 or Day 13 and the mean consumption ratios observed on

similar post-treatment days for Group 2, the group which received LiCl in Experiment II.

All groups showed reduced levels of consumption on Day 13 compared to levels observed on Day 10. However, as noted in preceding passages, no differences were detected in the degree of aversion demonstrated between Day 10 and Day 13 except for the two groups for which no evidence of aversion compared to controls was obtained at either time of test.

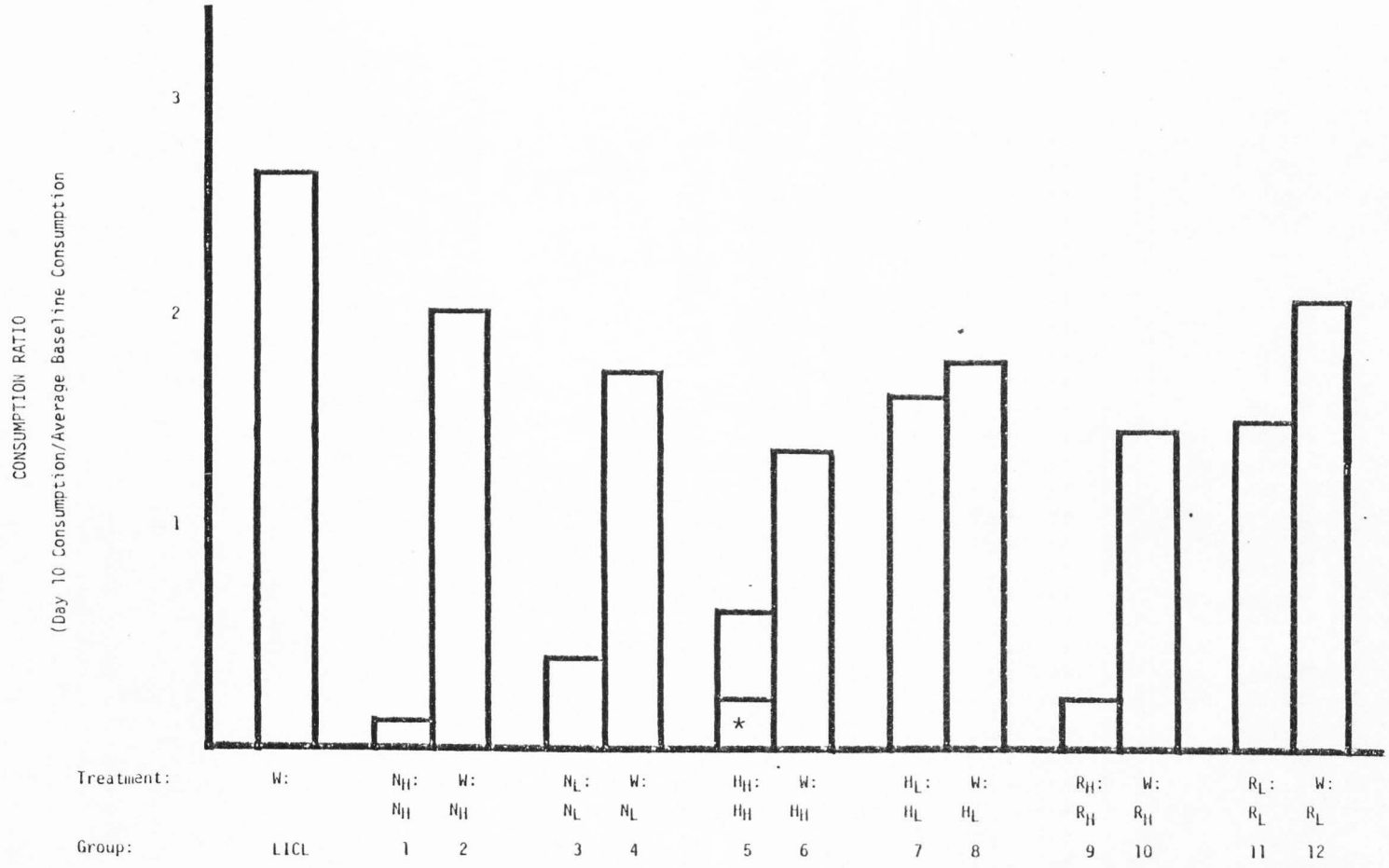

Figure 8: Day 10 test consumption for conditioned and non-conditioned groups.

*Consumption of group 5A

A significant increase in suppression of experimental group consumption levels was expected between Days 10 and 13 since the LiCl Group (group from Experiment II) mean consumption ratio decreased from approximately 2.5 on Day 10 to 1.0 on Day 13 (Figures 8 vs. 9). However, such effects were not observed. In fact, analysis of several comparisons yielded information which, if taken on face value, would indicate that stronger aversions were demonstrated at Day 10 than on Day 13. Table 8 presents data from four comparisons involving the two experimental groups which displayed elevated consumption levels on Day 10. As can be seen, the contrast between Group LiCl and Group 19 (a group which received 0.012 HCl) was significant on Day 10 when illness effects should have had their greatest influence. Yet, the comparison of consumption on Day 13 between Group LiCl and Group 19 was not significant.

Table 8

Selected Contrasts Between Consumption Ratios Following LiCl Treatment With and Without a CS Present

Contrast	Test Day	Mean Ratios	Results	Significance
LiCl vs. 7	10	2.51 vs. 1.56	Z = 2.86	$p < 0.01$
LiCl vs. 19	13	1.09 vs. 0.98	Z = 0.92	$p < 0.40$
LiCl vs. 11	10	2.51 vs. 1.46	Z = 3.05	$p < 0.01$
LiCl vs. 23	13	1.09 vs. 0.72	Z = 2.39	$p < 0.02$

Z = Protected Rank Sum Test

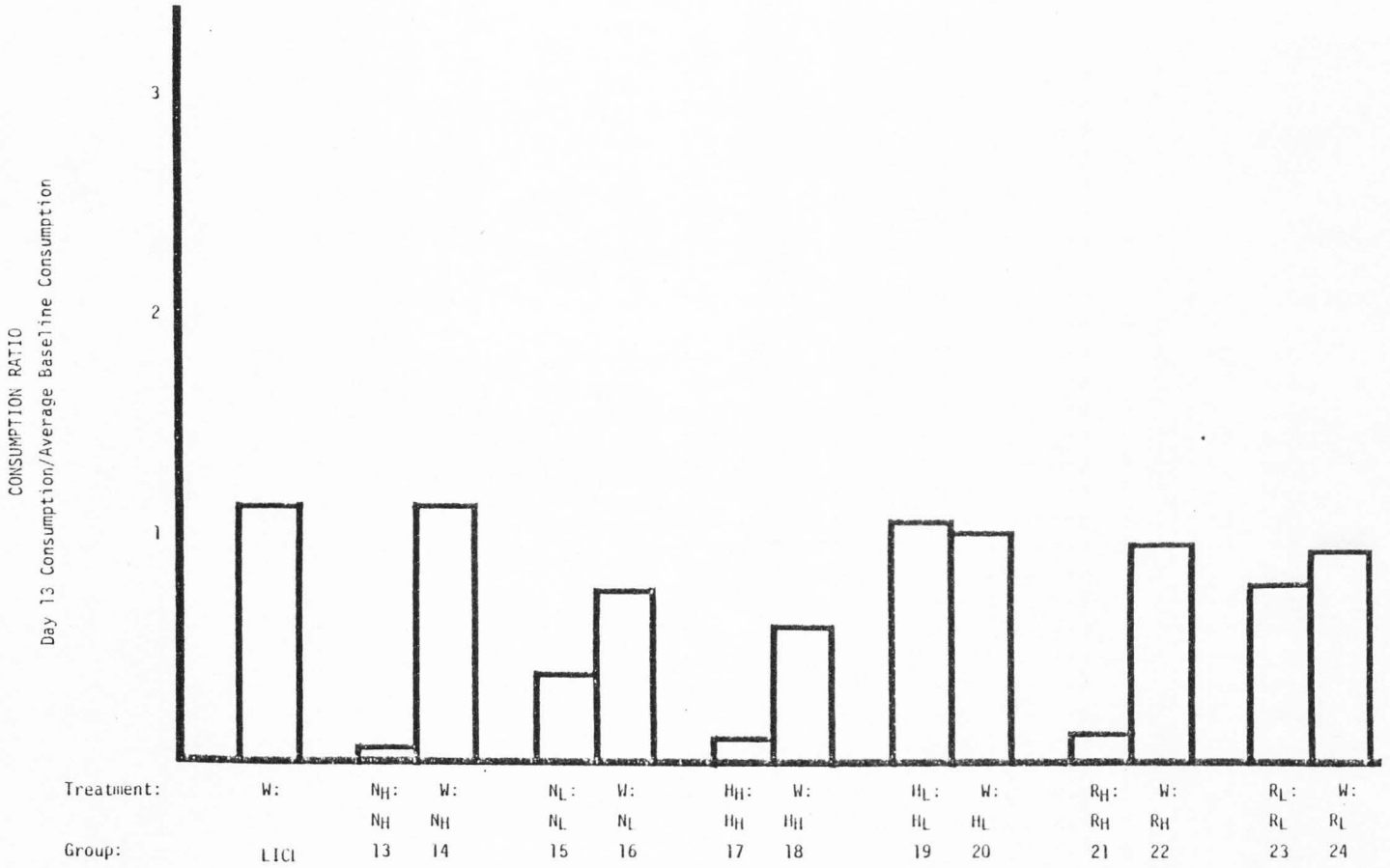

Figure 9: Day 13 test consumption for conditioned and non-conditioned groups.

Similar diminutions of effect were also observed for the comparisons between Group LiCl and Groups 11 and 23 which received 0.1 red water. These results are contradictory to the assumptions made concerning the influence of LiCl-induced illness upon consumption and the detection of aversions. It was assumed that the differences between the consumption levels obtained in Experiment II and those obtained to conditioned stimuli of various concentrations in the current experiment might have been used to aid in the prediction of consumption in the presence of a CS at a particular post-treatment time. That is, a proposal was made which suggested that the reduction in consumption due to an association between a particular CS and UCS might be a constant which could be manipulated in an additive fashion with another factor, the influence of illness upon consumption, to enable prediction of PBAL. The results obtained are at odds with such assumptions. As a consequence, the proposed assessment methodology was abandoned.

In the compound conditioning investigation, four groups were treated (Appendix G). The data from six birds (Group 27) assigned to the various conditions were not analyzed since these birds demonstrated complete suppression to the compound red-HCl water (R_HH_H) on their initial exposure on Day eight. Because of this suppression, one cannot include these birds as they obviously did not contact the flavor stimulus. Table 9 lists the four groups exposed to the compound stimulus as well as other appropriate contrast groups from the single substance conditioning phase of this experiment. Day 10 mean consumption ratios are listed for all the aforementioned groups.

Table 9

Mean Consumption Ratio for Compound Conditioning Phase

Group	Treatment	N	Mean Ratio	
25	R_HH_H:R_H	6	0.27	
26	R_HH_H:H_H	5	0.53	
27	R_HH_H:R_HH_H	6	0.00	(total suppression)
28	W:R_HH_H	8	0.33	
6	W:R_H	8	1.43	
10	W:H_H	8	1.33	
9	R_H:R_H	8	0.26	
5	H_H:H_H	8	0.36	

Letters left of the colon in the treatment column indicate the initial substance and intensity to which subjects were exposed on Day 8. Letters to the right of the colon indicate the Day 10 test substance.

R_H = 1.5% red water H_H = 0.036 HCl water

R_HH_H = 1.5% red water + 0.036 HCl water

A non-parametric analysis of the mean consumption ratios of all eight groups listed in Table 9 was conducted. This analysis determined that the groups significantly differed in their test day fluid consumption relative to their average baseline consumption ($H = 33.6$, $p < .001$). Aversion was present and significant in all experimental groups.

As shown in Figure 10, Group 27, the group tested on the compound stimulus (R_HH_H:R_HH_H) demonstrated the greatest degree of aversion. In fact, the birds in that group completely suppressed their consumption of the compound flavor-color stimulus.

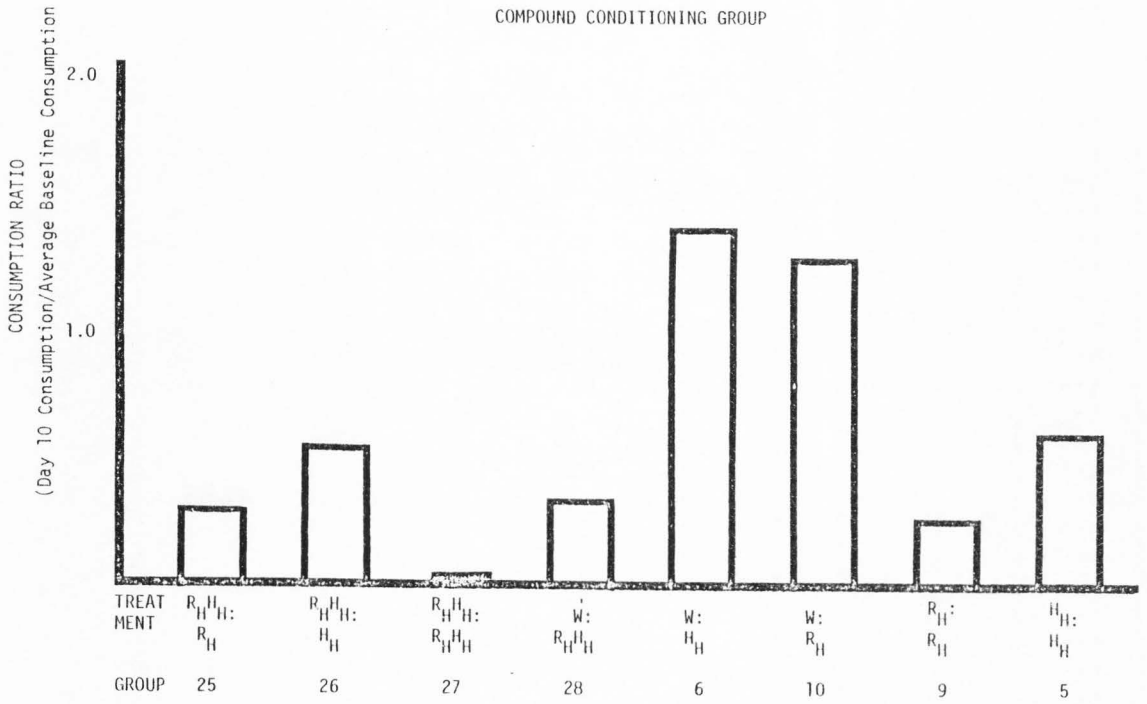

Figure 10: Consumption comparisons between groups receiving compound conditioning and their controls.

The results of all between-group comparisons are listed in Table 10. A Kruskal-Wallis analysis of the three groups tested on either the compound or the elements following the initial pairing of the compound with illness on Day eight (Contrast B), confirmed that the groups' mean Day ten consumption ratios differed. Subsequent applications of protected rank sums tests (Welkowitz et al., 1976) revealed that Group 27 tested with the compound demonstrated significantly greater aversion than did Group 26 tested on the HCl water element (Contrast H, $p < .01$), but did not differ from Group 25 tested with red water (Contrast G, $p < .40$). In addition, these two groups tested on the elements only did not differ from each other in their Day 10 consumption (Contrast F, $p < .10$).

To determine whether overshadowing or potentiation occurred to either the flavor or color stimuli as a result of compound presentation, two additional comparisons were made. Contrasts I and J compared the mean consumption ratios of Groups 25 and 26 with Groups 9 and 5 from the first phase. The results (nonsignificant) indicate that the degree of aversion to either 0.036% HCl water or 1.5% red water was not different whether the stimuli were conditioned singly or in compound. These results argue strongly against an interpretation that either overshadowing or potentiation of one element by another occurred. However, since Group 27, which was both conditioned and tested on the compound, evidenced the greatest degree of aversion (although the contrast with the color element alone group was nonsignificant) one is forced to recognize that a summation effect of

Table 10

Results of Contrasts of Consumption Between Compound or Single Modality Stimuli

Contrast	Mean Ratios	Results	Significance
A. 25 vs. 26 vs. 27 vs. 28 vs. 5 vs. 6 vs. 9 vs. 10	0.27 vs. 0.53 vs. 0.00 vs. 0.33 vs. 0.63 vs. 1.33 vs. 0.26 vs. 1.43	H = 33.6*	p < .001
B. 25 vs. 26 vs. 27	0.27 vs. 0.53 vs. 0.00	H = 19.72*	p < .001
C. 25 vs. 6	0.27 vs. 1.33	Z = 2.54*	p < .01
D. 26 vs. 10	0.53 vs. 1.43	Z = 2.28	p < .025
E. 27 vs. 28	0.00 vs. 0.33	Z = 2.16*	p < .01
F. 25 vs. 26	0.27 vs. 0.53	Z = 1.92*	p < .10
G. 25 vs. 27	0.27 vs. 0.00	Z = 1.00*	p < .40
H. 27 vs. 26	0.00 vs. 0.53	Z = 2.74	p < .01
I. 25 vs. 9	0.27 vs. 0.26	Z = 0.57*	p > .50
J. 26 vs. 5	0.53 vs. 0.63	Z = 0.44	p > .50

* Values were corrected for tied ranks (Ferguson, 1981).

H = Kruskal-Wallis Test

Z = Protected Rank Sum

sorts occurred whereby conditioning to each of the elements combined in an additive manner when the stimuli were presented in compound. This finding requires further empirical examination.

Day eight mean consumption ratios for the experimental groups are presented together with corresponding data from Experiment I in Table 11. Data from the current experiment (III) were pooled across groups tested at either Day 10 or Day 13. Following statistical analyses which confirmed that the combined groups (groups from both Experiment I and the current experiment) differed in their intake of the novel

Table 11

Mean Consumption Ratios of Novel Fluid on Day Eight*

Group	Current Ratio (N=16)	Experiment I (N=8)
Enhancement		
R_L (0.1% RW)	0.97	1.14
H_L (0.012% HCl)	1.02	1.15
N_L (0.16M NaCl)	1.02	1.27
Supression		
R_H (1.5% RW)	0.73	0.73
H_H (0.012% HCl)	0.76	0.75
N_H (0.16M NaCl)	0.74	0.76

* The number is the ratio of Day 8 consumption over baseline which indicates both increases and decreases.

fluids on Day eight ($H = 43.32$, $p < 0.001$), protected rank sum tests were conducted with the results presented in Table 12. The results of comparisons number one and two indicate that the groups which received fluids associated with suppression and enhancement of novel fluid intake, respectively, did not differ in the current experiment. Comparisons three through eight reveal no statistical differences between the neophobia of groups in the first and current experiments to the six fluids. These results confirm that the scaling procedure resulted in measures which were reliable across experiments (Experiment I and III).

Pearson product moment correlation coefficients were calculated from individual difference scores to assess the degree of correlation between the neophobia observed on Day eight (treatment day) and the aversion demonstrated on test days 10 or 13. Difference scores for Days eight, ten, and thirteen were obtained by subtracting the fluid intake on those days from the average baseline consumption of each bird in each of the twelve experimental groups. Table 13 presents the correlation coefficients for these twelve groups. The variability of the correlations between groups and the absence of significant correlations between neophobia and subsequent aversion are apparent.

Considering the variability within groups (Appendices E and F), four additional coefficients of correlation between neophobia and aversion were calculated from mean group, as opposed to individual, difference scores for the same days as in the preceeding analysis. Table 14 presents these additional results.

Table 12

Results of Statistical Analyses

of Neophobia Data

	Comparison	Mean Ratio	Statistic	df	Significance
1.	* III R_H vs H_H vs N_H	0.73 vs. 0.76 vs. 0.54	H = 4.95	2	$p < .10$
2.	**III R_L vs H_L vs H_L	0.97 vs. 1.02 vs. 1.03	H = 0.9	2	$p < .40$
3.	III R_L vs I R_L	0.97 vs. 1.14	Z = 0.46	-	$p < .65$
4.	III R_H vs I R_H	0.73 vs. 0.73	Z = 0.37	-	$p < .75$
5.	III H_L vs I H_L	1.02 vs. 1.15	Z = 1.13	-	$p < .30$
6.	III H_H vs I H_H	0.76 vs. 0.75	Z = 0.03	-	$p < .98$
7.	III N_L vs I N_L	1.03 vs. 1.27	Z = 1.56	-	$p < .15$
8.	III N_H vs I N_H	0.54 vs. 0.67	Z = 0.67	-	$p < .50$

H = Kruskal-Wallis Test

Z = Protected Rank Sum Test

1. * Comparison of Day 8 consumption ratios for the groups which received stimuli to which <u>suppression</u> was evidenced in Experiment I.
2. ** Comparison of Day 8 consumption ratios for the groups which received stimuli to which <u>enhancement</u> was evidenced in Experiment I.
3. III indicates an Experiment III group.
4. I indicates an Experiment I group.

Table 13

Correlation Between Day Eight and Test Day

Fluid Consumption

Group	Test Day	Mean Difference (in ml) Avg - Day 8	Avg - Test Day	Pearson Correlation Coefficient (r)
1 (N_H)	10	7.37	11.74	0.74
3 (N_L)	10	1.37	8.87	0.29
5 (H_H)	10	2.63	4.87	0.26
7 (H_L)	10	1.42	-8.08	0.37
9 (R_H)	10	4.00	10.00	0.22
11 (R_L)	10	1.29	-4.59	0.37
13 (N_H)	13	6.29	14.67	-0.04
15 (N_L)	13	-0.63	10.12	0.38
17 (H_H)	13	4.79	13.54	0.64
19 (H_L)	13	-2.05	0.95	0.10
21 (R_H)	13	3.25	13.37	0.67
23 (R_L)	13	-0.04	4.21	-0.56

The correlation coefficients for the experimental groups tested on Day ten and on Day thirteen were 0.67 and 0.87 respectively with the latter coefficient being significant ($p < .05$). Analysis of these groups equated for suppression (row 3, Table 3) yielded Pearson correlation coefficients of 0.55 for those groups tested on Days ten and thirteen, while a coefficient of 0.92 was obtained for the three groups tested on Day thirteen. These results allow for the suggestion that while the individual data may not support prediction, proposals

Table 14

Correlation Between Day Eight and Test Day Fluid Consumption for Combined Groups

Combined Groups	Mean Difference (in ml) Avg-Day 8	Avg-Test Day	Test Day	Correlation Coefficient	
1, 3, 5, 7, 9, 11	18.08	22.81	10	0.67	df = 4
13, 15, 17, 19, 21, 23	11.61	56.86	13	0.87*	df = 4
1, 5, 9, 13, 17, 21	28.33	68.19	10,13	0.55	df = 4
13, 17, 21	14.33	41.58	13	0.92	df = 1

* Significant $p < .05$

may be made based upon group analyses. First, factors associated with the time of test, such as the rate of recovery from illness, may have influenced the nature of the relationship detected. Second, the degree of intake suppression may be a more reliable predictor of subsequent aversion than is the degree of enhancement. The failure to obtain a significant relationship between the intake of novel fluids (neophobia) and subsequent aversion presents problems for predicting aversion with respect to the assumption of a linear relationship between novel stimulus intake and aversion.

However, the results of the present experiment provide important information with regard to the issues of the relative associability of stimuli and the conformance of PBAL to the general laws of learning. These issues and their relationship to the finding of this study are discussed in detail in the subsequent chapter.

CHAPTER VII

GENERAL DISCUSSION

The present study demonstrates several findings of importance to the PBAL literature. First, stimuli affecting different sensory receptors can be scaled with respect to the pigeons' consummatory response in their presence. Second, equally strong aversions were obtained to both visual and flavor stimuli when these stimuli were initially equated on the basis of fluid intake suppression. Third, summation rather than potentiation or overshadowing was observed in a compound conditioning procedure. Finally, CS intensity effects were observed in that the more intense the concentration of a CS solution stronger the aversion. These findings and their relationship to PBAL literature in general, and the avian literature specifically, are discussed in the following.

As noted in the Review of the Literature, it has been suggested that not all stimuli are equally associable (Seligman & Hager, 1972) and that either visual (Wilcoxon et al., 1971) or flavor (Clarke et al., 1979; Lett, 1980) cues are more readily associable than the other with illness with avians. The issue was raised that in most studies stimuli had not been equated in any manner and thus equal stimuli may not have been employed. Experiment I of the present research showed that stimuli could be equated for either suppression or enhancement of intake of novel colored or flavored fluids. The stimuli associated with suppression provided the more consistent results. Importantly,

the suppression and enhancement effects observed in Experiment I were replicated in Experiment III. The degree of enhancement or suppression in Experiment III was not different from that observed in Experiment I for the same stimuli. While the degrees of suppression observed in one segment of this study were reliably observed in another, it should not be assumed that either the same absolute levels or relative relationship would be obtained in other settings under different procedures. For example, the length of the habituation period before assessment may affect the degree of neophobia observed. Also the history of the birds or the nature of the stimuli employed might act to produce different results. Since the use of stimuli that were equated for enhancement resulted in different outcomes, it may be that stimuli to which an organism's novelty response is increased consumption associate in a different manner with illness than those stimuli to which the response is suppression of intake. Since the low concentration of red water and HCl water used did not result in significant enhancement during neophobia assessment nor in significant aversions, it might be argued that the pigeons failed to detect these stimuli. However, the salt water solution equated on the basis of neophobia with these stimuli did result in a significant aversion. But, the solution of salt water used was higher than the concentration successfully employed by Lett (1980). Perhaps pigeons also respond in a unique manner to NaCl so that detectability is confounded with flavor preference or physiological need.

As mentioned earlier, claims have been made to the effect that avians respond differentially to visual and flavor cues (Brett et al., 1976; Clark et al., 1979; Lett, 1980; Wilcoxon, 1977). No support for

either of the positions was found in Experiment III where the stimuli which were equated with respect to novel fluid intake suppression were associated with equal demonstrations of aversion. These results suggest that some of the differential findings reported elsewhere may reflect methodological inadequacies rather than the avian's abilities. The present findings of equal associability of the scaled stimuli with illness do not provide support for Rozin and Kalat's (1971) concept of "adaptive specializations for learning" unless it is assumed that avians and pigeons, in this instance, are specially adapted to associate flavor and visual cues with illness. It may be argued that what has been manipulated in this study is the ease with which associations are formed. By that, it is meant that perhaps visual cues are more readily associated with illness at low intensity levels, but if intensity is increased sufficiently, the flavor stimulus paired with illness results in a similar or greater demonstration of aversion. That argument is difficult to lay aside and also difficult to prove since either proof would appear to necessitate indirect methods of assessment.

The results of the compound conditioning component of the present study are of particular interest since Wilcoxon et al. (1971) has reported overshadowing of flavor by color with quail while Lett (1980) and Clark et al. (1979) have reported potentiation of color aversion by flavor. Neither effect was observed in results obtained in Experiment III. Rather, a summation effect was observed. The aversion to the red HCl water compound was significantly greater than that to the HCl water element and greater (although not significantly so) than the aversion

to the red water element. In addition, the aversions to the elements conditioned in compound did not differ from that associated with those elements conditioned singly. These results do not necessarily negate the results obtained by the aforementioned investigators; rather they may complement them and suggest that compound conditioning may take various forms depending upon relative stimulus intensities. Thus, flavor may not always serve to potentiate color aversions.

Testa and Ternes (1977) have cited the relationship of conditioning to CS intensity as an example of results which are observed in PBAL and other forms of laboratory conditioning. The present study also found that degree of aversion and CS intensity were related. Those groups which received the higher concentrations (stronger CSs) demonstrated greater reductions in consumption to the test stimuli than corresponding groups which received lower concentrations. These results suggest that the appropriate reaction to an observed failure to detect an aversion would be to increase stimulus intensity rather than suggest that the organism is unable to form an association.

The information gathered in Experiment II concerning the effects of LiCl administration upon consumption in a limited access to water environment appears to have utility for two reasons. First, the data demonstrate that birds can clearly be maintained on a limited access to fluid regimen and remain viable allowing for earlier post-treatment testing. This has been an argument put forth by those advocating preference testing only after sufficient recovery from illness (Dragoin, 1971; Dragoin et al., 1971; Grote & Brown, 1971). Second, although no differential effects of illness-induced increased

consumption were observed on the detection of aversion in the present study, the possibility that other intensities or stimuli might be affected remains. Thus, information about the nature of the increased consumption functions will be of value in the future.

It is not clear which variables account for the individual differences found between subjects within groups. These differences may have been responsible for the failure to detect significant correlations between neophobia and subsequent aversion for specific substances. However, individual differences in the metabolism of the drug could produce different associations. If drug effect onset varied internally, then different interstimulus intervals among birds could have occurred producing a range of variability. Such occurrences may be common in this literature necessitating the use of large n studies and probably contributing to the many apparent contradictions.

A non-quantitative observation appears in order. The phenomena studied was robust. In fact, after one pairing of LiCl with red water, pigeons were observed to retreat from the front cage panel when they were later tested and to begin vomiting while shaking their heads and wings. These behaviors could be observed on the second day post-injection when birds treated with LiCl normally consume an average of two and one half times their average baseline amount of fluid. Birds were also observed to vomit on the test day following tentative consumption of flavored waters although more birds responded in that manner to colored water. Clearly, the birds were able to associate visual and flavor information with illness.

In conclusion, the data reported here support the view that PBAL is a specialized subset of classical conditioning.

Demonstrations of equal aversions to visual and flavor cues as well as stimulus intensity effects provide support for this view. While robust learning took place in one trial, this phenomenon may be regarded as a quantitative difference from those acquisition effects normally observed rather than a qualitative difference (Logue, 1979). Since the pigeons in the present study averted equally to visual and flavor cues, it does not appear necessary to use concepts such as "adaptive specialization" (Rozin & Kalat, 1971) or "biological preparedness" (Seligman, 1970) to account for the data reported here.

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APPENDICES

Appendix A

Experiment I Data

Group	Bird	Consumption (in ml) Average Baseline (Last 3 days)	Novel Stimulus	Novel Stimulus consumption As A Ratio of Avg. Baseline Consumption
0.12M NaCl	1	9.0	9.0	1.00
	2	11.0	16.0	1.45
	3	20.67	25.0	1.21
	4	13.33	14.0	1.05
	5	12.0	29.0	2.42
	6	11.0	10.0	0.91
	7	12.0	13.0	1.08
	8	14.67	25.0	1.70
	Total	103.67	141.0	10.83
	Mean	12.96	17.63	1.35
	Standard Deviation	3.53	7.63	0.50
0.06M NaCl	9	8.67	17.0	1.96
	10	11.67	16.0	1.37
	11	15.0	14.0	0.93
	12	15.0	20.0	1.33
	13	14.0	26.0	1.86
	14	8.33	15.0	1.80
	15	10.67	10.0	0.94
	16	15.0	17.0	1.13
	Total	98.34	135.0	11.32
	Mean	12.29	16.88	1.42
	Standard Deviation	2.85	4.67	0.41
0.012% HCl	17	11.0	12.0	1.09
	18	15.67	24.0	1.53
	19	14.33	12.0	0.84
	20	11.33	13.0	1.15
	21	14.67	15.0	1.02
	22	15.67	14.0	0.89
	23	8.0	9.0	1.13
	24	12.0	19.0	1.58
	Total	102.67	118.0	9.23
	Mean	12.83	14.75	1.15
	Standard Deviation	2.71	4.71	0.27

Group	Bird	Consumption (in ml) Average Baseline (Last 3 days)	Novel Stimulus	Novel Stimulus consumption As A Ratio of Avg. Baseline Consumption
1% Red Water	25	12.33	15.0	1.27
	26	11.0	5.0	0.45
	27	10.33	15.0	1.45
	28	8.0	1.0	0.13
	29	14.0	2.0	0.14
	30	13.33	12.0	0.90
	31	11.0	7.0	0.64
	32	13.67	14.0	1.02
	Total	93.66	71.0	6.00
	Mean	11.71	8.88	0.75
	Standard Deviation	2.03	5.84	0.49
0.1% Red Water	33	8.0	17.0	2.13
	34	11.0	11.0	1.00
	35	14.33	16.0	1.12
	36	15.33	8.0	0.52
	37	12.67	11.0	0.87
	38	15.0	16.0	1.07
	39	13.67	24.0	1.76
	40	11.0	7.0	0.64
	Total	101.0	110.0	9.11
	Mean	12.63	13.75	1.14
	Standard Deviation	2.50	5.60	0.55
0.5% Red Water	41	22.0	21.0	0.95
	42	9.0	4.0	0.44
	43	9.67	9.0	0.93
	44	11.67	6.0	0.51
	45	10.67	11.0	1.03
	46	7.67	7.0	0.91
	47	18.0	15.0	0.83
	48	17.0	10.0	0.59
	Total	105.68	83.0	6.19
	Mean	13.21	10.38	0.77
	Standard Deviation	5.13	5.45	0.23

Group	Bird	Consumption (in ml) Average Baseline (Last 3 days)	Novel Stimulus	Novel Stimulus consumption As A Ratio of Avg. Baseline Consumption
1.5 Red Water	49	19.0	14.0	0.74
	50	12.67	15.0	1.18
	51	8.33	9.0	1.08
	52	21.33	12.0	0.56
	53	21.67	10.0	0.46
	54	12.67	8.0	0.63
	55	9.0	6.0	0.67
	56	10.0	5.0	0.50
	Total	114.67	79.0	5.82
	Mean	14.33	9.88	0.73
	Standard Deviation	5.52	3.60	0.27
0.024% HCl	57	17.67	24.0	1.36
	58	16.0	15.0	0.94
	59	11.0	9.0	0.82
	60	9.33	13.0	1.39
	61	20.0	19.0	0.95
	62	11.67	11.0	0.94
	63	9.67	8.0	0.83
	64	13.33	13.0	0.98
	Total	108.67	112.0	8.21
	Mean	13.58	14.0	1.03
	Standard Deviation	3.92	5.32	0.22
0.036% HCl	65	9.0	6.0	0.67
	66	7.33	10.0	1.36
	67	23.67	14.0	0.59
	68	17.33	12.0	0.69
	69	16.67	7.0	0.42
	70	13.0	13.0	1.00
	71	13.67	5.0	0.37
	72	12.67	11.0	0.87
	Total	113.34	78.0	5.97
	Mean	14.17	9.75	0.75
	Standard Deviation	5.13	3.37	0.32

Group	Bird	Consumption (in ml) Average Baseline (Last 3 days)	Novel Stimulus	Novel Stimulus consumption As A Ratio of Avg. Baseline Consumption
0.18M NaCl	73	15.0	11.0	0.73
	74	13.0	5.0	0.38
	75	15.0	28.0	1.87
	76	17.0	5.0	0.29
	77	11.67	6.0	0.51
	78	18.33	14.0	0.76
	79	10.0	9.0	0.90
	80	23.67	27	1.14
	Total	123.67	105.0	6.58
	Mean	15.46	13.13	0.82
	Standard Deviation	4.29	9.40	0.51
0.24M NaCl	81	12.33	10.0	0.81
	82	17.0	14.0	0.82
	83	9.33	2.0	0.21
	84	15.67	14.0	0.89
	85	12.67	14.0	1.11
	86	11.33	3.0	0.26
	87	14.67	3.0	0.20
	88	9.67	10.0	1.03
	Total	102.67	70.0	5.33
	Mean	12.83	8.75	0.67
	Standard Deviation	2.77	5.31	0.38
0.054% HCl	89	13.67	4.0	0.29
	90	18.0	6.0	0.33
	91	14.0	14.0	1.00
	92	13.67	4.0	0.29
	93	16.33	16.0	0.98
	94	18.67	6.0	0.32
	95	16.0	3.0	0.19
	96	9.0	5.0	0.56
	Total	119.34	58.0	3.96
	Mean	14.92	7.25	0.50
	Standard Deviation	3.06	4.92	0.32

Group	Bird	Consumption (in ml) Average Baseline (Last 3 days)	Novel Stimulus	Novel Stimulus consumption As A Ratio of Avg. Baseline Consumption
0.2% Red Water	97	10.0	12.0	1.20
	98	14.67	14.0	0.95
	99	16.0	18.0	1.13
	100	12.67	10.0	0.79
	101	10.33	8.0	0.77
	102	16.67	6.0	0.36
	103	18.0	16.0	0.89
	104	12.33	8.0	0.65
	Total	110.67	92.0	6.74
	Mean	13.83	11.50	0.84
	Standard Deviation	2.96	4.24	0.27
0.137M NaCl	105	16.33	12.0	0.73
	106	9.0	30.0	3.33
	107	15.33	23.0	1.50
	108	17.67	25.0	1.41
	109	11.33	28.0	2.47
	110	18.0	25.0	1.39
	111	16.67	18.0	1.08
	112	13.33	22.0	1.65
	Total	117.66	183.0	13.56
	Mean	14.71	22.88	1.70
	Standard Deviation	3.22	5.72	0.83
0.154M NaCl	113	11.0	14.0	1.27
	114	14.0	28.0	2.00
	115	12.33	16.0	1.30
	116	22.0	25.0	1.14
	117	8.67	16.0	1.85
	118	19.0	22.0	1.16
	119	15.0	18.0	1.20
	120	15.0	20.0	1.33
	Total	117.0	159.0	11.25
	Mean	14.63	19.88	1.41
	Standard Deviation	4.28	4.85	0.33

Group	Bird	Consumption (in ml) Average Baseline (Last 3 days)	Novel Stimulus	Novel Stimulus consumption As A Ratio of Avg. Baseline Consumption
0.163M NaCl	121	8.67	14.0	1.61
	122	20.67	25.0	1.21
	123	16.0	15.0	0.94
	124	14.0	10.0	0.71
	125	11.0	20.0	1.82
	126	18.33	20.0	1.09
	127	13.33	20.0	1.50
	128	16.33	21.0	1.29
	Total	118.33	145.0	10.17
	Mean	14.79	18.13	1.27
	Standard Deviation	3.88	4.76	0.36

Appendix B

Fluid Consumption Over Ten Days Following Lithium Chloride Treatment

Bird	Average (last 3 days)	Consumption (in ML)										Post Treatment Consumption Ratio (Daily Consumption/Baseline Average Consumption)									
		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
5	12.0	10.0	12.0	16.0	12.0	15.0	15.0	10.0	15.0	16.0	15.0	0.83	1.00	1.33	1.00	1.25	1.25	0.83	1.25	1.33	1.25
6	11.0	7.0	10.0	8.0	8.0	9.0	10.0	10.0	10.0	8.0	10.0	0.63	0.91	0.73	0.73	0.82	0.91	0.91	0.91	0.73	0.91
7	12.0	11.0	14.0	11.0	11.0	11.0	12.0	11.0	12.0	14.0	14.0	0.92	1.17	0.92	0.92	0.92	1.00	0.92	1.00	1.17	1.17
8	14.67	6.0	17.0	13.0	13.0	14.0	13.0	14.0	13.0	12.0	11.0	0.41	1.16	0.89	0.89	0.95	0.89	0.95	0.89	0.82	0.75
13	14.0	9.0	15.0	13.0	13.0	13.0	11.0	18.0	15.0	18.0	19.0	0.64	1.07	0.93	0.93	0.93	0.79	1.29	1.07	1.29	1.36
14	8.33	14.0	16.0	8.0	5.0	9.0	11.0	9.0	10.0	11.0	11.0	1.68	1.92	0.96	0.60	1.08	1.32	1.08	1.20	1.52	1.32
15	10.67	10.0	14.0	11.0	9.0	11.0	13.0	12.0	10.0	12.0	15.0	0.94	1.31	1.03	0.84	1.03	1.22	1.12	0.94	1.12	1.41
16	15.0	12.0	16.0	15.0	11.0	16.0	15.0	24.0	12.0	13.0	17.0	0.80	1.07	1.00	0.73	1.07	1.00	1.60	0.80	0.87	1.13
21	14.67	14.0	23.0	14.0	11.0	14.0	15.0	15.0	14.0	15.0	16.0	0.95	1.57	0.95	0.75	0.95	1.02	1.02	0.95	1.02	1.10
22	15.67	21.0	14.0	17.0	13.0	18.0	13.0	21.0	13.0	23.0	19.0	1.34	0.89	1.08	0.83	1.15	0.83	1.34	0.83	1.47	1.21
23	8.0	5.0	10.0	9.0	7.0	10.0	11.0	6.0	8.0	10.0	11.0	0.63	1.25	1.13	0.88	1.25	1.38	0.75	1.00	1.25	1.38
24	12.0	9.0	14.0	10.0	12.0	14.0	14.0	18.0	12.0	14.0	20.0	0.75	1.17	0.83	1.00	1.17	1.17	1.50	1.00	1.17	1.67
29	14.0	17.0	14.0	16.0	10.0	13.0	19.0	12.0	11.0	13.0	18.0	1.21	1.00	1.14	0.71	0.93	1.36	0.86	0.79	0.93	1.29
30	13.33	17.0	20.0	13.0	10.0	15.0	15.0	14.0	15.0	14.0	19.0	1.28	1.50	0.98	0.75	1.13	1.13	1.05	1.13	1.05	1.43
31	11.0	6.0	15.0	8.0	10.0	9.0	11.0	14.0	8.0	10.0	10.0	0.55	1.37	0.73	0.91	0.82	1.00	1.27	0.73	0.91	0.91
32	13.67	16.0	16.0	11.0	15.0	13.0	12.0	20.0	15.0	20.0	19.0	1.17	1.17	0.80	1.10	0.95	0.88	1.46	1.10	1.46	1.39
37	12.67	10.0	14.0	14.0	11.0	10.0	10.0	11.0	11.0	12.0	12.0	0.79	1.11	1.11	0.87	0.79	0.79	0.87	0.87	0.95	0.95
38	15.0	15.0	19.0	12.0	16.0	13.0	16.0	17.0	15.0	18.0	12.0	1.00	1.27	0.80	1.07	0.87	1.07	1.13	1.00	1.20	0.80
39	13.67	3.0	16.0	13.0	10.0	15.0	17.0	12.0	12.0	13.0	10.0	0.22	1.17	0.95	0.73	1.10	1.24	0.88	0.88	0.95	1.46
40	11.0	7.0	10.0	10.0	10.0	10.0	10.0	15.0	12.0	10.0	10.0	0.63	0.91	0.91	0.91	0.91	0.91	1.36	1.10	0.91	0.91
45	10.67	9.0	12.0	10.0	13.0	9.0	11.0	16.0	9.0	13.0	10.0	0.84	1.12	0.94	1.22	0.84	1.03	1.50	0.84	1.22	0.94
46	7.67	4.0	6.0	4.0	5.0	5.0	9.0	13.0	6.0	8.0	7.0	0.52	0.78	0.52	0.65	0.65	1.17	1.69	0.78	1.04	0.91
47	18.0	8.0	13.0	13.0	15.0	13.0	12.0	17.0	12.0	11.0	10.0	0.44	0.72	0.72	0.83	0.72	0.67	0.94	0.67	0.61	0.56
48	17.0	10.0	15.0	13.0	20.0	7.0	13.0	17.0	8.0	12.0	15.0	0.59	0.88	0.76	1.18	0.41	0.76	1.00	0.47	0.71	0.88
54	12.67	11.0	13.0	11.0	10.0	15.0	11.0	18.0	11.0	13.0	11.0	0.87	1.03	0.87	0.87	1.18	0.87	1.42	0.87	1.03	0.87
55	9.0	6.0	10.0	8.0	8.0	7.0	11.0	12.0	8.0	8.0	11.0	0.67	1.11	0.89	0.89	0.78	1.22	1.33	0.89	0.89	1.22
56	10.0	5.0	10.0	7.0	9.0	6.0	11.0	13.0	11.0	7.0	14.0	0.50	1.00	0.70	0.70	0.60	1.10	1.30	1.10	0.70	1.40
61	20.0	17.0	14.0	14.0	14.0	12.0	13.0	17.0	15.0	12.0	17.0	0.85	0.70	0.70	0.70	0.60	0.65	0.85	0.75	0.60	0.85
62	11.67	5.0	11.0	7.0	7.0	9.0	7.0	12.0	10.0	9.0	12.0	0.43	0.94	0.60	0.60	0.77	0.60	1.03	0.86	0.77	1.03
63	9.67	6.0	9.0	9.0	7.0	8.0	10.0	12.0	8.0	12.0	7.0	0.62	0.93	0.93	0.93	0.83	1.03	1.24	0.83	1.24	0.72
64	13.33	5.0	12.0	10.0	10.0	12.0	11.0	13.0	10.0	4.0	14.0	0.38	0.90	0.75	0.75	0.90	0.83	0.98	0.75	0.30	1.05
69	16.67	10.0	5.0	18.0	16.0	16.0	13.0	18.0	11.0	10.0	11.0	0.60	0.30	1.08	1.08	0.96	0.78	1.08	0.66	0.60	0.66
70	13.0	6.0	10.0	16.0	8.0	13.0	10.0	17.0	7.0	14.0	11.0	0.46	0.77	1.23	1.23	1.00	0.77	1.31	0.54	1.08	0.85
71	13.67	13.0	9.0	13.0	18.0	8.0	13.0	15.0	8.0	17.0	12.0	0.95	0.66	0.95	0.95	0.50	0.95	1.10	0.59	1.24	0.88
72	12.67	9.0	12.0	9.0	9.0	11.0	7.0	14.0	8.0	10.0	11.0	0.71	0.95	0.71	0.71	0.87	0.55	1.11	0.63	0.79	0.87
77	11.67	13.0	13.0	11.0	9.0	11.0	14.0	13.0	11.0	14.0	12.0	1.11	1.11	0.94	0.94	0.94	1.20	1.11	0.94	1.20	1.03
78	18.33	19.0	19.0	15.0	20.0	11.0	12.0	12.0	16.0	9.0	11.0	1.04	1.04	0.82	0.82	0.60	0.65	0.65	0.87	0.49	0.60
79	10.0	9.0	11.0	11.0	8.0	9.0	10.0	11.0	10.0	8.0	10.0	0.90	1.10	1.10	1.10	0.90	1.00	1.10	1.00	0.80	1.00
80	23.67	27.0	26.0	23.0	12.0	16.0	24.0	24.0	20.0	20.0	30.0	1.14	1.10	0.97	0.97	0.68	1.01	1.01	0.85	0.85	1.27

		Consumption (in ML)										Post Treatment Consumption Ratio (Daily Consumption/Baseline Average Consumption)									
Bird	Average (last 3 days)	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
75	15.0	50.0	52.0	58.0	29.0	17.0	28.0	30.0	15.0	20.0	20.0	3.33	3.47	3.87	1.93	1.13	1.87	2.00	1.00	1.33	1.33
76*	17.0	29.0	32.0	34.0	12.0	12.0	14.0	15.0	11.0	12.0	---	1.71	1.89	2.00	0.71	0.71	0.82	0.88	0.65	0.71	---
81	12.33	20.0	17.0	12.0	12.0	12.0	12.0	11.0	10.0	8.0	11.0	1.62	1.38	0.97	0.97	0.97	0.97	0.89	0.81	0.65	.89
82	17.0	41.0	28.0	20.0	17.0	20.0	16.0	15.0	15.0	15.0	20.0	2.41	1.65	1.18	1.00	1.18	0.94	0.88	0.88	0.88	1.18
83	9.33	39.0	32.0	11.0	6.0	10.0	5.0	13.0	6.0	10.0	10.0	4.18	3.43	1.18	0.64	1.07	0.54	1.39	0.64	1.07	1.07
84	15.67	41.0	32.0	22.0	21.0	15.0	18.0	11.0	16.0	22.0	15.0	2.62	2.04	1.40	1.34	0.96	1.15	0.70	1.02	1.40	0.96
89*	13.67	31.0	49.0	29.0	23.0	0.0	30.0	17.0	14.0	12.0	---	2.27	3.58	2.12	1.68	0.0	2.19	1.24	1.02	0.88	---
90*	18.0	30.0	59.0	33.0	9.0	23.0	25.0	25.0	13.0	17.0	---	1.67	3.28	1.83	0.50	1.28	1.39	1.39	0.72	0.94	---
91*	14.0	32.0	25.0	20.0	10.0	9.0	12.0	13.0	12.0	14.0	---	2.29	1.79	1.43	0.71	0.64	0.86	0.93	0.86	1.00	---
92*	13.67	20.0	28.0	24.0	21.0	12.0	15.0	18.0	15.0	---	---	1.46	2.05	1.76	1.54	0.88	1.10	1.32	1.10	---	---
97*	10.0	36.0	36.0	23.0	19.0	20.0	22.0	17.0	11.0	12.0	---	3.60	3.60	2.30	1.90	2.00	2.20	1.70	1.10	1.20	---
98*	14.67	25.0	26.0	23.0	14.0	14.0	13.0	14.0	11.0	15.0	---	1.70	1.77	1.57	0.95	0.95	0.89	0.95	0.75	1.02	---
99*	16.0	46.0	32.0	26.0	22.0	16.0	20.0	17.0	18.0	16.0	---	2.88	2.00	1.63	1.38	1.00	1.25	1.06	1.13	1.00	---
100*	12.67	26.0	36.0	20.0	14.0	10.0	18.0	16.0	12.0	10.0	---	2.05	2.84	1.58	1.11	0.79	1.42	1.26	0.95	0.79-	---
121	8.67	23.0	30.0	15.0	16.0	15.0	5.0	14.0	0.0	18.0	10.0	2.65	3.46	1.73	1.85	1.73	0.58	2.08	0.0	2.08	1.15
122	20.67	55.0	24.0	29.0	21.0	15.0	32.0	18.0	23.0	21.0	20.0	2.66	1.16	1.40	1.02	0.73	1.55	0.87	1.11	1.02	0.97
123	16.0	34.0	32.0	28.0	21.0	24.0	21.0	20.0	13.0	20.0	23.0	2.13	2.00	1.75	1.31	1.50	1.31	1.25	0.81	1.25	1.44
124	14.0	21.0	26.0	25.0	25.0	24.0	23.0	21.0	15.0	24.0	17.0	1.50	1.86	1.79	1.79	1.71	1.64	1.50	1.07	1.71	1.21
N=47																					
TOTAL	628.33	1430.00	1477.00	1035.00	758.00	661.00	719.00	706.00	545.00	693.00	639.00	112.92	117.76	80.42	58.54	51.16	54.60	54.97	41.58	52.37	48.41
MEAN	13.37	30.43	31.43	22.02	16.13	14.06	15.30	15.02	11.60	14.74	13.60	2.40	2.51	1.71	1.25	1.09	1.16	1.17	0.88	1.11	1.03
S.D.	4.12	11.24	10.34	9.30	6.89	5.50	5.72	6.39	4.78	5.53	5.25	0.92	0.92	0.66	0.51	0.38	0.33	0.49	0.31	0.31	0.28

*Data from subjects with incomplete data, birds #76, 89-92, and 97-100 are not included in totals. In addition, data from one subject randomly selected, bird #41, was not included for the statistical purpose of equating the number of subjects between the lithium chloride and distilled water treated groups.

Appendix C

Fluid Consumption Over Ten Days Following Distilled Water Treatment

Bird	Average (last 3 days)	Consumption (in ML)										Post Treatment Consumption Ratio (Daily Consumption/Baseline Average Consumption)									
		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
1	9.0	39.0	26.0	20.0	7.0	10.0	10.0	9.0	5.0	9.0	8.0	4.33	2.89	2.22	0.78	1.11	1.11	1.00	0.56	1.00	0.89
2	11.0	19.0	24.0	19.0	14.0	15.0	18.0	15.0	10.0	11.0	15.0	1.73	2.18	1.73	1.27	1.36	1.64	1.36	0.91	1.00	1.36
3	20.67	43.0	37.0	25.0	22.0	19.0	23.0	18.0	19.0	25.0	26.0	2.08	1.79	1.21	1.06	0.92	1.11	0.87	0.92	1.21	1.26
4	13.33	50.0	46.0	38.0	27.0	15.0	21.0	16.0	17.0	21.0	26.0	3.75	3.45	2.85	2.03	1.13	1.58	1.20	1.28	1.58	1.95
9	8.67	28.0	25.0	9.0	9.0	11.0	10.0	9.0	10.0	12.0	10.0	3.23	2.88	1.04	1.04	1.27	1.15	1.04	1.15	1.38	1.15
10	11.67	23.0	24.0	22.0	12.0	13.0	15.0	9.0	17.0	13.0	14.0	1.97	2.06	1.89	1.03	1.11	1.29	0.77	1.46	1.11	1.20
11	15.0	20.0	27.0	18.0	13.0	10.0	15.0	7.0	9.0	15.0	18.0	1.33	1.80	1.20	0.87	0.67	1.00	0.47	0.60	1.00	1.20
12	15.0	20.0	17.0	10.0	19.0	12.0	15.0	14.0	11.0	17.0	14.0	1.33	1.13	0.67	1.27	0.80	1.00	0.93	0.73	1.13	0.93
17	11.0	39.0	21.0	20.0	10.0	11.0	11.0	10.0	10.0	12.0	10.0	3.55	1.91	1.82	0.91	1.00	1.00	0.91	0.91	1.09	0.91
18	15.67	40.0	36.0	30.0	21.0	18.0	19.0	18.0	18.0	23.0	17.0	2.55	2.30	1.91	1.34	1.15	1.21	1.15	1.15	1.47	1.08
19	14.33	30.0	20.0	18.0	18.0	9.0	13.0	6.0	10.0	14.0	13.0	2.09	1.40	1.26	1.26	0.63	0.91	0.42	0.70	0.98	0.91
20	11.33	12.0	33.0	22.0	17.0	6.0	15.0	14.0	11.0	10.0	8.0	1.06	2.91	1.94	1.50	0.53	1.32	1.24	0.97	0.88	0.71
25	12.33	26.0	41.0	26.0	6.0	7.0	17.0	11.0	16.0	16.0	16.0	2.11	3.33	2.11	0.49	0.57	1.38	0.89	1.30	1.30	1.30
26	11.0	25.0	30.0	24.0	21.0	19.0	12.0	0.0	15.0	13.0	10.0	2.27	2.73	2.18	1.91	1.73	1.09	0.00	1.36	1.18	0.91
27	10.33	30.0	32.0	22.0	13.0	8.0	13.0	9.0	16.0	15.0	10.0	2.90	3.10	2.13	1.26	0.77	1.26	0.87	1.55	1.45	0.97
28	8.0	15.0	20.0	11.0	10.0	10.0	9.0	7.0	8.0	10.0	12.0	1.88	2.50	1.38	1.25	1.25	1.13	0.88	1.00	1.25	1.50
33	8.0	26.0	30.0	12.0	10.0	9.0	12.0	10.0	9.0	12.0	12.0	3.25	3.75	1.50	1.25	1.13	1.50	1.25	1.13	1.50	1.50
34	11.0	37.0	24.0	25.0	15.0	11.0	10.0	9.0	9.0	12.0	12.0	3.36	2.18	2.27	1.36	1.00	0.91	0.82	0.82	1.09	1.09
35	14.33	41.0	49.0	27.0	20.0	11.0	11.0	16.0	7.0	13.0	9.0	2.86	3.42	1.88	1.40	0.77	0.77	1.12	0.49	0.91	0.63
36	15.33	17.0	17.0	20.0	18.0	9.0	12.0	17.0	10.0	21.0	8.0	1.11	1.11	1.30	1.17	0.59	0.78	1.11	0.65	1.37	0.52
41*	22.0	27.0	50.0	51.0	51.0	38.0	26.0	23.0	10.0	14.0	13.0	1.23	2.27	2.32	2.32	1.73	1.18	1.05	0.45	0.64	0.59
42	9.0	22.0	23.0	16.0	9.0	9.0	9.0	15.0	5.0	6.0	7.0	2.44	2.56	1.78	1.00	1.00	1.00	1.67	0.56	0.67	0.78
43	9.67	35.0	43.0	21.0	10.0	7.0	8.0	12.0	7.0	5.0	5.0	3.62	4.45	2.17	1.03	0.72	0.83	1.24	0.72	0.52	0.52
44	11.67	41.0	40.0	28.0	21.0	19.0	19.0	15.0	9.0	10.0	8.0	3.51	3.43	2.40	1.80	1.63	1.63	1.29	0.77	0.86	0.69
49	19.0	22.0	35.0	9.0	17.0	20.0	16.0	15.0	13.0	20.0	15.0	1.16	1.84	0.47	0.89	1.05	0.84	0.79	0.68	1.05	0.79
50	12.67	48.0	64.0	37.0	37.0	29.0	26.0	23.0	11.0	20.0	13.0	3.79	5.05	2.92	2.92	2.29	2.05	1.81	0.87	1.58	1.03
51	8.33	16.0	18.0	13.0	12.0	11.0	11.0	15.0	11.0	10.0	11.0	1.92	2.16	1.56	1.44	1.32	1.32	1.80	1.32	1.20	1.32
52	21.33	22.0	30.0	22.0	23.0	22.0	19.0	23.0	22.0	24.0	25.0	1.03	1.41	1.03	1.08	1.03	0.89	1.08	1.03	1.13	1.17
53	21.67	45.0	56.0	37.0	9.0	27.0	25.0	21.0	18.0	25.0	24.0	2.08	2.58	1.71	0.42	1.25	1.15	0.97	0.83	1.16	1.11
57	17.67	34.0	44.0	29.0	16.0	10.0	14.0	21.0	6.0	13.0	13.0	1.92	2.49	1.64	0.91	0.57	0.79	1.19	0.34	0.73	0.74
58	16.0	42.0	34.0	35.0	29.0	21.0	15.0	37.0	7.0	21.0	14.0	2.63	2.13	2.19	1.81	1.31	0.94	2.31	0.44	1.31	0.88
59	11.0	35.0	32.0	12.0	7.0	10.0	14.0	17.0	14.0	10.0	10.0	3.18	2.91	1.09	0.63	0.91	1.27	1.55	1.27	0.91	0.91
60	9.33	31.0	34.0	25.0	25.0	18.0	16.0	19.0	10.0	7.0	9.0	3.32	3.64	2.68	2.68	1.93	1.71	2.04	1.07	0.75	0.96
65	9.0	28.0	29.0	10.0	8.0	11.0	11.0	9.0	6.0	8.0	10.0	3.11	3.22	1.11	0.89	1.22	1.22	1.00	0.67	0.89	1.11
66	7.33	11.0	28.0	21.0	10.0	9.0	10.0	13.0	7.0	7.0	8.0	1.50	3.82	2.86	1.36	1.23	1.36	2.46	0.96	0.96	1.09
67	23.67	13.0	35.0	23.0	14.0	12.0	16.0	15.0	8.0	14.0	16.0	0.55	1.48	0.97	0.59	0.51	0.68	0.63	0.34	0.59	0.68
68	17.33	36.0	30.0	15.0	12.0	15.0	20.0	23.0	13.0	12.0	14.0	2.08	1.73	0.87	0.69	0.87	1.15	1.33	0.75	0.69	0.81
73	15.0	22.0	20.0	17.0	13.0	14.0	14.0	12.0	17.0	13.0	11.0	1.47	1.33	1.13	0.87	0.93	0.93	0.80	1.13	0.87	0.73
74	13.0	23.0	30.0	27.0	16.0	12.0	15.0	15.0	11.0	16.0	12.0	1.77	2.31	2.08	1.23	0.92	1.15	1.15	0.85	1.23	0.92

Bird	Average (last 3 days)	Consumption (in ML)										Post Treatment Consumption Ratio (Daily Consumption/Baseline Average Consumption)									
		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
85	12.67	11.0	13.0	11.0	10.0	15.0	11.0	12.0	10.0	13.0	12.0	0.87	1.03	0.87	0.79	1.18	0.87	0.95	0.79	1.03	0.95
86	11.33	5.0	15.0	12.0	10.0	11.0	13.0	13.0	11.0	13.0	14.0	0.44	1.32	1.06	0.88	0.97	1.15	1.15	0.97	1.15	1.15
87	14.67	18.0	11.0	15.0	11.0	13.0	14.0	11.0	15.0	14.0	17.0	1.23	0.75	1.02	0.75	0.89	0.95	0.75	1.02	0.95	1.16
88	9.67	15.0	12.0	13.0	11.0	13.0	10.0	10.0	15.0	13.0	10.0	1.55	1.25	1.34	1.14	1.34	1.03	1.03	1.55	1.34	1.03
93*	16.33	10.0	17.0	19.0	14.0	18.0	15.0	17.0	15.0	21.0	---	0.61	1.04	1.16	0.86	1.10	0.92	1.04	0.92	1.29	---
94*	18.67	17.0	19.0	20.0	21.0	12.0	23.0	17.0	15.0	---	---	0.91	1.02	1.07	1.13	0.64	1.23	0.91	0.80	---	---
95*	16.0	19.0	15.0	15.0	12.0	14.0	15.0	15.0	12.0	12.0	---	1.19	0.94	0.94	0.75	0.88	0.94	0.94	0.75	0.75	---
96*	9.0	9.0	---	9.0	10.0	8.0	10.0	9.0	5.0	11.0	---	1.00	---	1.00	1.11	0.89	1.11	1.00	0.56	1.22	---
101*	10.33	7.0	8.0	17.0	8.0	13.0	8.0	15.0	8.0	9.0	---	0.68	0.77	1.65	0.77	1.26	0.77	1.45	0.77	0.87	---
102*	16.67	11.0	10.0	14.0	11.0	---	13.0	20.0	14.0	16.0	---	0.66	0.60	0.84	0.66	---	0.78	1.20	0.84	0.96	---
103*	18.0	19.0	15.0	15.0	12.0	24.0	20.0	20.0	14.0	28.0	---	1.06	0.83	0.83	0.67	1.33	1.11	1.11	0.78	1.56	---
104*	12.33	11.0	7.0	13.0	8.0	12.0	14.0	15.0	14.0	15.0	---	0.89	0.57	1.05	0.65	0.97	1.14	1.22	1.14	1.22	---
125	11.0	9.0	13.0	10.0	9.0	10.0	12.0	11.0	9.0	9.0	7.0	0.82	1.19	0.91	0.82	0.91	1.09	1.00	0.82	0.83	0.64
126	18.33	17.0	15.0	12.0	15.0	18.0	16.0	13.0	9.0	15.0	18.0	0.93	0.82	0.65	0.82	0.98	0.87	0.71	0.49	0.82	0.98
127	13.33	19.0	13.0	14.0	17.0	17.0	15.0	18.0	17.0	20.0	15.0	1.43	0.96	1.05	1.28	1.28	1.13	1.35	1.28	1.50	1.13
128	16.33	18.0	13.0	16.0	15.0	14.0	17.0	7.0	13.0	14.0	15.0	1.10	0.80	0.98	0.92	0.86	1.04	0.43	0.80	0.86	0.92
N=47																					
TOTAL	619.04	523.00	634.00	568.00	533.00	561.00	593.00	662.00	541.00	598.00	642.00	39.36	40.25	43.26	40.57	43.30	46.13	51.31	42.05	46.56	49.35
MEAN	13.17	11.13	13.49	12.06	11.34	11.94	12.62	14.09	11.51	12.72	13.66	0.84	1.05	0.92	0.86	0.92	0.98	1.09	0.89	0.99	1.05
S.D.	3.23	5.31	3.83	3.39	3.52	3.15	3.02	3.96	2.98	3.78	4.31	0.33	0.26	0.18	0.18	0.20	0.02	0.26	0.21	0.27	0.25

*Data from subjects with incomplete data, birds #93-96 and #101-104 are not included in totals.

Appendix D

Experiment III: Single-substance Experimental and Control Groups

(N = 8 per group)

Early Test		Late Test	
Group	Sequence of Stimuli	Group	Sequence of Stimuli
1	N_H:N_H	13	N_H:N_H
2	W:N_H	14	W:N_H
3	N_L:N_L	15	N_L:N_L
4	W:N_L	16	W:N_L
5	H_H:H_H	17	H_H:H_H
6	W:H_H	18	W:H_H
7	H_L:H_L	19	H_L:H_L
8	W:H_L	20	W:H_L
9	R_H:R_H	21	R_H:R_H
10	W:R_H	22	W:R_H
11	R_L:R_L	23	R_L:R_L
12	W:R_L	24	W:R_L

The letter(s) to the left of the colon represent the stimuli to be presented on the treatment day. The letter(s) to the right of the colon refer(s) to stimuli presented on the test day. With respect to the above:

N_H = 0.24M NaCl

N_L = 0.163M NaCl

H_H = .036% HCl

H_L = .012% HCl

R_H = 1.5% Red Water

R_L = 0.1% Red Water

W = Plain Water

Appendix E

Experiment III

Day Ten Test Data: Experimental Groups and Control Groups

Experimental Groups

Group	Bird	Consumption (in ml) Average Baseline (Last 3 Days)	Day 8 (Treatment)	Day 10 (Test)	Consumption Ratio (Consumption on day of interest/ average baseline consumption) Day 8	Day 10
#1	129	8.00	8	1	1.00	0.13
N_H	130	14.33	8	8	0.56	0.56
	131	20.33	10	4	0.49	0.20
	132	13.33	4	2	0.30	0.15
	133	15.67	6	0	0.38	0.00
	134	13.33	7	0	0.53	0.00
	135	12.67	6	2	0.47	0.00
	136	17.33	7	4	0.40	0.23
	TOTAL	114.99	56.00	21.00	4.13	1.27
	MEAN	14.37	7.00	2.63	0.52	0.15
	S.D.	3.61	1.77	2.67	0.21	0.19
#3	145	11.33	5	0	0.44	0.00
N_L	146	12.33	17	0	1.38	0.00
	147	19.00	16	2	0.84	0.11
	148	14.67	8	4	0.55	0.27
	149	23.67	17	8	0.72	0.34
	150	11.00	12	23	1.09	2.09
	151	11.00	13	4	1.18	0.36
	152	11.00	15	2	1.36	0.18
	TOTAL	114.00	103.00	43.00	7.56	3.35
	MEAN	14.25	12.88	5.38	0.95	0.42
	S.D.	4.71	4.39	7.58	0.36	0.69

N_H = 0.24M NaCl

N_L = 0.163M NaCl

H_H = .036% HCl

H_L = .012% HCl

R_H = 1.5% Red Water

R_L = 0.1% Red Water

W = Plain Water

Experimental Groups

Group	Bird	Consumption (in ml) Average Baseline (Last 3 Days)	Day 8 (Treatment)	Day 10 (Test)	Consumption Ratio (Consumption on day of interest/ average baseline consumption) Day 8	Day 10
#5	161	17.00	10	1	0.59	0.06
H_H	162	16.00	11	8	0.69	0.50
	163	13.00	3	1	0.23	0.08
	164	12.67	6	5	0.47	0.39
	165	12.00	15	4	1.25	0.33
	166	12.00	11	19	0.92	1.58
	167	13.33	12	5	0.90	0.38
	168	20.00	27	34	1.35	1.70
	TOTAL	116.00	95.00	77.00	6.40	5.02
	MEAN	14.50	11.87	9.63	0.80	0.63
	S.D.	2.88	7.14	11.39	0.38	0.64
#5A	322	18.67	5	2	0.27	0.11
H_H	323	18.67	6	0	0.32	0.00
	324	18.67	3	3	0.16	0.16
	TOTAL**	121.34	65.00	29.00	4.56	2.01
	MEAN**	15.17	8.13	3.63	0.57	0.25
	S.D.**	2.75	4.49	2.39	0.37	0.17
#7	177	13.00	13	19	1.00	1.46
H_L	178	17.33	13	27	0.75	1.56
	179	15.67	20	30	1.28	1.91
	180	12.67	13	21	1.03	1.66
	181	13.00	11	15	0.85	1.15
	182	16.67	13	26	0.78	1.56
	183	12.33	10	25	0.81	2.03
	184	16.67	13	19	0.78	1.14
	TOTAL	117.34	106.00	182.00	7.28	12.47
	MEAN	14.67	13.25	22.75	0.91	1.56
	S.D.	2.11	2.96	5.04	0.18	0.32

**Total includes birds 322 and 324 with birds 161-166, and 167 in place of birds 166 and 168.

Experimental Groups

Group	Bird	Consumption (in ml)			Consumption Ratio (Consumption on day of interest/ average baseline consumption)	
		Average Baseline (Last 3 Days)	Day 8 (Treatment)	Day 10 (Test)	Day 8	Day 10
#9	193	19.33	20	6	1.03	0.31
R_H	194	9.67	6	0	0.62	0.00
	195	14.67	11	0	0.75	0.00
	196	13.00	10	12	0.77	0.92
	197	13.00	12	11	0.92	0.85
	198	12.33	6	0	0.49	0.00
	199	14.00	2	0	0.14	0.00
	200	13.00	10	0	0.77	0.00
	TOTAL	109.00	77.00	29.00	5.49	2.08
	MEAN	13.63	9.63	3.63	0.69	0.26
	S.D.	2.73	5.34	5.29	0.28	0.40
#11	209	14.00	17	21	1.21	1.50
R_L	210	9.33	6	19	0.64	2.04
	211	20.00	19	20	0.95	1.00
	212	13.33	11	15	0.83	1.13
	213	10.00	10	20	1.00	2.00
	214	10.67	9	20	0.84	1.87
	215	10.00	13	12	1.30	1.20
	216	29.00	21	26	0.72	0.90
	TOTAL	116.33	106.00	153.00	7.49	11.64
	MEAN	14.54	13.25	19.13	0.94	1.46
	S.D.	6.80	5.26	4.16	0.23	0.46

Control Groups

Group	Bird	Consumption (in ml) Average Baseline (Last 3 Days)	Day 8 (Treatment)	Day 10 (Test)	Consumption Ratio (Consumption on day of interest/ average baseline consumption) Day 8	Day 10
#2	137	12.33	11	24	0.89	1.95
N_H	138	19.67	16	26	0.81	1.32
	139	14.67	12	27	0.82	1.84
	140	9.33	11	18	1.18	1.93
	141	16.67	19	30	1.14	1.80
	142	16.33	16	7	0.98	0.43
	143	13.00	17	46	0.85	3.54
	144	11.67	15	31	1.29	2.66
	TOTAL	113.67	111.00	209.00	7.96	15.47
	MEAN	14.21	13.88	26.13	1.00	1.93
	S.D.	3.29	3.04	11.15	0.18	0.91
#4	153	19.00	13	29	0.68	1.53
N_L	154	9.67	6	39	0.62	4.03
	155	15.00	14	10	0.93	0.67
	156	12.33	11	7	0.89	0.57
	157	18.00	15	47	0.83	2.61
	158	13.00	13	20	1.00	1.54
	159	12.00	13	19	1.08	1.58
	160	16.33	15	12	0.92	0.73
	TOTAL	115.33	100.00	183.00	6.95	13.26
	MEAN	14.42	12.50	22.88	0.87	1.66
	S.D.	3.22	2.93	14.34	1.15	1.17

Control Groups

Group	Bird	Consumption (in ml) Average Baseline (Last 3 Days)	Day 8 (Treatment)	Day 10 (Test)	Consumption Ratio (Consumption on day of interest/ average baseline consumption) Day 8	Day 10
#6	169	11.67	10	19	0.86	1.63
H_H	170	13.67	17	15	1.24	1.10
	171	17.67	16	5	0.91	0.28
	172	16.00	17	27	1.06	1.69
	173	18.00	14	23	0.78	1.28
	174	12.00	13	20	1.08	1.67
	175	11.33	9	22	0.79	1.94
	176	17.33	18	18	1.04	1.04
	TOTAL	117.67	114.00	149.00	7.76	10.63
	MEAN	14.71	14.25	18.63	0.97	1.33
	S.D.	2.86	3.37	6.57	0.16	0.53
#8	185	12.00	14	18	1.17	1.50
H_L	186	13.00	13	32	1.00	2.46
	187	17.33	18	27	1.04	1.56
	188	15.33	12	24	0.78	1.57
	189	15.67	19	25	1.21	1.60
	190	13.67	15	23	1.10	1.68
	191	12.00	17	22	1.42	1.83
	192	17.33	6	24	0.35	1.38
	TOTAL	116.33	114.00	195.00	8.07	13.58
	MEAN	14.54	14.25	24.38	1.01	1.70
	S.D.	2.19	4.13	4.03	0.32	0.33

Control Groups

Group	Bird	Consumption (in ml) Average Baseline (Last 3 Days)	Day 8 (Treatment)	Day 10 (Test)	Consumption Ratio (Consumption on day of interest/ average baseline consumption) Day 8	Day 10
#10	201	12.67	14	19	1.10	1.50
R_H	202	15.67	18	22	1.15	1.40
	203	19.00	18	15	0.95	0.79
	204	12.67	12	15	0.95	1.18
	205	11.67	15	18	1.29	1.54
	206	19.67	24	37	1.22	1.88
	207	13.67	11	18	0.80	1.32
	208	14.00	17	25	1.21	1.79
	TOTAL	119.02	129.00	169.00	8.67	11.40
	MEAN	14.88	16.13	21.13	1.08	1.43
	S.D.	3.00	4.12	7.24	0.17	0.35
#12	217	14.67	17	17	1.16	1.16
R_L	218	12.33	10	19	0.81	1.54
	219	9.67	15	24	1.55	2.48
	220	19.00	16	40	0.84	2.11
	221	12.33	14	27	1.14	2.19
	222	19.33	26	40	1.35	2.07
	223	15.67	15	29	0.96	1.85
	224	11.33	22	27	1.94	2.38
	TOTAL	114.33	135.00	223.00	9.75	15.78
	MEAN	14.29	16.88	27.88	1.22	1.97
	S.D.	3.53	4.97	8.53	0.38	0.44

Appendix F

Experiment III

Day Thirteen Test Data:

Experimental Groups and Control Groups

Experimental Groups

Group	Bird	Consumption (in ml) Average Baseline (Last 3 Days)	Day 8 (Treatment)	Day 13 (Test)	Consumption Ratio (Consumption on day of interest/ average baseline consumption) Day 8	Day 13
#13	225	13.33	11	0	0.83	0.00
N_H	226	18.00	17	1	0.94	0.06
	227	12.33	6	0	0.49	0.00
	228	16.00	10	0	0.63	0.00
	229	10.33	5	1	0.48	0.10
	230	13.33	2	2	0.15	0.15
	231	23.00	15	0	0.65	0.00
	232	15.00	5	0	0.33	0.00
	TOTAL	121.32	71.00	4.00	4.50	0.31
	MEAN	15.17	8.88	0.50	0.56	0.04
	S.D.	3.93	5.28	0.78	0.26	0.06
#15	241	19.00	44	5	2.32	0.26
N_L	242	15.33	17	5	1.11	0.33
	243	10.33	28	13	2.71	1.26
	244	14.33	9	2	0.63	0.14
	245	13.00	5	1	0.38	0.08
	246	20.33	5	2	0.25	0.10
	247	11.33	11	1	0.97	0.09
	248	18.33	8	12	0.44	0.65
	TOTAL	121.98	127.00	41.00	8.81	2.91
	MEAN	15.25	15.88	5.13	1.10	0.36
	S.D.	3.68	13.67	4.82	0.93	0.41

N_H = 0.24M NaCl

N_L = 0.163M NaCl

H_H = .036% HCl

H_L = .012% HCl

R_H = 1.5% Red Water

R_L = 0.1% Red Water

W = Plain Water

Experimental Groups

Group	Bird	Consumption (in ml) Average Baseline (Last 3 Days)	Day 8 (Treatment)	Day 13 (Test)	Consumption Ratio (Consumption on day of interest/ average baseline consumption) Day 8	Day 13
#17 H_H	257	11.00	4	0	0.36	0.00
	258	22.33	10	0	0.45	0.00
	259	14.00	14	0	1.00	0.00
	260	12.33	4	0	0.32	0.00
	261	11.67	16	1	1.37	0.09
	262	14.00	13	2	0.93	0.14
	263	15.00	11	5	0.73	0.33
	264	20.00	10	4	0.50	0.20
	TOTAL	120.33	82.00	12.00	5.66	0.76
	MEAN	15.04	10.25	1.50	0.71	0.10
	S.D.	4.05	4.37	2.00	0.37	0.12
#19 H_L	273	14.33	13	18	0.91	1.26
	274	13.00	16	7	1.23	0.54
	275	19.33	20	12	1.03	0.62
	276	13.00	18	25	1.38	1.92
	277	15.00	15	12	1.00	0.80
	278	13.33	14	14	1.05	1.05
	279	11.33	13	12	1.15	1.06
	280	21.33	28	13	1.31	0.61
	TOTAL	120.65	137.00	113.00	9.06	7.86
	MEAN	15.08	17.13	14.13	1.13	0.98
	S.D.	3.45	5.03	5.33	0.16	0.46

Experimental Groups

Group	Bird	Consumption (in ml) Average Baseline (Last 3 Days)	Day 8 (Treatment)	Day 13 (Test)	Consumption Ratio (Consumption on day of interest/ average baseline consumption) Day 8	Day 13
#21	289	11.67	5	0	0.43	0.00
R_H	290	18.67	17	0	0.91	0.00
	291	13.33	9	0	0.68	0.00
	292	16.00	17	0	1.06	0.00
	293	13.67	10	0	0.73	0.00
	294	23.67	17	0	0.72	0.00
	295	15.00	15	15	1.00	1.00
	296	10.00	6	0	0.60	0.00
	TOTAL	122.01	96.00	15.00	6.13	1.00
	MEAN	15.25	12.00	1.88	0.77	0.13
	S.D.	4.31	5.10	5.30	0.21	0.35
#23	305*	14.00	10	--	--	--
R_L	306	8.67	8	6	0.92	0.69
	307	23.67	24	22	1.01	0.93
	308	12.33	15	9	1.22	0.73
	309	10.00	9	11	0.90	1.10
	310	13.33	18	0	1.35	0.00
	311	25.33	27	18	1.07	0.71
	312	15.67	13	15	0.83	0.96
	313	14.67	10	9	0.68	0.61
	TOTAL	123.67	124.00	90.00	7.98	5.73
	MEAN	15.46	15.50	11.25	1.00	0.72
	S.D.	6.04	7.03	6.96	0.21	0.33

* Bird 305 died on Day 9.

Control Groups

Group	Bird	Consumption (in ml) Average Baseline (Last 3 Days)	Day 8 (Treatment)	Day 13 (Test)	Consumption Ratio (Consumption on day of interest/ average baseline consumption) Day 8	Day 13
#14	233	15.00	14	27	0.93	1.80
N_H	234	10.33	15	39	1.45	2.90
	235	17.33	17	8	1.02	0.46
	236	17.67	28	20	1.58	1.13
	237	13.67	19	3	1.39	0.22
	238	17.33	15	10	0.87	0.58
	239	13.50	20	4	1.48	0.30
	240	15.33	14	16	0.91	1.04
	TOTAL	120.16	142.00	185.00	9.63	8.43
	MEAN	15.02	17.75	14.75	1.20	1.05
	S.D.	2.50	4.71	10.24	0.30	0.91
#16	249	8.67	13	9	1.50	1.04
N_L	250	19.00	19	16	1.00	0.84
	251	15.00	13	7	0.87	0.47
	252	15.00	15	6	1.00	0.40
	253	12.67	10	11	0.79	0.87
	254	19.00	17	24	0.89	1.26
	255	14.67	12	6	0.82	0.41
	256	17.67	23	5	0.77	0.28
	TOTAL	121.68	122.00	84.00	7.64	5.57
	MEAN	15.21	15.25	10.50	0.96	0.70
	S.D.	3.47	4.23	6.52	0.24	0.35

Control Groups

Group	Bird	Consumption (in ml) Average Baseline (Last 3 Days)	Day 8 (Treatment)	Day 13 (Test)	Consumption Ratio (Consumption on day of interest/ average baseline consumption) Day 8	Day 13
#18	265	11.33	12	3	1.06	0.26
H_H	266	18.00	15	13	0.83	0.72
	267	16.67	21	5	1.26	0.30
	268	13.33	17	9	1.28	0.68
	269	18.33	12	4	0.65	0.87
	270	12.00	13	4	1.08	0.33
	271	19.33	20	5	1.03	0.26
	272	13.67	14	12	1.02	0.88
	TOTAL	122.66	124.00	55.00	8.21	4.30
	MEAN	15.33	15.50	6.88	1.03	0.54
	S.D.	3.11	3.51	3.91	0.21	0.28
#20	281	11.00	16	10	1.45	0.91
H_L	282	14.00	14	17	1.00	1.21
	283	12.33	14	12	1.14	0.97
	284	22.00	22	15	1.00	0.68
	285	18.00	20	11	1.11	0.61
	286	19.00	11	14	0.58	0.74
	287	12.00	10	18	0.83	1.50
	288	14.67	17	13	1.16	0.89
	TOTAL	123.00	124.00	110.00	8.27	7.51
	MEAN	15.38	15.50	13.75	1.03	0.94
	S.D.	3.89	4.14	2.82	0.26	0.29

Control Groups

Group	Bird	Consumption (in ml) Average Baseline (Last 3 Days)	Day 8 (Treatment)	Day 13 (Test)	Consumption Ratio (Consumption on day of interest/ average baseline consumption) Day 8	Day 13
#22	297	16.33	17	17	1.04	1.04
R_H	298	9.00	9	5	1.00	0.56
	299	15.33	17	12	1.11	0.78
	300	17.67	23	19	1.30	1.08
	301	11.67	8	16	0.69	1.37
	302	18.00	15	12	0.83	0.67
	303	19.33	20	17	1.03	0.88
	304	18.00	25	14	1.39	0.78
	TOTAL	125.33	134.00	112.00	8.39	7.16
	MEAN	15.66	16.75	14.00	1.05	0.90
	S.D.	3.57	6.07	4.41	0.23	0.26
#24	314	15.67	12	13	0.77	0.83
R_L	315	17.67	15	20	0.85	1.13
	316	8.67	15	6	1.73	0.69
	317	16.33	14	18	0.86	1.10
	318	16.67	14	19	0.84	1.14
	319	13.67	17	19	1.24	1.39
	320	11.67	13	5	1.11	0.43
	321	19.67	22	5	1.12	0.25
	TOTAL	120.02	122.00	105.00	8.52	6.96
	MEAN	15.00	15.25	13.13	1.07	0.87
	S.D.	3.52	3.11	6.79	0.32	0.39

Appendix G

Experiment III

Compound Conditioning Day Ten Test Data

Experimental and Control Groups

(N = 8 in all groups)

Group	Sequence of Stimuli
25	R_HH_H:R_H
26	R_HH_H:H_H
27	R_HH_H:R_HH_H
28	W:R_HH_H

The letter(s) to the left of the colon represent the stimuli to be presented on the treatment day. The letter(s) to the right of the colon represent the stimuli to be presented on the test day. With respect to the above:

R_HH_H = Red Sour Water (1.5% RW combined with 0.36% HCl)

R_H = 1.5% Red Water

H_H = 0.36 HCl

W = Plain Water

Appendix H

Experiment III

Data From Day Ten Tests

Compound Conditioning Groups

Group	Bird	Consumption (in ml)			Consumption Ratio (Consumption on day of interest/ average baseline consumption)	
		Average Baseline (Last 3 Days)	Day 8 (Treatment)	Day 10 (Test)	Day 8	Day 10
#25	325	17.00	2	0	0.12	0.00
R_H	326	15.67	12	25	0.76	1.60
	327	14.67	2	0	0.14	0.00
N=6	328	18.67	--	--	--	--
	329	12.67	11	0	0.87	0.00
	330	15.67	5	0	0.32	0.00
	331	16.67	2	0	0.12	0.00
	TOTAL	92.35	34.00	25.00	2.33	1.60
	MEAN	15.39	5.67	4.17	0.38	0.27
	S.D.	1.57	4.68	10.2	0.34	0.65
#26	332	16.33	-	-	--	--
H_H	333	13.00	2	2	0.15	0.15
	334	15.67	-	-	0.12	0.48
N=5	335	16.67	2	8	0.26	0.26
	336	15.33	4	4	0.18	0.24
	337	17.00	3	4	--	--
	338	17.00	-	-	--	--
	339	18.67	-	-	0.26	1.53
	340	15.67	4	24		
	TOTAL	77.67	15.00	42.00	0.97	2.66
	MEAN	15.53	3.00	8.40	0.19	0.53
	S.D.	1.57	1.00	8.99	0.06	0.57
#27	341	18.67	-	-	--	--
H_H	342	17.33	17	0	0.98	0.00
	343	17.00	3	0	0.18	0.00
N=5	344	15.67	8	0	0.51	0.00
	345	16.00	5	0	0.31	0.00
	346	14.33	2	0	0.14	0.00
	347	16.00	-	-	--	--
	348	12.67	2	0	0.16	0.00
	TOTAL	93.00	37.00	0.00	2.28	0.00
	MEAN	15.50	6.17	0.00	0.38	0.00
	S.D.	1.75	5.78	0.00	0.32	0.00

Group	Bird	Consumption (in ml)			Consumption Ratio (Consumption on day of interest/ average baseline consumption)	
		Average Baseline (Last 3 Days)	Day 8 (Treatment)	Day 10 (Test)	Day 8	Day 10
#28	349	13.67	15	11	1.10	0.80
R_H	350	16.33	5	2	0.31	0.12
	351	13.00	13	2	1.00	0.15
N=8	352	17.33	20	5	1.15	0.29
	353	16.67	16	15	0.96	0.90
	354	16.33	16	6	0.98	0.37
	355	18.33	26	0	1.42	0.00
	356	15.67	17	0	1.08	0.00
	TOTAL	127.33	128.00	41.00	8.00	2.63
	MEAN	15.93	16.00	5.13	1.00	0.33
	S.D.	1.79	5.95	5.41	0.31	0.35

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SUMMARY

Professional Interests	Analysis of behavior in laboratory and applied settings; behavioral medicine; instruction.
Research Background	Instrumental and respondent conditioning; human and animal research; group and single-subject research designs; psychophysiological and psychopharmacological research.
Practicum Experience	Behavior therapy -university counseling center; biofeedback - hospital setting; behavior analysis and program implementation -exceptional child center.
Teaching Experience	Full-time instruction -community college level--introductory psychology; child development; adolescent development.

EDUCATION

Institution	Years	Degree
Utah State University Logan, Utah Major Professor: Carl D. Cheney	1978-present	Candidate for the Ph.D. in Analysis of Behavior--Spring, 1981

University of South Florida Tampa, Florida Major Professor: H. D. Kimmel	1975-1978	Psychology - major
Eastern Washington University Cheney, Washington Major Professor: William A. Greene	1973-1975	MS (1975) - Psychology
Eastern Washington University Cheney, Washington	1965-1970	BA (1970) Political Science-major Psychology-minor

PROFESSIONAL EXPERIENCE

Teaching Assistant: Utah State University, Psychology Department, Logan, Utah June 1980-present. Assistant for Elementary Statistics Course.

Animal Laboratory Manager: Utah State University, Psychology Department, Logan, Utah. Fall 1978-fall 1979. Responsibilities included coordinating research activities, acquiring equipment and supplies, and assisting in instrumentation.

Instructor: Pasco-Hernando Community College, Brooksville, Florida. January 1976-August 1978. Taught 15 contract hours per term. Courses included introductory and developmental psychology. Had full responsibility for course content and evaluation. Developed behavioral course objectives for departmental use in introductory psychology.

Teaching Assistant: Eastern Washington University, Psychology Department, Cheney, Washington September 1974 -June 1975. Assistant for Introductory Psychology.

PRACTICUM EXPERIENCE

Exceptional Child Center, Utah State University, Logan Utah. Two quarters of child development practicum. Experience includes training in observational techniques and in the development and implementation of behavioral programs. Supervisor: Frank Ascione, Ph.D.

Sacred Heart Medical Center, Spokane Washington. Spring 1975. Employed biofeedback techniques in treatment of chronic medical disorders on both an impatient and outpatient basis. Supervisor: William A. Greene, Ph.D.

Center for Psychological Services, Eastern Washington University. Three quarters of part-time practicum experience with a student and staff population. Employed behaviorally-based intervention techniques. Supervisor: Roger Harmon, Ph.D.

PUBLICATIONS

Pounds, D., Williamson, P., & Cheney, C. Interocular transfer of a color aversion in pigeons. Bulletin of the Psychonomic Society. 1980, 15, 178-180.

PRESENTATIONS

Pounds, D., & Cheney, C. Confounded Taste and Color Aversions in Pigeons. Paper presented at the Psychonomic Society Annual Meeting, St. Louis, Mo., November, 1980.

Evans, R. D., Pounds, D., & Cheney, C. Color-Mediated Aversions in Pigeons: Resistance to Extinction. Paper presented at Utah Academy of Science, Arts, and Letters. Logan, November, 1980.

Frome, A., Pounds, D., & Cheney, C. Combinations of Color and Flavor Preferences in Pigeons. Paper presented at Utah Academy of Science, Arts, and Letters. Logan, November, 1980.

Pounds, D.; Riches, W.; Williamson, P. N.; & Cheney, C. D. Visual Aversions in Avians: A Device for Stimulus Presentation. Paper presented at Utah Academy of Sciences, Arts, & Letters Meeting, Ogden, April 1980.

Pounds, D.; Williamson, P.; Cheney, C. & Riches, W. Visual Stimuli Aversions in Pigeons. Paper presented at Rocky Mountain Psychological Association Meeting, Tuscon, April 1980.

Williamson, P. N.; Ascione, F. R.; & Pounds, D. Satiation of Social Stimuli: Theoretical and Methodological Considerations. Paper presented at Utah Academy of Science, Arts, & Letters Meeting, Ogden, April 1980.

Pounds, D. A reinterpretation of Levine's hypothesis, Paper presented at Utah Academy of Sciences, Arts, and Letters meeting, Salt Lake City, November, 1979.

Pounds, D., Williamson, P., & Cheney, C. Interocular transfer, color and flavor aversions in pigeons. Paper presented at Rocky Mountain Psychological Association meeting, Las Vegas, April, 1979.

RESEARCH EXPERIENCES

Research in progress: Primary investigator:

1. Color and pattern aversion in pigeons
2. Interocular transfer of pattern aversion in pigeons
3. Conditioned Immunosuppression
4. Reduction of nasality in the hearing impaired with feedback

1976 Primary investigator in study of effects of variable stimuli and variable interstimulus intervals on habituation of the GSR in humans. As yet unpublished study.

1975 Instrumental conditioning of the GSR in female subjects using an affective reinforcer. Unpublished master's research.

1974 Primary investigator in study of instrumental autonomic conditioning in human females. Unpublished.

PROFESSIONAL AFFILIATIONS

Association for Behavior Analyses - student member

Association for Advancement of Behavior Therapy - student membership pending

American Psychological Association - student member

Rocky Mountain Psychological Association - student member

AWARDS AND HONORS

University of South Florida, Graduate School Tuition Scholarship - 1977

Utah State University School of Graduate Studies Stipend 1979

Phi Kappa Phi - Induction 1980

PERSONAL DATA

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