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On the effect of informative and redundant novel stimuli in the learning and extinction of a conditioned taste aversion.

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ON THE EFFECT OF INFORMATIVE AND REDUNDANT NOVEL STIMULI IN THE LEARNING AND EXTINCTION OF A CONDITIONED TASTE AVERSION

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Abstract

This experiment tests two hypotheses, "the information" hypothesis and "the most recent novel taste" hypothesis, as explanations of some characteristics of conditioned taste aversion. The information hypothesis predicts that a leading, informative stimulus acquires greater reinforcing strength than a second, redundant stimulus. In contrast, the most recent novel taste hypothesis predicts that the most recent of two consecutive stimuli acquires greater reinforcing strength. The strong version of either hypothesis predicts that one stimulus alone acquires reinforcing strength, while the weak version of either hypothesis predicts simply that one stimulus acquires significantly greater reinforcing strength than the other.

Rats, habituated to drinking distilled water during two consecutive drinking periods of three and seven minutes, respectively, were presented two distinctively flavored fluids, one sweet and one salty. The sweet tasting fluid was always flavored with saccharin; the salty tasting fluid contained toxic lithium chloride during acquisition and reacquisition, and it contained non-toxic sodium chloride during extinction. There were two groups; one

received the sweet tasting fluid followed by the salty tasting fluid, while the other the fluids in the reverse order.

Both groups demonstrated the acquisition, extinction, and reacquisition of a conditioned taste aversion. Although both groups suppressed the intake of both fluids substantially during acquisition, they suppressed the toxic fluid significantly more than the non-toxic fluid during reacquisition, suggesting that a discrimination had taken place over the course of the experiment between the toxic fluid and the non-toxic fluid, regardless of position.

Some support for the weak version of the most recent novel taste hypothesis over the information hypothesis was found in the extinction phase of the experiment alone, as indicated by the possibly lower asymptote for the group with sodium chloride in the second position.

Research review and introduction

Associative learning with a compound CS

Two challenges to the traditional understanding of associative learning have arisen on the basis of research over the past two decades. The first results from the increasing experimental control of attention, while the other, a new and distinctive area of study, is conditioned taste aversion. Of special concern here, is the increased understanding of the complexity and variety of responses to a compound CS.

Recent experimental work (Rescorla & Wagner, 1972; Wagner, 1969; & Kamin, 1969b) suggests that animals do not pay equal attention to all components of a compound CS. Examples of differential responses to the individual components of a compound CS are Kamin's "blocking effect" and Wagner's "overshadowing." Kamin raises the possibility that mere contiguity is too simple an explanation for the association of a compound CS with reinforcers. He reports

> a fundamental dissatisfaction with the notion that contiguous occurrence of events in time is the necessary and sufficient condition for establishment of an association. This simple and skeletal proposition, however, has been at the core of virtually all theorizing about conditioning. The conception of an animal attending to, selecting, and choosing from among stimuli

> presented to it is clearly alien to the temper in which most experimental studies of learning have been performed.
>
> (Kamin, 1969b, p. 42)

He suggests that with the experimental control of attention a more accurate understanding of associative principles is possible.

Rescorla and Wagner have proposed an alternate model to the one postulating that a compound CS acquires reinforcing strength as a whole. They propose instead that the individual components of a compound CS may acquire reinforcing strength individually and sum to some maximum.

Of particular interest to the present study is the work of Egger and Miller (1963, 1964) who found that the individual components of their compound CS did acquire different amounts of reinforcing strength. They developed a paradigm to test their "information" hypothesis. They proposed that the leading stimulus of a compound CS acquires greater reinforcing strength than a second, redundant stimulus.

In contrast, a central hypothesis in conditioned taste aversion is "the most recent novel taste" hypothesis. Garcia and Revusky (1970) suggest that in conditioned taste aversion the most recent of two consecutive taste stimuli acquires greater reinforcing strength.

Here then are two hypotheses with different predictions for two stimuli, when the presentation of one follows the presentation of the other. In the present experiment, these two hypotheses will be applied to conditioned taste aversion. Before the opposing experimental predictions for this study are developed, a general discussion of conditioned taste aversion will be set forth. Also, the background for the information hypothesis will be presented.

Conditioned taste aversion: "The most recent novel taste" hypothesis

The natural phenomenon, "bait-shyness," is well-known (Barnett, 1963). Wild animals which have been poisoned or become ill from contaminated food, and survive, tend to reject any novel tasting substance which they consumed within a day or less prior to their illness (Garcia, Erwin, & Koelling, 1967). Garcia demonstrated this effect in the laboratory by producing a conditioned aversion to saccharin (sacc.) in rats after gamma ray exposure, an event which produces nausea (Garcia, Kimeldorf, & Koelling, 1967). Thus, conditioned taste aversion is frequently referred to in the literature as the "Garcia effect."

Conditioned taste aversion, then, is that learning which occurs when animals which have consumed a fluid or food with a novel taste and suffer aversive effects such as nausea, subsequently reduce their intake of the food or fluid in question. When this occurs, it is theorized that the animals associate the aversive effects following intake of the flavor with its novel taste. This process of conditioned taste aversion is distinguishable from a neophobic response where animals reduce the amount of a substance they consume when they first encounter its novel taste.

Learning in which taste and gastrovisceral effects are associated is not restricted to avoidance learning. The positive form of this learning is called "learned safety." In general a weaker effect, it occurs when an animal associates a taste with a positive visceral effect such as recuperation from an illness or recovery from a nutritional deficiency. Green and Garcia (1971) demonstrated that rats increased their preference for milk or grape juice, after they drank one of those fluids during the period of recuperation from the ill effects of apomorphine injections. Rozin and Kalat (1971) worked with thiamine deficient rats. They showed that the rats increased their preference for a food or fluid containing thiamine or which was followed by an injection of thiamine. A persistent change in taste preference is known as the palatability effect.

Conditioned taste aversion differs from other types of learning in at least four ways. Garcia and Koelling

(1967) described three characteristics as distinctive features of conditioned taste aversion, while the fourth is crucial to an understanding of the most recent novel taste hypothesis. They are: (1) unusual length of the interval between stimulus and reinforcement, (2) the precedence of taste stimuli and gastrovisceral effects, (3) the rapidity of learning, and (4) the importance of novelty.

Unusual length of the interstimulus (CS-US) interval Nachman and Jones (1974) demonstrated reliable conditioned taste aversion for intervals of 8 to 12 hours between taste stimulus and aversive effects. That is, animals consumed a novel substance and suffered aversive effects 8 to 12 hours later. On the next day they suppressed the intake of the novel tasting substance significantly.

Ordinarily, a .5 second interval between the conditioned stimulus and the unconditioned stimulus is required in order for classical conditioning to occur maximally; three seconds is normally cited as the longest possible interstimulus interval. Clearly, conditioned taste aversion far exceeds these limits. The strength of learning, however, does decrease monotonically as the interstimulus interval increases (Barker, Suarez, & Gray, 1972).

Attempts to use notions of contiguity to explain learning which takes place over such a long time interval have failed. The traditional explanation of the formation of an association where reinforcement does not immediately follow signal or response is the existence of a chain of stimulus-response events capable of bridging the gap. Regurgitation, remnants of food in the gastro-intestinal tract, and aftertastes have all been suggested and refuted as possible links in the chain. It is now generally accepted that conditioned taste aversion is not established by means of mediating chains (Rozin, 1969).

Since conditioned taste aversion does occur over long interstimulus intervals, animals need some means by which to select the appropriate stimulus from among the great variety of stimuli to which the animal is subject over the intervening period.

Taste stimuli and gastrovisceral effects When sufficient LiCl is consumed or injected after a novel taste has been consumed, suppression of drinking is the result. For long interstimulus intervals, such as 30 minutes, Hankins, Garcia, and Rusiniak (1973) report that a novel taste is the only stimulus dimension which rats consistently and easily associated with nausea. Even the closely related dimension of smell required repeated and immediate reinforcement for conditioning to occur. When Rusiniak, Garcia, and Hankins (1976) by-passed the taste receptors and all other oral cues completely by introducing lithium chloride

(LiCl) directly into the stomach of rats by intubation, no conditioned occurred. Hankins et al. concluded that post-ingestional cues were not sufficient for conditioning to occur.

Even with short interstimulus intervals, taste and nausea are superior to other stimulus-reinforcer combinations in conditioned taste aversion with regard to ease of association. In an experiment, Garcia and Koelling (1966) offered rats either water flavored with sacc. or tap water accompanied by light and noise. When the reinforcer was radiation with its aversive gastrovisceral effects, the intake of the sacc.-flavored water was suppressed. The intake of the water accompanied by brightness and noise was not affected. In contrast, when the reinforcement was shock, the intake of the water accompanied by brightness and noise was suppressed. The intake of the sacc.-flavored water was not. They concluded that reinforcers are not equally effective for all classes of stimuli.

Preference for the taste stimulus plays a role in the strength of learning. Although Green (1969) established conditioning with non-preferred flavors, preferred flavors produced more consistent results, as well as stronger aversion. For example, Green and Churchill (1970) report that when grape juice and milk (the preferred taste) were followed by injections of apomorphine, the aversion to milk was greater.

<u>Rapidity of learning</u> The specificity of taste stimuli and gastrovisceral effects may be part of the reason for the rapidity of learning in conditioned taste aversion. Condtioned taste aversion is learned quickly - often in one trial and at most in five to eight trials (Garcia, 1967). Although "learned safety" is a slower process than conditioned taste aversion, it is still learned more quickly than associations are typically learned in classical conditioning.

<u>Importance of novelty</u> Understanding "the most recent novel taste" hypothesis requires an appreciation of the particular role which novelty plays in conditioned taste aversion. Conditioned taste aversion requires a novel taste.

Elkins (1973, 1974) reports that prior experience with either taste or illness lessens the effect of a conditioned taste aversion. In fact, 20 prior experiences with taste alone (sacc.) or six prior experiences with illness alone (produced by injections of apomorphine) virtually eliminated any evidence of conditioning. That is, when a taste or illness became sufficiently familiar and was then paired with illness or taste, respectively, there was no apparent conditioning. Although taste is the stimulus of primary importance in conditioned taste aversion, conditioning will not occur if the taste is not sufficiently novel.

Another way of considering the relationship of novelty and familiarity is to examine the importance of these two factors in an experiment involving consecutive tastes. Using novel and familiar tastes as the independent variables, Revusky and Bedarf (1967) presented two consecutive tastes, one novel and one familiar, in both orders. Regardless of position, the intake of the novel tasty fluid was suppressed more than the familiar tasty fluid.

Rozin and Kalat (1970) challenged the notion that the most recent novel taste always acquires the most reinforcing strength, when two tastes which are both novel are presented consecutively in a conditioned taste aversion paradigm. They proposed, instead, a salience hypothesis; they suggested that the stimulus which is most distinctive in terms of flavor quality and concentration as well as novelty acquires the greatest reinforcing strength.

They presented one novel taste stimulus for two and one half minutes, followed 15 minutes later by a second novel taste stimulus, also for two and one half minutes. After 15 minutes they intubated the rats with six ml. of .15 M LiCl. Eight sequences, pairs of the four following novel tastes, were presented: 5% casein hydrolysate, .15 M sodium chloride (NaCl), 10% sucrose, and .17% vanilla extract.

Kalat and Rozin found that it was not always the most recent novel taste which acquired the greatest reinforcing strength, as demonstrated by suppression of drinking. There seemed to be a hierarchy based on salience. They concluded that some flavors, such as casein hydrolysate, were more salient than others and therefore would be suppressed by conditioning more than a more recent novel, but less salient flavor.

Best, Best, and Lindsey (1976) have shown more recently how the role of cue additivity rather than salience could account more accurately for the results of Kalat and Rozin's experiment. They used the same tastes, except that they substituted non-nutritive sacc. for sucrose. They provided two-minute access to the tasty fluids, one following immediately after removal of the other, and then immediately ended with an injection of apomorphine (15 mg/kg, i. p.). Best et al. pointed out that the stimuli which Kalat and Rozin used differed in other ways besides taste quality and concentration. One stimulus, casein hydrolysate was, in fact, a compound CS with with dimensions of both taste and smell. The other three were simple stimuli, but not all of the same dimension. Sacc. and NaCl are primarily taste stimuli, while vanilla is primarily an olfactory stimulus. They determined this by rendering the rats anosmic with a 6.75% zinc sulfate solution and comparing suppression response with those of normal rats. Since compound stimuli are more easily associated than simple stimuli (Kamin, 1969a), it was expected that casein-hydrolysate would be the stimulus for which the normal rats developed the strongest aversion. It was. Since conditioned taste aversion is more readily accomplished with taste than with smell,.it would be expected that the NaCl and sacc. would become more aversive than the vanilla. This, too, was exactly the case. When sacc. and NaCl were paired, the most recent taste stimulus regardless of substance was suppressed more.

Kalat (1974) carried out his own more definitive conditioned taste aversion experiment to answer the question of salience versus novelty. He tested one against the other by comparing suppression responses to two concentrations of sacc., .26 g/l and .05 g/l, after he conditioned rats to a concentration of .51 g/l with injections of LiCl. He reasoned that while the higher concentration of sacc. was more salient, the weaker concentration was more novel as compared with the control concentration of sacc. The stronger association was formed with the concentration which was weaker (less salient), but which differed more (more novel) from the familiar concentration, thus supporting the novelty hypothesis.

"The information" hypothesis

Egger and Miller (1962, 1963) developed the paradigm with which to test the information hypothesis. They used two stimuli, one following the other. The first or "leading" stimulus was thought to be more informative than the second or redundant stimulus. They proposed both a strong and a weak version of the hypothesis. The strong version predicts that the leading stimulus acquires greater reinforcing strength.[1]

Egger and Miller assessed the reinforcing strength acquired by two stimuli presented one after the other and conditioned with positive reinforcement (food for bar pressing). They conditioned two stimuli, a tone and a light as follows: they presented the first stimulus and maintained it, while introducing the second stimulus. After presenting the food reinforcement, they terminated both stimuli together. They tested the acquired reinforcing strength by measuring the extinction rate for bar pressing in the presence of each individual stimulus. They reasoned that the stimulus which had acquired greater reinforcing strength would show a slower rate of

---

[1] Egger and Miller also tested both reliable (occurring every trial) and non-reliable (only occurring on some trials) stimuli. Due to the limited scope of this experiment, discussion here will be limited to the reliable case alone.

extinction than the stimulus with less reinforcing strength. Their results supported the strong hypothesis: the leading, informative stimulus alone acquired reinforcing strength.

The information hypothesis has also been tested with negative reinforcement, namely, shock, where learning is fast and often difficult to extinquish. In 1966, Seligman tested the information hypothesis using shock to condition tone and light stimuli. He then compared the extinction rate for previously learned bar-pressing in the presence of each of the individual stimuli. His experiment also confirmed the information hypothesis, since the leading, informative stimulus acquired significantly more strength than the redundant stimulus. In contrast to Egger and Miller, however, the redundant stimulus did acquire some reinforcing strength in Seligman's experiment. Thus, he found support for the weak version of the information hypothesis. He suggested that in negative reinforcement situations there might be a certain spill-over of association to contiguous stimuli, thus eliminating the possibility of support for the strong hypothesis.

Experimental predictions

There are then two hypotheses which can be applied to predict results in conditioned taste aversion experiments in which there is a compound CS composed of two consecutive stimuli: "the information" hypothesis and "the most recent novel taste" hypothesis. The information hypothesis predicts that a leading, informative, and reliable stimulus acquires more reinforcing strength than a second, reliable, but redundant stimulus. This prediction contrasts with the prediction of the most recent novel taste hypothesis that the second or most recent novel stimulus acquires greater reinforcing strength. This latter prediction is based on the idea that the novel stimulus closest in time to the aversive effect acquires greater reinforcing strength. In short, the two hypotheses disagree as to which stimulus acquires the greater reinforcing strength, the stimulus in the first position (information hypothesis) or the stimulus in the second position (the most recent novel taste hypothesis).

There are both strong and weak versions of the experimental predictions. The strong version of either hypothesis predicts that one stimulus alone acquires reinforcing strength, while the weak version of either hypothesis predicts that one stimulus acquires significantly more reinforcing strength than the other.

There are two groups of rats in the present experiment; they receive, in succession, two novel, distinctive, and highly preferred tasty fluids. One taste is sweet and one salty. These tastes are approximately equal in salience and preference. The groups differ in the order in which they receive the two tasty fluids. One group receives first the salty-tasting fluid followed by the sweet-tasting fluid. The other group receives the sweet-tasting fluid followed by the salty-tasting fluid.

The intake of the sweet fluid in the first position for one group then can be compared with the intake of the sweet fluid in the second position for the other group. Likewise, the intake of the salty fluid in the first position can be compared with the intake of the salty fluid in the second position. Thus, the independent variable is the position of a particular taste, while the dependent variable is the amount of fluid consumed (in the leading or most recent position.)

There are three phases to the experiment: acquisition, extinction, and reacquisition. The salty-tasting fluid used in acquisition and reacquisition is a toxic fluid, which produces aversive effects. A similarly-tasting (salty), but non-toxic fluid is substituted for the toxic fluid during the extinction phase of the experiment.

The hypotheses can be tested in the acquisition as well as the extinction phase of the present experiment. Egger and Miller as well as Seligman could not test the information hypothesis in the acquisition phase of their experiments. Having maintained the leading stimulus through the presentation of reinforcement, they had no way in acquisition to distinguish operationally the responses to the two stimuli (light and tone) and hence to measure the degree of reinforcing strength acquired by each stimulus. This is not the case for conditioned taste aversion.

Several experiments cited earlier in this paper demonstrated that the conditioning of the first of two consecutive taste stimuli can take place without the contiguity of that stimulus with reinforcement. In the present experiment the first stimulus can be terminated before the second one is introduced. Thus, the use of consecutive taste stimuli provides an advantage over the tasks used by Egger and Miller and by Seligman: separate tests of the hypotheses are possible in acquisition and extinction.

Since the measurements of acquired reinforcing strength are different in acquisition and extinction, more specific descriptions of the predictions derived from the hypotheses in operational terms are given in the results section of this paper. Reacquisition has been included in the experiment to clarify further the process of learning; both generalization of extinction, and reacquisition of the conditioned taste aversion will be considered.

Method

Subjects

Subjects were 20 male hooded rats, approximately 100 days old at the beginning of the experiment. They were housed singly in wire cages under conditions of constant temperature and humidity and kept on a 12-hour day-night cycle (7 AM - 7 PM). They received Purina rat chow ad-lib.[2] Fluid intake is described below.

Apparatus

The following substances were mixed with distilled water: .1% sacc., .12 M LiCl and .12 M NaCl.[3] The LiCl solution was sublethal, but strong enough to cause

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[2] It is important that there always be food in the cage, since a pilot study (Flesher, 1975) has demonstrated that the absence of food prior to the drinking period will cause significant variations in the amount of fluid subsequently consumed.

[3] LiCl is one of the chief substances used in studies of conditioned taste aversion. Sacc., a non-nutritive sweet, is also used frequently. These two substances have been chosen for this experiment because they both have a highly preferred taste. Also, information concerning the dosages needed for sufficiently equal distinctiveness can be found in the literature (Best, Best, & Lindsey, 1976). An additional important property of LiCl is its great similarity in taste to NaCl. Nachman (1963) reports that rats cannot distinguish between LiCl and NaCl in a three-minute taste test. Therefore, both Nachman and Garcia have frequently used NaCl in the extinction phase of experiments with LiCl. Since the rats in the experiment are not salt-deprived, the nutritive value of salt should not cause a significant relative increase in salt intake as compared with the non-nutritive sacc.

suppression of intake of fluids with novel tastes.

All fluids were stored in uniform glass bottles with bent metal spouts and were refrigerated in order to reduce the amount of bacterial growth. One half a disposable was used with each bottle by placing it underneath the appropriate cage, in order to catch the drips. Bottles and diapers were weighed on a Mettler electronic scale (Type P 1200; 1 Div. = 0.1 g).

Procedure

The same procedure was used for each trial throughout all phases of the experiment. The refrigerated bottles, each with the appropriate fluid, and the disposable diapers were weighed separately on the electronic scale prior to the trial. Two bottles and two diapers were used for each rat. First, a diaper was placed under the home cage and then a bottle was set in place. The bottle was available to the rat for three minutes. Then it was removed, followed by the removal of the diaper. Immediately, a second diaper was placed under the cage and the second bottle made available to the rat for seven minutes. The reasons for the choice of three and seven minute drinking periods are discussed below. The diapers were set in place before the bottles were inserted and removed after the bottles were removed, in order that as much of the dripping as possible could be absorbed by the diapers. Then the diapers and the bottles were weighed again.

The amount of fluid reduction in each bottle less the amount of fluid absorbed by each diaper was recorded as the closest approximation to the fluid intake of each rat.

The first of the experimental fluids was given at 9 AM after 16-hours water deprivation. Water was provided at 5 PM.[4] This type of deprivation schedule provided a remarkably consistent intake of fluid, especially during the three-minute period. Lyons (1965) reports that rats will drink .03 ml. of water per second, when in a state of water deprivation. In the present study, the three-minute mean water intake for four days at base-line was 5.4 ml. (.03 ml. X 180 sec.), as Lyons predicted.

The time required for setting the bottles in place and removing them from the cages permitted only half of the rats in the experiment to receive their assigned treatments at one time. The following procedure was designed to eliminate any bias because 10 of the rats had to wait for their bottles, while the other 10 received theirs.

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[4] More than six hours is required between the drinking causing illness and the drinking of water to ensure sufficient daily intake of fluid to keep the rats well and alive (Fregly, 1958). Here, there is an eight-hour interval.

The two treatment groups, designated A and B, each had 10 rats. Every time the bottles were administered to 10 of the 20 rats, there were always five rats representing each of the two treatment groups. The five rats from each group were selected by dividing groups A and B into two sub-groups: A1 and A2, B1 and B2. These four sub-groups always contained the same five rats in the same order.

Table 1 shows the eight possible combinations of four sub-groups with the restraint that each presentation always contain a sub-group from group A and one from group B. One of the eight possible combinations was used each day in selecting which two sub-groups were treated first and which two sub-groups waited. The combination also indicated whether a rat from group A or group B received the first bottle.

Once it was determined which 10 rats were to be treated together and which group would provide the rat to receive the first bottle, the bottles were presented alternately to rats from groups A and B.

Each day for eigth days one of these eight combinations was selected on a random basis until all eight had been used. This procedure was repeated until the experiment ended.

Table 1

Eight possible combinations of four groups: A1 and A2, B1 and B2 for the presentation of treatments

	First presentation	Second presentation
1.	A1, B1	A2, B2
2.	A1, B1	B2, A2
3.	B1, A1	A2, B2
4.	B1, A1	B2, A2
5.	A2, B2	A1, B1
6.	A2, B2	B1, A1
7.	B2, A2	A1, B1
8.	B2, A2	B1, A1

Design

In order for the first taste stimulus to precede the effects of the toxin, the first drinking period is three minutes in length. In order for the aversive effects to take place during the second drinking period for both groups, the second drinking period is of seven minutes length. Nachman (1963) demonstrated that the drinking of .12 M LiCl by rats deprived of fluid for 24 hours starts to taper off between four and one half and five and one half minutes after drinking has begun. This appears to be an indication that the toxic effect of the LiCl has begun to affect the drinking behavior of the rats.

A notation has been introduced to facilitate discussion.[5] Table 2 presents the design of the experiment.

Training The training period accustomed the rats to get their daily fluid intake during two 10-minute trials, each divided into three-minute and seven-minute drinking periods, and thereby allowed base-line rates for drinking

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[5] The following notation is used throughout the rest of the paper: LiCl/sacc. represents the group given the salty taste followed by the sweet taste, that is, group A. Sacc./LiCl represents the group given the sweet taste followed by the salty taste, that is, group B. A line under a given substance, for instance, LiCl/sacc., indicates that the discussion concerns group A's mean intake of the particular substance LiCl presented in the first position. Likewise, sacc./NaCl refers to group B's mean intake of NaCl presented in the second position. The particular day will be made clear within the context.

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Table 2

Design of experiment

	Training	Acquisition	Extinction	Reacquisition
Days	14	9	9	2
Group A	H_2O/H_2O	LiCl/sacc.	NaCl/sacc.	LiCl/sacc.
Group B	H_2O/H_2O	sacc./LiCl	sacc./NaCl	sacc./LiCl

to become stabilized. It also accustomed the rats to the experimenter's presence throughout the course of the trial and especially to the process of switching bottles. In the morning during training and each evening during the entire course of the experiment the rats were given distilled water.

The training period lasted fourteen days, that is, until the base-line had stabilized. A two-way factorial analysis of variance was performed to confirm that the base-line intake of water had stabilized for the last four days for both the three-minute and the seven-minute drinking periods for each group. The factors were days (4) and groups (2). The analysis of variance was performed separately on the morning water intake for the three-minute and the seven-minute drinking periods. Since there were no available data for the water consumption on day 13 due to experimenter error, the analysis was performed on the data from days 10-12 and day 14.

There were no significant differences in intake for the three-minute drinking period for the main effect of days: $F(3, 72) = 2.1$, or for the main effect of groups: $F(1, 72) = 0.0$. There were also no significant differences in intake for the seven-minute drinking period for the main effect of days: $F(3, 72) = .87$, or for the main effect of groups: $F(1, 72) = .05$. There were also no significant interaction effects (days X groups) for either drinking period. Thus, since the base-line appeared to have stabilized and the intakes of the two groups were similar, the specific treatments were begun.

Acquisition Group A (LiCl/sacc.) received LiCl during the three-minute drinking period, and sacc. during the subsequent seven-minute drinking period. Group B (sacc./LiCl) received sacc. first and LiCl second. Otherwise, the treatment of both groups was the same. The purpose of the acquisition phase was to allow time for the rats to associate a taste(s) with any aversive effects produced by the intake of LiCl.

No data are available for the morning of day 19, the fifth day of the acquisition phase, due to experimenter error. The rats received 10 minutes of water rather than the experimental fluids. An additional trial day was added to the acquisition phase, in order to have nine days of data.

Extinction NaCl was substituted for LiCl in each group. That is, group A (LiCl/sacc.) received three minutes of NaCl followed by seven minutes of sacc., while group B (sacc./LiCl) received three minutes of sacc. followed by seven minutes of NaCl. There were nine days of extinction.

Reacquisition LiCl was reintroduced in place of

NaCl in both groups. Group A (LiCl/sacc.) once again received LiCl first and sacc. second; group B (sacc./LiCl) the reverse. There were two days of reacquisition trials similar in other respects to the acquisition trials.

Results

The analyses for all three phases of the experiment were performed on transformed data. The results of the analyses of variance for acquisition and extinction will be presented. Then several post-hoc analyses will follow: the results for reacquisition, and some analyses based on questions arising from the reacquisition results.

Transformation of the data

Since each comparison between groups of a given fluid involved the comparison of the measurements made for a three-minute and a seven-minute drinking period, respectively, the data were transformed as follows. For each rat the mean intake was found for the three-minute drinking period over days 10-12 and day 14 of the training phase of the experiment. Then the scores for each rat in all three-minute drinking periods during acquisition, extinction, and reacquisition were divided by the rat's mean three-minute intake from the training phase. Similarly, the individual scores from the seven-minute drinking periods were divided by the individual mean intakes from the seven-minute drinking periods for the same days of training. These results multiplied by 100 produced scores which are percentages of the base-line mean intake.

Figure 1 depicts graphically the daily means of the transformed scores for groups A (LiCl/sacc.) and B (sacc./LiCl) for intakes of the fluids during training, acquisition, extinction, and reacquisition.

Analyses of variance to test for learning and for support of the hypotheses

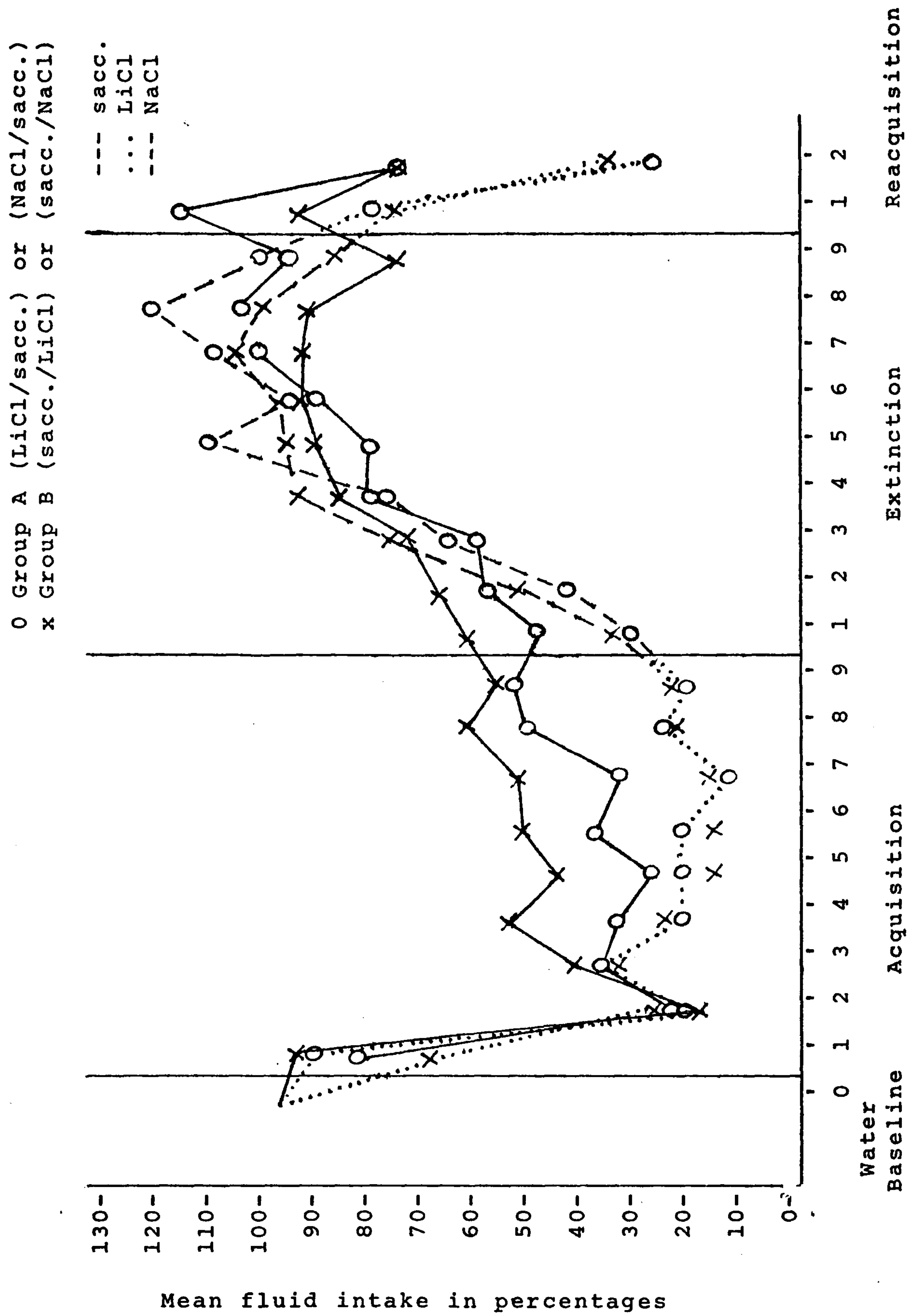
A two-way factorial analysis of variance with main effects of days and presentation order of the tasty fluids (position), with subjects nested under position, was performed for both acquisition and extinction. The days effect should provide evidence for the learning of a conditioned taste aversion in the different phases of the experiment, while the position effect should provide evidence for the information and the most-recent-novel-taste hypotheses.

Acquisition A decrease in fluid intake over days, reflected in a significant days effect, indicates the acquisition of a conditioned taste aversion.

A difference in the intake of a given tasty fluid between group A and group B, if resulting in a significant position effect, indicates support for one of the two hypotheses. Greater suppression of the fluid intake in the first position supports the information hypothesis as opposed to the most recent novel taste hypothesis. Conversely, greater suppression of fluid intake in the second

Figure 1

Daily means of the transformed scores for groups A and B for intakes of the fluids during training, acquisition, extinction, and reacquisition


O Group A (LiCl/sacc.) or (NaCl/sacc.)
x Group B (sacc./LiCl) or (sacc./NaCl)
--- sacc.
... LiCl
-- -- NaCl
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2
Water Baseline
Acquisition
Extinction
Reacquisition
Mean fluid intake in percentages

position supports the most recent novel taste hypothesis as opposed to the information hypothesis.

Significant suppression in intake for only one position provides support for the strong version of the hypothesis in question. Suppression for both groups, but to significantly different degrees, provides support for the weak version of the hypothesis. Equal suppression for both groups may provide support for both hypotheses.

The analysis of variance was performed on the non-toxic fluid, sacc., rather than on the toxic fluid, LiCl.[6] Table 3 presents the results of the analysis of variance performed on the daily mean intakes of transformed sacc. scores with the factors of days (9) and position (2).

The main effect of days was significant, $F(8, 144) = 17.02$, $p < .01$, suggesting that the acquisition of a conditioned taste aversion occurred. There is, in fact, a dramatic drop in sacc. intake from day one to day two of acquisition. It is a substantial effect. It is probably responsible for the significant days effect, despite the

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[6] As mentioned, Nachman (1963) demonstrated that the intake of LiCl tapers off between four and one half and five and one half minutes after drinking begins. If the analysis of variance were performed on the intake of LiCl, the following confounding might arise. Suppose LiCl in the second position did not acquire reinforcing strength. As the intake of LiCl rose, it could be curtailed before the end of the seven-minute drinking period by the onset of aversive effects. Using sacc., this particular problem is avoided.

Table 3

Analysis of variance on the daily mean intakes of the transformed sacc. scores over nine days of acquisition.

Source	SS	df	MS	F
Days (D)	58,269.8	8	7,283.7	17.02*
Positions (P)	4,671.6	1	4,671.6	0.73
Subjects (S)	115,933.0	18	6,440.7	
D X P	2,491.7	8	311.5	0.72
D X S	61,619.9	144	427.9	

*$p < .01$

gradual increase in sacc. intake from day two through day nine which would tend to reduce the value of the effect.

The main effect of position, however, was not significant, $F(1, 18) = .73$, indicating no critical difference in the suppression of sacc. intake between group A and Group B. The interaction effect was also not significant, $F(8, 144) = .72$. The strong version of either hypothesis is clearly not supported.

Extinction Having failed to find a significant difference in position effect during acquisition, there remains a second and better test for position effect during extinction (Elkins, 1963).

An increase in fluid intake over days, resulting in a significant days effect, suggests that extinction of the conditioned taste aversion is occurring. During extinction, greater reinforcing strength is said to be reflected in a slower rate of extinction and/or a lower asymptotic level of fluid intake. The position and interaction effects are analyzed to see whether they indicate differences in rate of extinction and or asymptotic level.

Again, different rates of extinction and/or asymptotic levels, reflected in significant differences in the amount of fluid intake for the two positions, would indicate support in favor of one hypothesis over the other.

Should the fluid intake in the first position rise at a significantly slower rate and/or level off at a lower intake than the fluid in the second position, this would be support for the information hypothesis over the most recent novel taste hypothesis. Should the reverse happen, that is, should the fluid in the second position rise at a significantly slower rate and/or level off at a lower intake than the fluid in the first position, then the most recent novel taste hypothesis would receive support over the information hypothesis.

Since it was expected that LiCl intake would be low for both groups at the end of acquisition, it was expected that NaCl intake would be nearly as low and approximately equal for both groups. This would provide the basis for a comparison of recovery rates. The analysis of variance was performed on the salty, but non-toxic NaCl, which is similar in taste to the toxic fluid, LiCl. Table 4 presents the results of the analysis of variance performed on the daily mean intakes of the transformed NaCl scores with the factors of days (9) and of position (2).

The main effect of days was again significant, $F(8, 144) = 31.75$, $p < .001$, indicating the increase in intake and thus the extinction of the conditioned taste aversion. The alternative interpretation of the increase in intake as a result of a discrimination

Table 4

Analysis of variance on the daily mean intakes of the transformed NaCl scores over nine days of extinction

Source	SS	df	MS	F
Days (D)	130,036.7	8	16,254.6	31.75**
Positions (P)	476.9	1	476.9	0.06
Subjects (S)	138,225.9	18	7,679.2	
D X P	8,215.0	8	1,026.9	2.01*
D X S	73,720.5	144	511.9	

*p < .01
**p < .001

occurring between the taste of toxic LiCl and non-toxic NaCl can be dismissed, when the intake of LiCl in reacquisition is considered both in the present study and in Nachman's study (1963). If the discrimination interpretation were correct, the intake of LiCl when it was reintroduced in reacquisition would be very low. Instead, both in the present study and in Nachman's study, the intake of LiCl on the first day of reacquisition is lower than the intake of NaCl, but still considerably higher than the intake of the last day of acquisition. This suggests that a generalization process is taking place, rather than a discriminative process.

The main effect of position was again not significant, $F\ (1,\ 18) = 0.06$, while the interaction effect was significant, $F\ (8,\ 144) = 2.01$, $p < .01$. However, an examination of the extinction curves for groups A and B suggests that there is no significant difference in the rate of extinction. The cross-over of curves A and B from the beginning to the end of the extinction period, with the curve for group A slightly above the curve for group B as the intake rises and then dropping slightly below the curve for group B as the intake levels off, may well be producing the significant interaction effect. While the curve for group B (sacc./LiCl) is fairly smooth as it levels off, the curve for group A (LiCl/sacc.) has several zig-zags. It is a possibility that interaction effect stems from these zig-zags in the data rather than being representative of a real difference in asymptotes. Therefore, it may only cautiously be suggested that there is a difference in asymptotes, with group A (LiCl/sacc.) having a higher asymptote than group B (sacc./LiCl).

In the transition from extinction to reacquisition, in particular, with the reintroduction of LiCl in place of NaCl, the question of generalization of extinction arises. It is of interest to see whether in this particular paradigm, with two consecutive taste stimuli, a generalization effect takes place from the response to NaCl to the response to LiCl. More directly related to the hypotheses of this experiment are the results of reacquisition and specifically how these results compare with the results of acquisition.

Generalization of Extinction When the highly similar-tasting LiCl was reintroduced on day one of reacquisition, after the rats had learned to drink a salty-tasting liquid (NaCl) again, the rats consumed almost as much LiCl as NaCl (see Figure 1). These results are an extension of Nachman's findings about the generalization of response from NaCl to LiCl (1963), in that the generalization occurs in a paradigm using two consecutive stimuli rather than a single taste stimulus as did Nachman's.

There is also a generalization effect apparent from day nine of acquisition to day one of extinction. Here the suppressed response to drinking LiCl is carried over to the drinking response to NaCl. As is expected, the suppression response is slightly attenuated, that is, the rats reduced the suppression response slightly as indicated by the small increase in their consumption of NaCl.

Reacquisition In order to look at which taste stimuli reacquire the conditioned taste aversion and to what degree, a new term — flavor-position combination — will be introduced. There are four flavor-position combinations in this experiment: LiCl in the first position, sacc. in the first position, LiCl in the second position, and sacc. in the second position. In contrast to the earlier discussions of acquisition and extinction where only one taste was considered each time, here the intake of all four flavor-position combinations is of interest. In order to compare the intake of fluid for each flavor-position combination, a new measure will also be introduced.

Elkins (1963) suggests that the drop in intake from day one to day two, expressed as a percentage of the intake on day one, is a good measure of strength of learning. He suggests, furthermore, that a drop of over 45% is a measure of strong learning.

Table 5 presents the percentage drop in intake for all four flavor-position combinations in both acquisition and reacquisition. It is clear from Table 5 that the drop in intake for all four flavor-position combinations in acquisition is well above 45%, indicating strong learning. In fact, there is one-trial learning in acquisition for all four flavor-position combinations. On the other hand, in reacquisition only the LiCl intake, in the both first and second positions, is well above 45%.

The results of reacquisition are consistent with the findings of the earlier phases of the experiment with regard to position effect, but they also provide evidence of a possible process of discrimination. In order to discuss these matters, the differences among the percentage drops in reacquisition were analyzed by a series of t-tests.

Of prime interest is the significance of the difference in the mean percentage drops in intake for LiCl/*sacc*. and *sacc*./LiCl. The difference was not significant when the mean percentage drop in sacc. intake was compared for the two groups, $t(18) = 1.98$. This result is consistent with the failure to find a significant position effect in either acquisition or extinction.

The mean percentage drops in sacc. intake in reacquisition are smaller than the mean percentage drops in sacc.

Table 5

Percentage drop in intake for LiCl and saccharin in both positions for acquisition and reacquisition

		Percentage drop in fluid intake	
		LiCl	sacc.
Group A (LiCl/sacc.)	Acquisition	56.9%	62.6%
	Reacquisition	55.5	35.3
Group B (sacc./LiCl)	Acquisition	77.5	78.8
	Reacquisition	61.2	19.7

intake in acquisition for both groups. (See Table 5.) However, the mean percentage drops in LiCl intake in reacquisition are comparable to the mean percentage drops in LiCl intake in acquisition. Thus, it appears now in reacquisition that there is a greater degree of reinforcing strength acquired by the LiCl stimulus than by the sacc. stimulus in both groups.

Looking at each group independently, a difference test for correlated means was performed to determine whether the difference in mean percentage drops in LiCl and sacc. intake in reacquisition was, in fact, significant. The mean difference in percentage intake for each group was computed by subtracting the percentage drop in LiCl intake from the percentage drop in sacc. intake for each individual rat. The results were highly significant for group A: $t\ (9) = 4.52$, $p < .005$ and were also significant for group B: $t\ (9) = 2.93$, $p < .05$. The rats in each group appear to discriminate between the safe fluid and the toxic fluid at this point, regardless of the position of the toxic fluid.

It is also possible to ask whether the discrimination was better for one group than for the other. A greater mean difference in intake between the two tasty fluids for one group over the other might be considered support for better discrimination taking place for one group than the other. The results of a t-test comparing the mean difference in the percentage drop in intake between the two tasty fluids for the two groups in reacquisition were significant: $t\ (18) = 4.93,\ p < .001$. Group A (LiCl/sacc.) has a smaller mean difference in intake than did group B (sacc./ LiCl); the differences are 20.2 and 41.5 percent, respectively.

Thus, reacquisition differs from acquisition in that LiCl is the only tasty fluid in each group that shows strong learning as indicated by the large percentage drop. The mean percentage drop for sacc. is significantly smaller in each group, which shows the rats acquiring a discrimination between the safe and toxic fluids. The discrimination is partial, in that the sacc. intake is still suppressed to a degree for each group. Further, the discrimination appears to take place to a lesser degree for group A (LiCl/sacc.) than for group B (sacc./ LiCl).

In summary, there was indication of the acquisition, extinction, and discriminative reacquisition of the conditioned taste aversion. There was no significant position or interaction effect in acquisition. There was also no significant position effect in extinction. There was a significant interaction effect in extinction pointing to a possible difference in asymptotic levels between the two groups. The substantial suppression of fluid intake in both positions for both tastes, also, needs to be evaluated as possible evidence in support of both hypotheses.

Discussion

According to the information hypothesis, the leading stimulus should acquire greater reinforcing strength, since it is the informative predictor of reinforcement. In contrast, according to the most novel taste hypothesis, the stimulus in the more recent position acquires greater reinforcing strength, since it is closer in time to the aversive effects. There was no support for the strong version of either hypothesis. Since there was no significant difference in the suppression of sacc. intake in the different positions during acquisition nor a difference in the extinction rates of NaCl, and only a possible difference in asymptotes during extinction, there is no clear support for one hypothesis over the other.

There were, however, some suggestive results which merit discussion. The significant interaction effect (days X position) in extinction, suggestive of a difference in asymptotic levels, could be interpreted as support for the weak version of the most recent novel taste hypothesis. However, since intake for animals in all four flavor-position combinations was suppressed, there is, probably, some more or less equal support for both hypotheses in the sense that stimuli in both positions are acquiring reinforcing strength. Design problems hamper the interpretation of these results. These difficulties suggest the consideration of an alternate design. Furthermore, such a design could investigate questions raised by the results of reacquisition. Each of these ideas is considered in further detail below.

Learning of a conditioned taste aversion

Acquisition Fluid intake in all four flavor-position combinations was suppressed on the second day of acquisition. It was a substantial effect. Thus, the experiment demonstrated the acquisition of a conditioned taste aversion in a paradigm using two consecutive taste stimuli.

Two of the distinctive characteristics of conditioned taste aversion described by Garcia - rapid learning and learning over a long interstimulus (CS-US) interval were apparent in the present study. First, learning took place in one trial for both groups. This was faster than was expected for group A (LiCl/sacc.), since Garcia et al. (1967) had demonstrated acquisition over three to five days with three-minute presentations of LiCl.

Second, conditioning occurred over a relatively long interval between taste and reinforcer. The subsequent sacc. intake, with sacc. in the first position, was suppressed even though the LiCl which produced the aversive effects was consumed after the sacc. had been removed. It may be noted that sacc. by itself at this concentration is known to be a highly preferred taste. The time between the removal of the sacc. bottle and the diaper and the placement of the new diaper and bottle - at least 10 seconds - is certainly beyond the limits of contiguity reported for classical conditioning.

There was no significant position or interaction effect in acquisition, which would have provided support for one of the hypotheses over the other. However, a critical analysis of the design of this experiment will suggest that it would have been difficult to interpret a difference if a statistically significant position effect had occurred. Comparison of the three-minute intakes of LiCl and sacc. on the first day of acquisition in the present experiment along with a reexamination of Nachman's study (1963) suggests that the rats in group A (LiCl/sacc.) may have experienced aversive effects already while the first taste stimulus was still present. This occurrence would have violated the design of the present experiment, which relied upon the onset of the aversive effects after the introduction of the second taste stimulus.

On day one the intake of fluid for each of the leading three-minute drinking periods in the present experiment is different. The mean raw intakes of LiCl/sacc. and sacc./LiCl on the first day of acquisition were 3.8 ml. and

5.2 ml., respectively. A t-test showed that this difference was highly significant, $t\ (18) = 10.15$, p .001. Since the salty and sweet tastes at this level of salience are highly preferred, the lower intake of LiCl/sacc. as compared to Sacc/LiCl suggests that the onset of aversive effects may well have occurred during the three-minute drinking period for group A (LiCl/sacc.).

The design of this experiment relied specifically on Nachman's report (1963) that the drinking of LiCl tapered off at a level somewhat greater than 9 ml. between four and one half and five and one half minutes after drinking began. The curve presented by Nachman, which shows the cumulative amount of water intake by the control group, was still rising at the end of the 10-minute drinking period and at that point the intake level was slightly over 12 ml. Therefore, it was assumed that it was safe to choose a leading three-minute drinking period for the present experiment. In fact, when the curve for LiCl intake from his study is examined, it appears that the rats consumed about 6 ml. of LiCl during the first three-minutes of their 10-minute drinking period.

The following argument is an attempt to infer indirectly the results of a statistical test, in which results in the present experiment are compared with results in Nachman's study. The 6 ml. of LiCl consumed during the first three minutes of Nachman's ten-minute drinking period is not very different from the sacc. intake of 5.2 ml. in the present experiment, but it does appear to be different from the 3.8 ml. intake of LiCl. Given the consistency of drinking rates when deprived rats begin to drink and the highly significant difference between the sacc. intake of the present experiment, it is most likely that there is also a significant difference in LiCl intake between Nachman's rats and those of the present experiment.

There are at least two possible reasons why the intake of LiCl is different in the two experiments. First of all, there is a difference in the amount of water deprivation. Nachman's rats were deprived for 24 hours and had no alternate source of fluid during the day. The rats in this experiment were deprived for 16 hours and had an alternate fluid source each day, namely, 10 minutes of water. Although less thirst is a possible explanation for less drinking of LiCl, it should then follow in the present experiment that less sacc. would have been consumed. This was not the case. What is more likely is that with less thirst deprivation in an approach-avodiance situation, the aversive effects of the LiCl curtailed drinking earlier.

It is possible then that Nachman's rats were experiencing aversive effects, but kept drinking due to greater deprivation. Nachman's measure indicated when the rats stopped drinking, but not when they first experienced aversive effects. If the rats in the present experiment were experiencing aversive effects during the leading three-minute drinking period, then there is a serious flaw in the design of the present study with several important implications for the interpretation of results as well as for a new experimental design.

The onset of aversive effects during the three-minute LiCl drinking period for group A would make the LiCl taste stimulus both a leading and a most recent taste stimulus, and it would also precede the first opportunity for the rats to encounter the sacc. taste stimulus. This would tend to increase the reinforcing strength acquired by the LiCl taste stimulus in the first position with implications for the course of NaCl intake in extinction due to the generalization effect. It would also tend to decrease the reinforcing strength acquired by the sacc. taste stimulus in the second position, since the stimulus would follow the onset of aversive effects. Boland (1973) demonstrated that backward conditioning is a weaker effect than forward conditioning for LiCl, but that it does occur for intervals of at least one-half hour between the injection of LiCl and the consumption of the non-toxic tasty fluid. There would be no comparable problems for group B, since LiCl was presented in the second position there.

Had the sacc. taste stimulus been the most recent one prior to the onset of aversive effects, as was intended by the design, the intake of LiCl/sacc. might have been lower than it was. Sacc./LiCl would have remained unaffected or been slightly higher than it was due to the apparently smaller interstimulus interval between sacc. and aversive effects than was expected. This would have resulted in an even greater difference in intake between sacc./LiCl and LiCl/sacc. than was the case. It is not possible, of course, to say whether this difference would then have been significant.

A second major problem in the present experiment was the degree of variability in the rats' responses after day two of acquisition. This reduced the power of the statistical test making it more difficult for a possible position effect to surface.

Extinction For both groups the intake of sacc. rose over the final seven days of acquisition. It continued to rise ahead of the rise of NaCl intake during extinction. If most of the rats had learned to reduce their thirst already by drinking more sacc. and were, indeed, less thirsty (having consumed increasing amounts of fluid day by day), there is less reason to expect the extinction of the suppression response to NaCl (which had been generalized from LiCl)/ Nonetheless, extinction took place for both groups. This is an extension of the findings of both Nachman (1963) and Garcia et al (1967) in so far as the suppression response to both of the consecutive tastes extinquished.

Hulse, Deese, and Egeth (1975) talk about conditioned taste aversion as if it were "permanent." This is not, obviously, an all-pervasive phenomenon. That the intake of both fluids in each group returns approximately to base-line is an indication of relatively impermanent learning.

Although the asymptotes of NaCl for both groups were near to base-line, the possibly lower asymptote for group B (sacc./NaCl) would be weak support for the most recent novel taste hypothesis. The difficulties noted during the discussion of acquisition also bear on the discussion of the extinction phase of the experiment. Had LiCl/sacc. not been the most recent as well as leading stimulus, it might have acquired less reinforcing strength. The resultant weaker reinforcing strength acquired in acquisition would tend to increase the asymptotic level of NaCl/sacc. (group A) during extinction. There would be no comparable effect on the asymptotic level for sacc./NaCl (group B). Thus, the difference in asymptotes might have been even greater had the design not been confounded.

Concluding evaluation of the hypotheses

Although the data do not clearly support one hypothesis over the other, sacc. in both positions (leading and most recent) seemed to acquire reinforcing strength. The significant days effect in acquisition without a significant interaction suggests that the intake of sacc. was suppressed to a comparable degree for both groups. Even without any contiguous aversive effects, sacc./LiCl was suppressed. The trends for differences in sacc. suppression in acquisition and reacquisition were both in the direction as would support the most recent novel taste hypothesis.[7] Thus, they were both consistent with each other and the possible asymptotic difference in extinction.

It was also true for Best et al. (1976) that the fluid in the first as well as the second position was suppressed to a fair degree. It appears then that all stimuli, regardless of position, acquired some reinforcing strength. The similarity in the amount of reinforcing

[7] In acquisition, there was greater suppression over days of sacc. in the second position than there was of sacc. in the first position, suggestive of greater reinforcing strength acquired by the stimulus in the second position (see Figure 1). In reacquisition, the percentage drop of sacc. in the second position (35.3%) was greater than that of sacc. in the first position (19.7%), although not significantly so. The discussion of design difficulties pertaining to sacc. in acquisition would also apply to reacquisition. This would imply that the difference here might also have been greater.

strength acquired by stimuli in different positions in this experiment may well be due to the difficulties of the design.

In the research of Kalat and Rozin (1970) and Best et al. (1976), designed to test hypotheses about salience, some support can be found for the most recent novel taste hypothesis. Kalat and Rozin, using sucrose and NaCl as consecutive stimuli followed by the intubation of LiCl, found significantly greater suppression of sucrose in the second position, and they found slightly greater suppression of NaCl in the second position. Best et al., using sacc. and NaCl, found significantly greater suppression of the fluid in the second position, regardless of the taste. However equivocal the results of the present experiment, the results of Best et al. seem to be consistent with predictions derived from the most recent novel taste hypothesis.

There appears then to be a difference between the strength acquired by the most recent stimulus in conditioned taste aversion and in the tasks described by Egger and Miller (1962, 1963) and Seligman (1970) where they test the information hypothesis. One possible explanation for this depends upon the fact that conditioned taste aversion is possible over long intervals. It may be more useful, in terms of survival value, for rats to associate aversive effects with the most recent novel taste encountered. Garcia (1974), Bolles (1973), and Seligman (1970) point to the biological adaptiveness of relating aversive gastrovisceral effects to the most recent novel taste encountered.

Discrimination during reacquisition

Of greatest interest in the reacquisition phase of the experiment is the apparent ability of the rats to differentiate between the two tastes. For each group, the percentage drop in LiCl intake was significantly greater than that for sacc. intake. Thus, in each group, the rats learned to suppress the intake of toxic fluid and increase the intake of the non-toxic fluid.

When the graph of the intakes is examined (see Figure 1), it appears that the sacc. intake is already rising and drawing away from the intake of LiCl after the first two days of acquisition. Most of those experiments testing conditioned taste aversion with consecutive tastes used an acquistion phase of one trial, so that there were typically not enough trials for the discrimination process to emerge. Further research would be useful to see whether this apparent discrimination is a general porcess, since it is not well documented.

During reacquisition the difference in the percentage drop between the two tasty fluids was significantly smaller for group A (20.2%) than for group B (41.5%). The interpretation of a difference of a difference must always be made with caution; nevertheless, it bears on the discrimination process. There are at least two possible reasons for the smaller difference for group A.

If the onset of aversive effects did happen during the first drinking period for group A (LiCl/Sacc), these effects most likely continued during the second drinking period when sacc. was the taste stimulus. This means that there would be aversive effects contiguous with the presence of both taste stimuli. It would seem likely that this would make it more difficult for the rats in group A to determine which tasty fluid was, in fact, toxic.

The second and more theoretical conjecture relies upon the suggestive evidence of a position effect in support of the most recent novel taste in the present experiment. If there were an interaction between the greater reinforcing strength acquired by the stimulus in the most recent position and the actual position of the toxic fluid, it might affect the ease with which rats in a particular group discriminate which flavor is, in fact, toxic. That is, it might be easier for rats to identify the actual toxic fluid, if it is in the most recent position. This would be due to the greater attention to that stimulus or a greater expectation that the most recent stimulus is the most important stimulus.

It is the case in the present experiment that for group A (LiCl/sacc.) the toxic fluid is in the leading position, while for group B (sacc./LiCl) the toxic fluid is in the most recent position. Furthermore, group A, with the toxic fluid in the first position, had the significantly smaller difference in fluid intake between its two tastes suggesting a more difficult discrimination. Group B, on the other hand, with the toxic fluid as the most recent fluid, showed a greater discrimination, as evidenced by the larger difference in intake between its two tastes.

Obviously, the confounding in this experiment does not allow for any clear support for either of these explanations. Another design, however, might enable the issue of discrimination to be formulated and tested more adequately.

Further research

Both the analysis of the design and the results of reacquisition suggested that a new design would be desirable. A greater degree of aversive effect would tend to reduce subject variability and enhance effects. Nachman's solution (1963) was to use a 10-minute drinking period for the acquisition trial. However, a long initial drinking period would not work in the present design. The onset of aversive effects for group A (LiCl/sacc.) appears to have occurred too early already. Likewise, increasing the amount consumed (and thereby the aversive effects) by increasing the deprivation level would only serve to further increase and mask the early onset of aversive effects.

Another means of increasing aversive effects is to provide higher concentrations of LiCl by intubation or injection following the ingestion of two consecutive tasty, but non-toxic fluids. When intubation or injection follows the drinking periods, the periods could be shorter (two minutes) and of equal length. The equal drinking periods would make less likely the need to transform the data, as was necessary in the present experiment. Drinking should be sustained at a fairly high and consistent rate for the total four minutes of drinking prior to the introduction of aversive effects. Were the intake of both fluids high and comparable on the first day, the acquisition of reinforcing strength apparent on day two would be due primarily to a position effect.

With the use of intubation or injection, NaCl could be used through all phases of the experiment. This would allow for the establishment of independent base-line levels for each distinctive taste apart from the aversive effects.

Ordinarily, with intubation or injection the taste stimuli and the aversive effects are independent. That is, the suppression of one or both of the fluids would not tell the rat when reinforcement occurred or not, since there would be no necessary correlation between the amount of fluids ingested and the aversive effects. In such a design, the amount of LiCl could be made to vary with the amount of fluids ingested and the aversive effects. In such a design, the amount of LiCl could be made to vary with the amount of tasty fluid consumed in one of the two consecutive positions, so that the rats could use the amount consumed as a discriminative cue. Balagura (1970) has shown that the amount of tasty fluid consumed can affect the amount of reinforcing strength acquired.

The aversive effects could be made to vary with the position of the fluids in each group. Tastes could also be controlled, by varying the order in different groups, and the position effect could be tested under more controlled conditions. Furthermore, it could be seen whether the discriminative process would be confirmed. If so, the possibility of an interaction between the discriminative porcess and the position effect could be tested.

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Biography

Family background of Mary June Mosher Flesher

Daughter of June Margaret Joudrey and Frederic Walter Mosher born on January 21, 1938 in New York City.
Wife of the Rev. Hubert Louis Flesher.
Mother of Erika Anne (9) and Jonathan Jay (7).

Education

B. A. magna cum laude with honors in religion, Smith College, Mass., 1960
Kirchliche Hochschüle, Berlin-Zehlendorf and Freie Universität, Berlin-Dahlem, Germany, 1960-61.
Universität zu Marburg/Lahn, Germany, 1961-62.
M. A. in religious studies, Yale University, Conn., 1962-64.
Workshops (1 week each):
Creative risk-taking, Human Relations department, Boston University, 1966.
Sensitivity training, MATC, 1968.
Conference design and evaluation, MATC, 1969.
Organizational change, MATC, 1969.

Honors and awards

National Merit scholarship, honorable mention, 1956.
Smith College Alumnae scholarships, 1956-60.
Henry Lewis Foote prize in biblical literature, 1960.
Adenauer fellowship, 1960-61.
DAAD Stipendium, 1961-62.
Woodrow Wilson scholarship, 1961-62 (not accepted).
Lilly Foundation fellowship, 1962-63.
Yale University fellow, 1963-64.
Lambda Alpha Lambda, 1973; Psi Chi, 1975.

Translation

von Harnack, Adolf. The relevance of theological faculties at the university. The Christian Scholar, fall, 1964.

Experience

Programmer, MIT-Lincoln Laboratories, 1964-66.
Consultant in Christian education, Christ Episcopal

church, Cambridge, Mass., 1965-66.

Co-founder of the Lancaster Independent Press, 1966. Office manager, reporter, board of directors, 1966-70.

Consultant in Christian education, Diocese of Harrisburg (Episcopal), one day a week, 1966-70.

Instructor in SKIP (program for pregnant high school girls), one day a week, 1968-70, social studies, languages, mathematics.

Discussion leader: Religion and Science (team-taught course), Moravian College, fall, 1971.

Staff associate, Dean of Student's Office, Lehigh University, half-time, spring, 1973.

Teaching assistant: Introduction to Psychology (PSI), spring, 1977; Encountering Self and Others, fall, 1977.