The Effect of Discrimination Training on Salt and Sugar Taste Thresholds of Preschool Children

Susan M. Castine
Western Michigan University

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THE EFFECT OF DISCRIMINATION TRAINING ON SALT AND SUGAR TASTE THRESHOLDS OF PRESCHOOL CHILDREN

by

Susan M. Castine

A Thesis
Submitted to the
Faculty of The Graduate College
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The Effect of Discrimination Training on Salt and Sugar Taste Thresholds of Preschool Children

Susan M. Castine, M.A.
Western Michigan University

Using a single-subject A-B-C-D design, this study examined NaCl and sucrose taste thresholds in water, tomato juice, and milk with four 4-year-old children. Taste thresholds were determined by presenting several concentrations of an adulterant (i.e. NaCl, sucrose) in each vehicle, in blocks of ten trials. Subjects evaluated each taste sample by pressing one of two levers (Yes/No response). Detection threshold was defined as the level at which there was 50% correct responding. During Baseline, subjects received no feedback regarding the accuracy of their response. During the differential reinforcement phase, subjects received reinforcement following each correct response. Results suggested that detection thresholds for the adulterants in tomato juice were lowered following differential reinforcement of correct discrimination of the presence versus absence of a specified adulterant. Similar lowering of thresholds was not obtained for the same adulterants in water. The data also indicated that there was a generalization of training effect to a novel vehicle (milk). Lowered thresholds in tomato juice maintained or improved at follow-up.
ACKNOWLEDGEMENTS

Several individuals deserve recognition for their efforts, support, and encouragement. I would like to thank Dr. R. Wayne Fuqua for his interest, suggestions, editing, and guidance during the formation and completion of this research project. Special recognition is also given to Mark Dean, mentor and friend, for his support from the onset of this thesis. And recognition is given to Ron Bowens for his assistance in preparing test solutions and collecting data. Thanks also goes to the staff at the Child Development Center for their interest and cooperation in providing subjects. Significant gratitude is extended to those special friends and family members who have been a strong source of motivation and support throughout my graduate work. Most of all, acknowledgement is given to Jesus Christ for the principles he taught me outside the classroom and for his unfailing love.

Susan M. Castine
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WESTERN MICHIGAN UNIVERSITY M.A. 1984

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CHAPTER I

INTRODUCTION

Of all the variables affecting man, food is probably one of the most potent. Its influence extends for the duration of the lifespan, exerting an effect on the course of development as well as the course of specific diseases. There has been increasing concern about the role that taste sensitivity and taste preferences play in the establishment of dietary patterns (Cowart, 1981).

Preferences for sweet tastes, evidenced by neonates persist in both older infants and preschool children (Desor, Maller and Greene, 1977). A recent study by Birch (1979) indicated that sweetness becomes an increasingly salient dimension underlying children's food preferences during the preschool years. These food preferences established early in life often persist throughout the lifespan (Beauchamp & Maller, 1977). Most children like sweets, and sugared foods often form a staple of their diet. While most of the research linking consumption of sugar to health problems is of necessity correlational, there is ample evidence to suggest that the consumption of refined sugar can have many deleterious health effects including the eventual development of hypoglycemia, atherosclerosis, obesity and dental caries (Cleave, 1974).
Investigators have also concluded that sucrose is the most cariogenic dietary carbohydrate (e.g., Newbrun, 1969; Brown, 1975). Furthermore, learning disabilities and hyperactivity have also been linked with sugar consumption (Hoffer & Walker, 1978).

Young children also have been shown to prefer salted to unsalted foods. In a study by Filer (1978), when 2-6 year-olds were presented with identical jars of salted or unsalted beef stew, they chose to eat the former with significantly greater frequency. Beauchamp (1981) also demonstrated that when given a choice, children aged 4-8 years selected salted pretzels significantly more often than unsalted ones. Such a preference may prove to be detrimental, as epidemiological observations suggest a relationship between salt ingestion and hypertension (Tobian, 1977). In the pediatric population alone, hypertension is estimated to afflict 6-11% of the population (Kaplan & Hernandez, 1982).

Because preferences for potentially harmful food substances is common among young children, and often extends into adulthood, it would be useful to train preschoolers to detect the presence of salt and sugar in food and beverages and to refuse foods with these ingredients. Hardy, Brennard and Wyse (1981) concluded from their study that younger individuals could not recognize salty, sweet, and bitter substances as readily
as adults. The inability of children to detect salt and sugar tastes is most likely a result of a lack of experience and incidental training mediated by others as to what the tastes are. It seems important that young children are taught "good" and "bad" tastes, as taste sensations often serve to both direct and motivate consummatory behavior (Epstein, 1967). While research has been done with preschoolers and young children determining taste thresholds of NaCl and sucrose in water (Cowart, 1981), no studies have been conducted to determine whether preschool children can be taught to lower their discrimination threshold for these substances in other liquids or foods, or whether lowered discrimination thresholds would generalize to the same adulterant in untrained vehicles. If it is possible to teach children to detect levels of salt and sugar in foods, it might then be possible to train children to follow effective rules concerning their consumption and reduce their dietary consumption of these substances.

A few researchers have studied children's taste thresholds relative to either age, sex, disease states or influence of food preferences. Within this body of literature, three kinds of procedures were used to determine NaCl and/or sucrose taste thresholds. Some researchers (e.g. Korslund & Eppright, 1967) established children's taste thresholds by a "recognition" procedure, presenting
successively higher concentrations of NaCl and/or sucrose solutions until the subjects indicated by verbal response or by facial expression a positive taste response. In this study, the average thresholds were .03 M for sucrose and .02 M for NaCl.

The second procedure used by researchers (e.g. Lauer, Filer, Reiter, and Clarke, 1976; Hardy, Brennard, and Wyse, 1981) in establishing taste thresholds of children consists of the titration method, presenting drops of various concentrations of NaCl and/or sucrose solutions on the subjects' tongue in addition to two drops of distilled water. The subjects were requested to state which of the three samples tasted different from the other two. Thresholds were determined as the concentration at which subjects consistently correctly identified the difference. In the Hardy et al. (1981) study, the average thresholds were .068-.9% (.001-.017 M) for NaCl, and .52-.65% (.025-.08 M) for sucrose. In the Lauer et al. (1976) study, salt threshold was 16-20 millimoles per liter (.16-.2 M).

The third method adopted by many researchers (e.g. Yasaki, Miyashita, Ahido, Hirano, Kamata and Iizuka, 1976; Glanville, Kaplan and Fischer, 1964; Henkin, Gill and Barter, 1963; Wotman, Mandel, Khotim, Thompson, Kutscher, Zegarelli, and Denning, 1964; Hertz, Cain, Bartoshuk,
and Dolan, 1975) to determine taste thresholds with children employs a method known as the Harris-Kalmus procedure. This technique requires trials where the subjects sort eight cups, four containing the test solution and four containing water, according to taste. The subjects are usually required to rinse their mouth between taste testing. Trials are continued until the subject can no longer correctly (100%) separate the test fluids from one another. The next higher concentration is deemed to be the taste threshold. In the Yasaki et al. (1976) study, the sucrose threshold for children was 47.9 ± 19.4 mM (.47 ± .194 M). In the Hertz et al. (1975) study, the NaCl threshold for children averaged 1.1 X 10^{-3} M (.001 M). Results from the Wotman et al. (1964) study found NaCl taste thresholds for children to be in the range of 40-80 mg% (.007-.01 M). And thresholds established in the Henkin et al. (1963) study averaged 12 mM/L (.12M) for NaCl and sucrose. Previous researchers have sought to determine taste thresholds using various procedures; however, unlike the present study, these studies have not attempted to shape thresholds.

The present study is similar to the Korslund and Eppright (1967) study in that both examine the preschool child's ability to recognize the taste of sucrose and NaCl. However, in the present study the subject's responses to trials were assessed by observing an easily classified
motor response rather than by subjectively judging the children's verbal responses to questioning and facial expressions of pleasure or displeasure. Also improving on the Lauer et al. (1976) and Hardy et al. (1981) studies, the present study examined salt and sucrose thresholds using blocks of trials for each concentration and required mouth rinses between taste tests. The present study also improved upon the Harris-Kalmus procedure used in the Yasaki et al. (1976), Glanville et al. (1964), Henkin et al. (1963), Wotman et al. (1964) and Hertz et al. (1975) studies by minimizing effort required of the subjects to make a categorizing response.

A strategy for threshold determination with animals is exemplified by a recent study by Mariotte and Fiore (1980) who tested the gustory capabilities of pigeons using a stimulus discrimination procedure. The pigeon was trained to peck keys corresponding to the presence and absence of a NaCl solution (yes/no response). Following the response, the bird received food for a correct choice. The experimental design did not include baseline measures, trials without positive reinforcement. A similar procedure was adopted for facilitating discrimination performance in the present study; however, baseline was taken to determine change in taste thresholds following differential reinforcement of correct responses.
Most prior investigations in the area of taste thresholds of children have sought to determine what the thresholds of discrimination were to various substances diluted in water, for purposes of comparison with other groups. And currently, no studies have attempted to lower children's, adult's, or non-human subject's taste thresholds to NaCl or sucrose in water or liquid foods. This study examined: 1) what taste thresholds preschool children have to NaCl and sucrose in water and liquid foods; 2) whether preschool children's threshold of discrimination to salt and sugar in both water and tomato juice can be lowered using a stimulus discrimination procedure; and 3) if the lowered threshold would generalize to the same adulterants dissolved in other solutions.
CHAPTER II

METHOD

Subjects

The subjects for this study were four preschool children, two males and two females, aged 4-years-old. The participants were normal, healthy children without formal training in nutrition. The experimenter chose the subjects based on their history of compliance with instructions as indicated by teacher report. Informed consent was obtained from the subjects' parents and approval was received from the research screening committee at the preschool.

Setting

The setting for the experiment was the Child Development Center, located in Kalamazoo, Michigan. The experimenter conducted sessions in a vacant 12 X 16 m classroom which contained a table and two chairs. This room provided an environment where visual and audible distractions were minimal. Only one subject and the observer were present during a session; sessions were held between 8-9 a.m. and 2-3 p.m. Monday-Friday.

Apparatus

This experiment used a two-lever response manipulandum.
A 16-inch board with attached levers was set on the table, six inches in front of the subject. For this experiment, depressing the right lever was considered a "yes" response (i.e. indicated the presence of salt or sugar), and pressing the left lever was considered a "no" response (i.e. indicated the absence of salt or sugar.

Materials

Solutions with varying concentrations (moles/liter) of commercial salt (NaCl) and sugar (sucrose) were prepared by dissolving these substances in one of three liquids. For water solutions there were five concentrations in increments of .002 M (beginning at .002 M) and two additional solutions of .0005 M and .001 M, for both salt and sugar. For the tomato juice and milk solutions, five salt and sugar concentrations were prepared for each liquid in increments of .2 M (beginning at .1 M) and one at .05 M. The experimenter selected this range to include concentrations above and below previously established taste thresholds of salt and sugar (Williams & Cohen, 1978; Lauer, Filer, Reiter & Clarke, 1976). Concentration ranges for milk and tomato juice were based on subjective judgements of the experimenter following discriminability probes of various concentrations.

The liquids used in testing were unsalted Hunt's tomato juice (ingredients- tomato concentrate, water) and
Country Fresh skim milk (ingredients—milk fat solids, skimmed milk, vitamins A & D), as well as distilled water. The salt (NaCl) and sucrose solutions were prepared by dissolving a known amount of the material in the appropriate volume of the test liquid. All preparations were based on the molecular weights of the salt (NaCl = 58.45 grams/mole) and sucrose (C_{12}H_{22}O_{11} = 342.3 grams/mole). The densities of the test solutions were assumed to be 100% pure. All substances were prepared at least 24 hours before testing and refrigerated between sessions to prevent decomposition. The solutions were brought to room temperature (22°C - 25°C) before use.

Other materials included 2 oz. plastic medicine cups, plastic chips (tokens) and an assortment of small toys and stickers, which were used as reinforcers.

Procedure

Correct and incorrect responses to the two-lever manipulandum were manually recorded. Correct responses were defined as presses to the right (yes) lever after tasting a liquid containing sugar or salt and lever presses to the left (no) lever when any amount of salt or sugar had been added. The percentage of correct responses per 10 trial blocks for each concentration was used to determine threshold. Detection threshold was defined as the level at which there was 50% correct responding (Blough
Thresholds were determined for each subject using concentrations of one of the two adulterants (either salt or sugar) in all three vehicles (i.e. water, tomato juice, milk) by assessing accuracy of detection across ten trial blocks. Within each ten trial block, five trials in which the test vehicle contained a specified concentration of either salt or sugar were unpredictably alternated with trials in which the same vehicle was presented without the added salt or sugar. The various concentrations in each vehicle were presented arbitrarily rather than in ascending or descending order. Approximately five milliliter samples were presented in a series of prearranged plastic medicine cups. Samples containing salt or sugar were visually identical and indiscriminable form samples lacking the adulterant. Subjects rinsed their mouths with distilled water and expectorated between taste samples. Ten trial blocks were repeated using a different concentration of sugar or salt in the same vehicle until all concentrations in that vehicle had been tested at which time testing of the various concentrations of a different vehicle-adulterant combination began. Throughout all experimental phases, Subjects 1 and 2 received test solutions adulterated with salt while Subjects 3 and 4 received only test solutions containing sugar.
A trained observer gave the subjects instructions, recorded correct and incorrect responses on a data sheet, delivered reinforcers for correct responses and also delivered the five milliliters of test solutions to the subjects in a 2 oz. medicine cup. The observer was instructed to keep a consistent facial expression and refrain from nodding his head, talking to the subjects or emitting other cues that might bias subject responding.

For each subject, interobserver agreement on response scoring was assessed once during each phase of the experiment by having another observer score the responses independently. Interobserver agreement percentages were computed by dividing the number of agreements on the location of a response by the total number of agreements plus disagreements and multiplying the quotient by 100%. Percentage agreement scores averaged 100% across phases for all subjects.

Experimental Sessions

Pretraining Sessions

The experiment required 40-45 sessions for each subject including the Pretraining session. Sessions were held once a day. During the Pretraining Session, subjects were trained to detect the presence of their predetermined adulterant (salt for Subjects 1 & 2, sugar for Subjects 3 & 4) and reliably indicate their response using the two-lever
response apparatus. The experimenter told Subjects 1 & 2 in the Pretraining Session, "I want to see if you know what salt tastes like. I will give you 20 "taste tests". Taste the sample; if the drink has salt in it, say "Yes" and press the right lever. If it doesn't, say "No!" and press the left lever. I will tell you if your answer was correct. Then rinse your mouth with water (distilled), spit it in the container, and be ready for the next taste test. When you get all the taste tests right, you'll get a prize." Similar instructions were given for Subjects 3 & 4, replacing "salt" with "sugar". The experimenter used sucrose and NaCl solutions of .125 M concentration in water, a level well above established thresholds. Twenty separate trials were given of which ten were distilled water and ten with the NaCl or sucrose adulterated solution depending on the subject. Criterion for completion of the pretraining phase was 100% correct responding for 20 consecutive trials. The subjects received a cartoon character sticker upon completion of the session.

Baseline Sessions

Baseline consisted of testing to determine each subject's taste threshold for either NaCl or sucrose in water, tomato juice and milk. At the beginning of these sessions, Subjects 1 & 2 were instructed as follows, "I want to see if you can tell if salt is in these drinks."
If the drink has salt in it, press the right lever. If it doesn't, press the left lever. Then rinse your mouth and spit it out in the container." Similar instructions were given to Subjects 3 & 4, substituting "sugar" for "salt". Following their response, the subjects did not receive verbal praise, tangible reinforcers or feedback on the accuracy of their responses. During Baseline, the experimenter tested the salt detection threshold of Subjects 1 & 2 by testing all salt concentrations in water first, followed by all NaCl concentrations in tomato juice, and then salt concentrations in milk. For subjects 3 & 4, sucrose solutions in all three vehicles were tested in the same order. Baseline was completed when the subjects had completed one ten trial block of taste tests for all concentrations of their assigned adulterant (either salt or sugar), in all three vehicles. Upon completion of each baseline session, the subjects received a sticker, regardless of their performance.

**Differential Reinforcement of Correct Responses**

During this phase, the experimenter delivered reinforcers (tokens) contingent on correct lever presses following each taste test. For the subjects, the experimenter presented two concentrations below, one at, and several above the established NaCl or sucrose thresholds with water and tomato juice from the Baseline Phase. Subjects 1 & 2 trained only on water and tomato juice with
salt. Subjects 3 & 4 trained only on water and tomato juice with sugar. Concentrations in milk were not tested in this phase. Prior to each session, the experimenter told Subject 1 & 2, "I want to see if you can tell if salt is in this drink. If the drink has salt in it, press the right lever. If it doesn't, press the left lever. Then rinse your mouth with water and spit it in the container. Everytime you make a correct lever press, you will get a chip. When we're done, if you have 16 chips, you can trade it for a small toy." Similar instructions with respect to sugar were given to Subjects 3 & 4. As in Baseline, there were two blocks of ten trials during each session until all concentrations were administered. When the subjects failed to meet the criterion to receive a toy, they received a sticker. Criterion for the completion of this experimental phase was completion of the taste tests with all concentrations.

Generalization Probe

This phase consisted of retesting the subjects' taste discriminations of either the NaCl or sucrose substances in milk. Procedures were identical to those described in Baseline except only milk was used for determining threshold levels. Subjects 1 & 2 were tested with salt-adulterated milk and Subjects 3 & 4 with sugar-adulterated milk.
Maintenance Phase

During this phase, the experimenter retested the subjects' taste threshold to NaCl or sucrose with tomato juice, using the concentrations used in Baseline. Once again, Subjects 1 & 2 were tested with salt and Subjects 3 & 4 with sugar. Procedures were identical to those described in Baseline except only tomato juice was used for determining thresholds. This phase provided information on the maintenance of lowered thresholds over time and under no reinforcement conditions identical to those of baseline.

Experimental Design

The experimenter implemented a single-subject A-B-C-D design. The experimental design is summarized in Table 1. Baseline measures using all three vehicles and an adulterant were taken for each subject (A) after which differential reinforcement of correct responses (B) was provided for two of the three vehicle-adulterant in combination with milk occurred, after which the final phase was implemented, a maintenance probe (D) in which threshold for tomato juice and the respective adulterant was assessed. In this study, replication of the A-B-C-D design across four subjects strengthened conclusions about the effect of the independent variable (i.e. differential reinforcement of correct responses).
Table 1

Experimental Design

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>1 &amp; 2</td>
<td>Water &amp; salt</td>
<td>X</td>
<td>X</td>
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<td></td>
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<tr>
<td></td>
<td>Tom.Juice &amp; salt</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td></td>
<td>Milk &amp; salt</td>
<td>X</td>
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<td>3 &amp; 4</td>
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<td>X</td>
<td>X</td>
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CHAPTER III

RESULTS

Figures 1 & 2 show the percentages of correct responses per 10 trial block for each vehicle-adulterant combination across phases. As can be seen in Figures 1 & 2, the pattern of percentages of correct responses per 10 trial block are similar across subjects; generally, percent accuracy increased with increasing concentration levels. All subjects did show a decrease in NaCl or sucrose taste threshold measures with tomato juice and milk following the Differential Reinforcement of Correct Responses Phase, as evidenced by the shift in the shift in the percent accuracies. For the subjects, differential reinforcement for correct discriminations did not decrease taste threshold measures with water, except for Subject 4. While the water threshold for Subject 3 did not change, increased accuracy at suprathreshold concentrations were noted.

In Table 2, are shown the NaCl and sucrose taste thresholds (i.e. 50% correct responding) for the three vehicles, in all phases. For water, taste thresholds following differential reinforcement for correct responding did not change for two subjects, decreased for one subject and increased for one subject. Taste thresholds in water for NaCl and sucrose ranged from .002-.004 M for both Baseline and the Differential Reinforcement of Correct
Responses Phases, well within the range reported by other experimenters (Hertz, Cain, Bartoshuk, Dolan, 1975). For tomato juice, taste thresholds in the Differential Reinforcement of Correct Responses Phase decreased from Baseline for all four subjects. At Baseline, NaCl and sucrose taste thresholds in tomato juice ranged from .2 M to .2 - .4 M respectively, and decreased by .1 & .15 M to .1 & .3 M during the Differential Reinforcement Phase. For tomato juice, the Maintenance Phase revealed NaCl and sucrose taste thresholds ranging from >.05-.05 M, a decrease from the same thresholds assessed during baseline. Detection thresholds for milk, which ranged from .2 M for salt-adulterated samples to .2 M & .4 M for sugar-adulterated samples, decreased by .15 M & .3 M respectively at the Generalization Probe.

Table 2

NaCl and sucrose taste thresholds in vehicles across phases

<table>
<thead>
<tr>
<th>Vehicles</th>
<th>Phases</th>
<th>NaCl 1</th>
<th>NaCl 2</th>
<th>NaCl 3</th>
<th>NaCl 4</th>
<th>Sucrose 3</th>
<th>Sucrose 4</th>
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<td>Water</td>
<td>Baseline</td>
<td>.002</td>
<td>.002</td>
<td>.002</td>
<td>.004</td>
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<td></td>
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<tr>
<td></td>
<td>Diff. Rein.</td>
<td>.004</td>
<td>.002</td>
<td>.002</td>
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<tr>
<td>Tomato juice</td>
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<td>.2</td>
<td>.4</td>
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<td></td>
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<tr>
<td></td>
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<td>.1</td>
<td>.1</td>
<td>.1</td>
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<tr>
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<td>.05</td>
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</tr>
<tr>
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<td>Baseline</td>
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<td>.2</td>
<td>.4</td>
<td>.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gen. Probe</td>
<td>&gt;.05</td>
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<td>.1</td>
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</table>

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FIG. 1 PERCENTAGE OF CORRECT RESPONSES PER 10 TRIAL BLOCKS FOR EACH VEHICLE-ADULTERANT CONCENTRATION ACROSS PHASES
FIG. 2 PERCENTAGE OF CORRECT RESPONSES PER 10 TRIAL BLOCKS FOR EACH VEHICLE-ADULTERANT-CONCENTRATION ACROSS PHASES
CHAPTER IV

DISCUSSION

Using a single-subject A-B-C-D design, the present study examined NaCl and sucrose taste thresholds in water, tomato juice and milk. Results suggest that detection thresholds may be lowered following differential reinforcement of correct discrimination of the presence versus absence of a specified adulterant. The results of the present study also indicated that lowered taste thresholds can generalize to other liquid foods containing the same adulterant.

For tomato juice, sucrose taste thresholds were appreciably lower for both subjects receiving differential reinforcement of correct responses for the detection of sugar in tomato juice. Similar results were attained for both subjects receiving differential reinforcement for correct detection of salt in tomato juice. Lowered taste thresholds for tomato juice were maintained and in some cases improved at follow-up. This change is probably a result of improved stimulus control following differential reinforcement for correct responses and does not reflect a change in the physiological mechanisms mediating flavor detections. In general, the subjects appeared more attentive (i.e. shorter response latency,
less off-task behavior) during the differential reinforcement phase and such attention may have contributed to the lowered thresholds. Noteworthy, however is the maintenance of the lowered thresholds during the final experimental phase when response contingencies could not have contributed to increased attention. Thus, the results are most parsimoniously explained, not by increased attention, but by the improved ability to discriminate each substance as a result of differential reinforcement.

For water concentrations, differential reinforcement of correct responses did not lower NaCl and sucrose taste thresholds for all subjects. Established NaCl and sucrose taste thresholds in water at Baseline were low (.002-.004 M) in contrast to baseline measures with tomato juice (.2-.4 M). The low NaCl and sucrose taste threshold values in water at Baseline proved resistant to any appreciable change following differential reinforcement of correct responses. This finding is probably a result of the stimuli in low concentrations being so weak as to produce a nondetect state, despite improved attention or motivational variables.

Following training on tomato juice and water, taste thresholds with milk declined without specific training on milk. Thus suggesting a generalization of training effects to a novel vehicle but with the same adulterant.
Generalization of lowered taste thresholds occurred from the tomato juice to milk across all subjects. This may be a result of repeated exposure to the taste of either NaCl or sucrose (increasing overall taste sensitivity to these substances) or perhaps improved motivation following Differential Reinforcement for Correct Responses Phases. In practical terms it suggested that if a child could be taught to have a lower threshold for NaCl or sucrose in one vehicle, it is probable that the results would transfer to other liquid foods. Conclusive statements about generalization of taste discrimination skills from liquid to solid foods can not be made because solid foods were not used in the tests reported herein. Furthermore, whether lowered thresholds would have generalized from one type of adulterant to another using the same liquid vehicle can not be determined from this experiment but would merit future research to determine if the observed effects were general to all flavorings or specific to the one involved in training.

Previous research has yielded several different taste thresholds for salt and sugar. Direct comparisons between the studies are difficult due to variations in threshold definitions, methodology in attaining thresholds, and units for expressing concentrations. The present study's taste threshold for salt in water (.002 M) approximates the threshold of .0011 M reported by Hertz et al. (1975) using procedures similar to those of the present study.
In contrast, Korslund & Eppright (1967) reported a NaCl threshold in water of .02 M which is ten times the value of the present study's NaCl taste threshold in water. Methodological differences in this study may account for the elevated threshold measure. In the Korslund & Eppright (1967) study, concentrations were presented in ascending order and there were no mouth rinses between taste samples. Hence, thresholds may have been influenced by the level of salivary sodium carrying over or by the effects of successive stimuli. Interestingly, the present study's taste threshold for NaCl in tomato juice (.2 M) was similar to the Lauer et al. (1976) study's threshold measure for NaCl in tomato juice (.162 M) despite some differences in threshold definitions and procedures.

Variations in threshold definitions and procedures seemed to play a role in obtaining sucrose taste threshold measures in water that differed from thresholds reported in other studies. In comparison to the present study's sucrose taste threshold in water of .002 M and .004 M, the Yasaki et al. (1976) study reported a higher sucrose threshold value of .048 ± .019 M for children of similar age. The higher taste threshold may have resulted from a number of procedural differences between the two studies that may have resulted in greater task complexity or motivational problems in the Yasaki et al. (1976) study.
In this study, the experimenters used a Harris-Kalmus sorting procedure which requires subjects to sort eight cups according to whether or not a taste is present. These young children may have found this procedure difficult because of the complexity of the stimulus presentation and may have failed to attend to the task at lower concentrations because of the difficulty of the discrimination and the absence of reinforcement for their efforts. These factors would yield higher error rates at lower concentrations and thus spuriously high thresholds. The Hardy et al. (1981) study also yielded a higher sucrose taste threshold value of .52% (.08 M). This may be attributable to their use of the titration taste method which often yields higher threshold values (Hardy et al., 1981) or a difference in threshold definitions. In this case, samples were presented in ascending concentrations and individual threshold values were "the first response of three correct responses"; overall, threshold was determined as "the point on the graph where 50% of the individuals could detect the particular taste." Clearly, variations in definitional criteria of "threshold" and procedural differences may account for discrepancies between taste threshold values.

In addition to variations in experimental methods and definitional criteria of "threshold" among studies, a lack of uniformity in the specification of the concentration
formulas can prevent direct threshold comparisons. While the molar unit (M) has increasingly become the preferred measure of concentration (Pfaffman, Young, Dethier, Reither, Stellar, 1955), researchers have specified solutions in terms of percentage concentration, inconsistently defining how the percentage is calculated. The molar unit is a standard unit (defined as the number of gram-molecular weights of a substance in one liter of solution) and is readily interpretable to the reader, thus the advantage.

In general, the experimenter found the manual "yes/no" format effective in maintaining the subjects' attention. Periodically, it appeared that a subject was "guessing" (i.e. false positives) but this occurred mainly at lower concentrations. A suggestion for further research in the area of taste thresholds would be to extend the blocks of trials for each concentration from 10 to 20, thereby increasing the probability of accurate measures. In addition, further studies should include control subjects for whom thresholds were repeatedly tested without training, to assess possible practice or ordering effects. Another suggestion would be to conduct research using suprathreshold measures. This study demonstrated that differential reinforcement was effective in increasing percent accuracy for most concentration levels. Perhaps suprathreshold concentrations could be used in training to increase taste sensitivity and lower thresholds. Such a procedure
might reduce frustration for children by reducing the
task difficulty and perhaps increasing the "intrinsic"
reinforcement of the task as the children contacted a
strong taste.

One practical application of this study lies in
its potential application to modify children's food
preferences. Korslund & Eppright (1967) demonstrated
that there is some relationship between taste sensitivity
and food preferences. These experimenters found that
children with low taste sensitivity accepted greater ....
numbers of high salt or sugar foods. Whether training
that resulted in lower taste thresholds would result
in lowered consumption of salty or sugary foods is a
topic for further study. Other researchers (Hardy,
Brennard, Wyse, 1981) have concluded that children do
no recognize salty, sweet and bitter substances as
readily as adults. Efforts to control children's diet
via rules would be limited by this ability to detect
salt and sugar. This study provides a method to
increase young childrens' awareness of salty and
sweet tastes and may be a prerequisite to teaching them
to follow effective rules concerning food consumption.
Theoretically, preferences could be modified by giving
a child a rule such as, "Eat foods that are not salty",
reinforcing food selections in accord with the rule, and
monitoring the emergence of rule controlled food selection
when reinforcement was not programmed.

To date, available psychophysical techniques have not been used to full advantage in the study of taste development and its functional significance in dietary management. Potential areas for research include: investigating whether there are developmental periods during which humans are more susceptible to the formation of strong taste preferences or aversions; and studying how food preferences can be changed to yield healthier food selection.


Enns, M., Van Itallie, T., Grinker, T. Contributions of age, sex, and degree of fatness on preferences and magnitude of estimations for sucrose in humans. Physiology and Behavior, 1979, 22, 999-1033.


