EFFECTS ON HUMAN GASTRIC ACID OUTPUT OF READING, RELAXATION TRAINING AND MAZE-SOLVING: STUDIES USING TELEMETRIC MEASUREMENTS

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Study I was designed to explore the effects of cognitive involvement on gastric acid output. Subjects had two sessions, one to compare the effects of reading with those of a control period within the same session, and another to study the effects of relaxation exercises. The latter was the ostensible purpose of the study in the subjects' minds. An incomplete crossover design was utilized to eliminate any possible temporal or habituation effects. Subjects (N = 13) decreased mean acid output by 32.2% while reading and 2.5% after relaxation exercises (N = 14). Further analysis of the data suggested that active cognitive involvement may have been a contributing factor to the decrease in acid output. Study II was designed to further test this hypothesis. Six subjects each had one session to compare the effects on acid output of a difficult maze-solving task with a control period in the same session. Mean acid output decreased 52.6% relative to the control period, suggesting that the degree of cognitive involvement was an important factor in the decrease of acid output in the two studies.

It was speculated that these effects could have been due to the inhibition of stressful cognitions during the task periods or to the decrease in parasympathetic vagal activity concomitant with the postulated sympathetically arousing nature of the task or both.

A modification of the Heidelberg telemetry equipment was described. It permitted a continuous measure of gastric acid output throughout an experimental session. It was relatively non-aversive to subjects and minimized the risk of cephalic or gastric phase effects of acid secretion due to the measuring technique.

It is suggested that the implications of these studies be explored with subjects under stress and in those suffering hyperacidity. The method developed to measure acid output as described in this thesis is recommended for use in future psychological research. It could be a valuable adjunct for behavioral approaches to lowering gastric acidity.

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M.S.

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GENERAL INTRODUCTION

The particular focus of this thesis was to study the effects of active cognitive involvement on the gastric acid output of healthy human subjects. The effects of reading, relaxation training and maze-solving on acid secretion were examined.

In previous experiments exploring the effects of biofeedback training and relaxation training on stomach acid, it was observed that when subjects appeared to be involved in interesting reading material or when they were engrossed in conversation with the experimenter, their acidity decreased relative to other periods in the same session (Sigman, Note 1). Throughout those studies there was a suggestion of links between cognitive states and acid secretion that merited systematic exploration. It was these observations that led to the development of the current set of studies.

Study I explored the effects of reading and relaxation training on acid output; Study II explored effects of maze-solving on acidity.

As early as 1929, Darrow reviewed a body of research which demonstrated that stimuli involving ideational or cognitive activity, e.g. problem-solving, were associated with activation of the sympathetic nervous system. A variety of cognitive stimuli have since been reported to effect differential changes in heart rate (e.g. Kahneman, Tursky, Shapiro & Crider, 1969; Adamowicz & Gibson, 1970; Elliott, 1974). Cannon (1934) wrote that extreme pleasure, anger or fright effected heart rate increases. He described an instance when fear of a serious diagnosis was associated with an arterial pressure 33% higher than after the patient was reassured that he was well. Paul (1969) has demonstrated that heart rate decreases were associated with lower anxiety differential scores after subjects performed relaxation exercises. Both heart rate and stomach acid secretion are mediated through the autonomic nervous system. Are there such links between the gut and the mind operationalized by cognitive or behavioral tasks or states? Would tasks such as reading, maze-solving or relaxation exercises affect gastric acid output?

In order to answer these questions it was necessary to have a method of measuring acid output that was accurate, non-aversive and not too physically intrusive. It was also essential that the method allow for an on-going measure throughout an experimental session. Therefore, the first task of this study was to develop a measuring technique with these characteristics, one that would not in itself stimulate acid secretion.

<u>Secretion of Acid by the Stomach</u>

Gastric acid secretion is stimulated in two major phases--cephalic and gastric.

The cephalic phase refers to the effects of psychological influences or the sight, smell and taste of food on gastric secretion. The stimulus acting on the brain is mediated through the autonomic nervous system, in particular the vagus nerve which is parasympathetic in activity (Hirschowitz, 1977). Vagal stimulation has a direct effect on the acid-producing parietal cell. As well, it has an indirect effect by stimulating release of the hormone gastrin which in turn stimulates the parietal cell to release acid (Walsh, 1973).

The second major phase of acid secretion is the gastric phase. This phase is initiated by stimuli arising in the stomach such as food, alkalinization of stomach contents, or gastric distension. These locally stimulate the release of the hormone gastrin which enters the circulation and returns to stimulate the acid cells of the stomach to release acid (Walsh, 1973).

The present set of studies was concerned with psychological influences on acidity, i.e. with the cephalic phase of acid secretion. Therefore, the subjects who participated in these studies were fasting in order to minimize gastric phase effects.

Methods of Assessing Acidity

Early methods of studying the cephalic phase of acid secretion as an isolated phenomenon involved direct observation using human subjects or dogs with esophageal and gastric fistulae (i.e. openings from the stomach to the skin), e.g. Beaumont, 1833; Richet, 1878; Pavlov, 1902; Gordon & Chernya, 1940; Wolf & Wolff, 1943; Reichsman, Engle & Segal, 1955. The effects of sham-feeding, sight or smell of food, and affective states were studied in this manner.

Presently, several other methods are available to assess the degree of acidity in the stomach. Samples of gastric juice may be aspirated through a swallowed gastric tube and its pH (degree of acidity) and volume measured in vitro. This method was used by Moore and Shenkenberg (1974) and Welgan (1974) in studies of the effects of classical conditioning and biofeedback training on acid secretion. The acid was withdrawn out of the tube and was titrated with an alkaline substance to a specific pH end-point, giving a measure of both the volume and the concentration of gastric juice over a specified period of time.

This method did not give an on-going, continuous measure, however, as it was interrupted at intervals by the withdrawal of acid out of the tube.

A modification of the Welgan (1974) method giving a continuous measure is to have subjects swallow a glass electrode with a tube and to titrate within the stomach with an alkali to a specific pH end-point. Whitehead, Renault and Goldiamond (1975) and Gorman (Note 2) used variations of this method in their studies of operant conditioning procedures and cephalic influences on acid secretion respectively. The methods involved infusing substantial amounts of water or titrant into the stomach which could have stimulated gastric phase effects.

Another method which also allowed for a continuous measure and which did not involve infusion of either titrant or large amounts of water was used with a single subject in a pilot biofeedback study (Sigman, Nowlis & Borzone, Note 3). However, the subject found that swallowing the tube and retaining it in place for 90 minutes was very uncomfortable. It was felt that although the method was technically adequate, it was too intrusive and aversive to use in psychological studies.

A telemetric method was described in 1960 by Noller (Note 4) whereby a capsule containing a small pH measuring cell was swallowed. It continuously transmitted pH values from the stomach through a belt antenna worn by the subject to a receiver where the results could be read off a panel meter. This pH measuring cell was enclosed in an indigestible plastic casing the size of a large antibiotic capsule (20 x 7 mm). The equipment is known as the Heidelberg Capsule telemetry system.

Evaluation of Heidelberg System

Evaluations of the Heidelberg system have been carried out (Yarbrough, McAlhany, Cooper & Weidner, 1969; Andres & Bingham, 1970; Johannesson, Magnusson, Sjoberg & Skov-Jensen, 1972) and the capsule method was reported to give results comparable to those obtained by the standard aspiration technique. The pH response to injection of dilute acid or bicarbonate is immediate and appropriate (Watson & Paton, 1965). Connell and Waters (1964) reported that the Heidelberg readings and the pH recorded by a glass electrode did not vary more than 0.5 pH unit. Our laboratory compared pH measures obtained by the Heidelberg unit with those from a Metrohm Herisau glass electrode in two separate studies. In the first, the solution used initially was distilled water to which small amounts of HCl acid were added. The Pearson product moment correlation (r) of the two measures was +.97. The second study started with a buffer solution of pH 7 to which small amounts of HCl were added, resulting in _r_ = +.99. These very high correlations indicate that the Heidelberg unit is a viable tool for measuring gastric acid pH.

The telemetering capsule was less aversive to swallow compared to the tube and glass electrode. Since psychological or cephalic effects could possibly result simply from the aversive nature of the non-telemetric methods described above, the elimination of the discomfort of such intubation was an important advantage of the telemetric system. Furthermore, this technique involved less manipulation of the stomach than did other methods of measuring acidity. This minimized gastric phase effects, allowing for a better study of the cephalic phase of acid secretion (Connell & Waters, 1964).

In previous psychological experiments in this laboratory using the telemetric procedure, surgical silk thread was tied to the capsule and the thread was tethered to the subject's cheek so that it would not leave the stomach during the course of the session (Sigman, Note 1). This allowed for a non-aversive, relatively non-intrusive, ongoing measure of gastric acid pH. The pH of most subjects was in the range of 1-2, representing a high degree of acidity. pH is the logarithm of the reciprocal of the hydrogen ion concentration in a solution. A low pH represents a large amount of acidity; a high pH, a much lesser amount. Because of the logarithmic nature of pH measurement, a large change in degree of acidity is reflected by only a small change in pH when pH is in the 1-2 range. Therefore, in some sessions in the previous experiments, a modification of Noller's method was used (Note 5). This involved having subjects swallow a small but constant amount of an alkali (5 ml 0.1N sodium bicarbonate) in order to bring the pH to a higher range (4-6) where subsequent changes of acidity could more readily be measured. This alkali was given in single doses at particular times, e.g. pre- and post-relaxation exercises or during some of the instructional periods of the biofeedback training sessions. This modification of Noller's method gave a measure of acid concentration in the stomach at the moment of swallowing the alkaline substance and, in addition, the rate of secretion during the ensuing minutes. However, it did not permit a continuous measure throughout a session. For the purposes of the current studies, it was necessary to develop a method of measuring acid secretion continuously over a 90 minute session, a method that would not intrude on the subject during his various cognitive or behavioral states. A continuous method of measuring acidity using telemetric equipment had been devised by Stacher, Berner, Naske, Schuster, Stärker and Schulze (1976). Doses of alkali were administered orally with a syringe. It was felt this method would be too disturbing to a subject who was reading, performing relaxation exercises or maze-solving. For these reasons, it was necessary to further modify the Heidelberg system.

Modification of Heidelberg System to Measure Acid Output

Acid secretion in the stomach can be measured by various techniques and reported in several ways (Davenport, 1977). A readily understood measure of acid secretion used in animal and human studies (e.g. Badgeley, Spiro & Lemay, 1969; Nezamis, 1971) is acid output, i.e. milliequivalents of acid per liter (mEq/l) secreted over a given period of time. The measure is arrived at by observing the volume of alkali of a known concentration required to neutralize the acid in the stomach to a specific pH end-point within a designated period of time.

In the present series of studies, instead of subjects swallowing the capsule tied to thread as in previous experiments, very thin polyethylene tubing was attached by thread to the capsule. A small hole was made at the side of the tubing near the capsule to allow titration of alkali into the stomach. The alkaline substance was infused into the other end of the tubing in constant small amounts (.5 ml) by a syringe. The concentration of alkali used in this study was equal to the amount that neutralizes an equivalent amount of acid. One ml of molar potassium bicarbonate ($KHCO_3$) neutralizes 1 mEq acid. Therefore, the amount of $KHCO_3$ infused in a given time period gives the dependent measure of acid output (Stacher et al., 1976). The diameter of the tubing was not much wider than the thread which was used in previous studies. The tubing was flexible and did not irritate the throat.

In pilot studies this method was reported by the same subjects to be as non-aversive as the method used previously. It gave a continuous measure of acid output throughout an experimental session. It was relatively non-intrusive, allowing subjects to read, perform relaxation exercises or solve a maze without disturbance. Thus, it meets the requirements outlined earlier.

Relevance of the Dependent Measure--Acid Output

At the present time, little is known about methods of inhibiting acid output other than through sympathetic stimulation, pharmacological or surgical means. Sympathetic stimulation causes vasoconstriction and this is associated with a decrease of secretion (Davenport, 1977). Pharmacologically, acid can be neutralized by antacids or decreased by other drugs, e.g. Cimetidine (Hastings, Skillman, Bushnell & Silen, 1978). Acid secretion can also be reduced by selectively cutting the vagus nerve. This surgical procedure, known as vagotomy, is recognized as a treatment to prevent the recurrence of peptic ulcer disease (Baron & Spencer, 1976).

Gastric acid output is of clinical importance since much evidence (e.g. Menguy, 1966; Isenberg, 1973; Eisenberg, 1977) suggests that it plays an important role in the development of peptic ulcer disease. It is reported that 12% of men and 9% of women have been diagnosed as having a stomach ulcer at some time in their life (Sturdevant & Walsh, 1978). It would, therefore, seem potentially important to explore whether acid output can be decreased by methods that are not pharmacological or surgical but rather through cognitive or behavioral means. In this regard, it was recognized that the effects of manipulations carried out in this study may be different in subjects who suffer from ulcer disease. The observation made in the previous experiments, that involvement in reading seemed to be associated with less acidity, occurred with healthy subjects. As noted earlier, the goal of those studies was to explore the effects of biofeedback training and of relaxation training. Therefore, the effects of reading had not yet been studied systematically, even in healthy subjects. This was the primary purpose of Study I.

Studies on Decreased Acid Secretion

In several reported instances of acid inhibition, the situations or influences described were frightening or overwhelming and of an acute rather than chronic nature. Cannon (1934) reported that acid was inhibited on two occasions when a dog "flew into a great fury in the presence of a cat." This occurred even under renewed conditions of sham feeding which, minutes earlier, had led to a flow of secretion. Wolf and Wolff (1943) studied a human subject with a gastric fistula over a period of years. They noted that his acidity was inhibited when he was frightened or overwhelmed. The acid of monkeys in an acute fear situation in a shock avoidance paradigm was observed to be inhibited (Polish, Brady, Mason, Thach, Niemeck, 1962). Weiss (1977) cited studies where acutely stressful conditions resulted in the inhibition of acid secretion in rats. These reported instances of acid inhibition were likely associated with sympathetic stimulation in part as a result of fright. Eichorn and Tracktir (1955) reported that the emotion "fear" affected acid secretion differentially, depending on the subject's level of anxiety, i.e. highly anxious subjects increased acid secretion when afraid in contrast to subjects with low anxiety who decreased acidity. These subjects, however, were under hypnosis which factor could have interacted with the feared stimulus to confound the results.

In the paucity of reported human studies, other factors that have been associated with decreased acid secretion are hypnosis itself (Eichorn & Tracktir, 1955), mental arithmetic (Badgeley et al., 1969), music (Demling, Tzschoppe & Classen, 1970), and morning awakening from sleep (Moore & Englert, 1970; Hall, Orr & Stahl, 1977). Gorman (Note 2) presented three subjects with warmed fresh canine feces; this resulted in transitory inhibition of secretion in two of them.

It should be noted that hypnosis induction has also been reported to be associated with an abrupt rise in acidity although not in volume of secretion (Luckhardt & Johnston, 1924). This subject, however, had previously been hypnotized and given a suggestion of food which may have confounded the results.

It is possible that the decrease in acid reported in the music study may have been due not to the music itself, but rather because the music may have been perceived by the subjects as noise since it was presented at concert hall intensity in the laboratory (Demling *et al.*, 1970).

Gastric acid secretion was measured during sleep and wakefulness by Stacher, Presslich and Starker (1955) but the measuring technique involved disturbing the subjects to swallow amounts of alkaline substance throughout the night which, in itself, could have affected acid output. The short periods of waking during the night were related to higher secretory levels in contrast to decreased acid in the morning.

Recently, some behavioral approaches to changing levels of acidity have been reported. Two examples are biofeedback training and relaxation training. Attempts to modify acid secretion using operant conditioning procedures have been made by Moore and Shenkenberg (1974); Welgan (1974); Whitehead *et al.* (1975); Gorman (Note 2); Sigman *et al.* (Note 3). They each tried to teach subjects to voluntarily control their acid secretion while receiving feedback on the response. The studies lent some tentative support to the concept that biofeedback training may enable subjects to achieve a degree of control over their gastric acidity, at least under the feedback conditions. However, the methods used to measure the acid and train the subjects were aversive and not conducive to replication or widespread use. A previous experiment carried out by the present author suggested that the telemetric equipment, although not aversive, may not be useful for biofeedback training for various technical reasons (Sigman, Note 1). Primarily, at the lower pH level the resolution of the equipment was not fine enough to provide adequate feedback. It was useful, however, to study the effects of relaxation training on acid secretion in that study (Note 1). The two subjects showed less acid pre- to post- in both control (reading) and relaxation sessions but this decrease in acid appeared to be a good deal larger after the control (reading) period relative to before each of those conditions respectively. In fact, subjects were permitted to read before and after the relaxation exercises as well, and did so in some sessions. Each subject had two sessions in each condition.

In the biofeedback study, it was noted that when subjects were reading or involved in interesting conversation with the experimenter, less acid was present. For these reasons, the present experiment was designed to study the effects of reading on gastric acid output.

On an intuitive level, it would seem that if a subject were cognitively involved in something of interest to him, he would not at the same time be able to dwell on a source of stress or worry in his life. Studies on humans have demonstrated acidity increases to be associated with situations of chronic worry or anxiety, e.g. Hoelzel (1942); Mahl (1950); Heller, Levine, Sohler (1953); Shay, Sun, Olin, Weiss (1958). One of the primary goals of this study was to learn if active cognitive involvement, as in reading, is associated with decreased acid secretion.

Rationale for Studying Effects of Relaxation Training

Previous studies suggested that the acid response may be sensitive to experimenter, subject and situation effects (Sigman, Note 1). The effects of instructional sets on gastric motility have already been demonstrated by Sternbach (1964). It is possible that if subjects had known that the purpose of the study was to measure the effects of involvement in reading on acid output, they may have held expectations about these effects during those sessions. Those expectations could have influenced the acid response. Furthermore, subjects may have felt compelled to read during the reading period. This feeling of "having to read" may have placed some stress on them, adding to the possibility of affecting acid output. It was for these reasons that the advertisement for subjects requested participation in a study exploring the effects of relaxation training on gastric acid secretion (Appendix A). Subjects were told that there would be two sessions, one in which the effects of relaxation exercises would be measured, and the other, a "control" session. In fact, the "control" session included a reading period and was the primary focus of the study for the experimenter. Subjects were casually told to bring reading material at the time of their reminder phone call the evening before their "control" session. The type of reading material was purposely not specified.

Relaxation training was chosen as the focus of the study in the subjects' minds for several reasons. (1) It was felt that subjects would be more inclined to participate in a study of this physiological response if they could learn something in exchange. (2) It is or could be made known to subjects that the effects of relaxation exercises have been studied on other physiological responses. Subjects would readily accept the notion that information on the acid response would be desirable. (3) A review of the literature suggested that effects of relaxation exercises on gastric acid output had not yet been systematically studied on more than the two subjects reported earlier (Sigman, Note 1). Relaxation training has frequently been suggested as a technique for alleviating anxiety, e.g. Jacobson (1938); Paul (1969). As noted earlier, anxiety has been reported to be associated with increased acidity, e.g. Mahl (1950); Heller et al. (1953). It is thus of interest to learn how the behavioral state of physical relaxation affects gastric acid output.

A second study was designed after the first to learn the effects of involvement in a difficult cognitive task on the acid response. This will be discussed later.

Hypotheses Underlying this Study

1) It was hypothesized that the mean acid output of subjects would be significantly less under reading conditions than under control periods within the same session. This hypothesis was based on (a) observations from the previous studies and (b) the intuition that cognitive involvement in reading would preclude intrusion of worrisome thoughts that may otherwise have increased acidity.

2) It was expected that there would be a relationship between subjects' reported interest in reading material and decreased acid output.

3) It was hypothesized that the mean acid output of subjects would be unaffected by the relaxation exercises when the post-exercise period was compared to the control period within the same session. This hypothesis was based on studies showing the effects of relaxation exercises to include lowered sympathetic arousal as indicated by lowered

heart rate and pulse pressure (Jacobson, 1938; Chinnian, Nammalvar, Rao, 1975; Reinking & Kohl, 1975). The antagonistic interaction of the adrenergic and cholinergic systems at the neurotransmitter level has been reported by Vizi (1974). If relaxation exercises produce lowered sympathetic arousal, some disinhibition of the parasympathetic system could be expected. Since the cholinergic vagus nerve is part of the parasympathetic system, this would leave it disinhibited to act on the acid-producing parietal cells. One can speculate that while the relaxation exercises can produce relaxing cognitive effects, as reported by Paul (1969), these could be countered by the physiological response of vagal disinhibition. One would then not expect to note a significant decrease in acid after relaxation exercises compared to control conditions.

4) Because of the reported physiological effects of relaxation exercises, and because of the possibility of intrusion of stressful thoughts, it was not expected that the mental and physical relaxation in the period following the exercises indicated by the subjects' self-reports would be related to acid output.

METHOD

Subjects

The subjects were fifteen male volunteers ranging in age from 16 to 28 years. None reported a history of ulcer disease when asked. Subjects were students either at the university or pre-university level. They responded to an advertisement posted throughout the university. They were paid $4 an hour for their participation. Subjects fasted for 8 hours prior to each session and were instructed to take no drugs for a 24-hour period before each session.

Apparatus

Acid output was studied by means of the Heidelberg telemetering equipment Model No. HK-26630231 (Figure 1). The equipment included a battery transmitter encapsulated in an indigestible acrylic container 20 x 7 mm, weighing 1.55 g. This pH measuring cell consists of an external annular antimony electrode and an internal silver chloride electrode, the two separated by a semi-permeable membrane. A belt antenna worn by the subject picked up signals from the capsule and transmitted them to a receiver, the pH meter. By prior calibration of the capsule in solutions of known pH, the pH of an unknown solution was determined from the

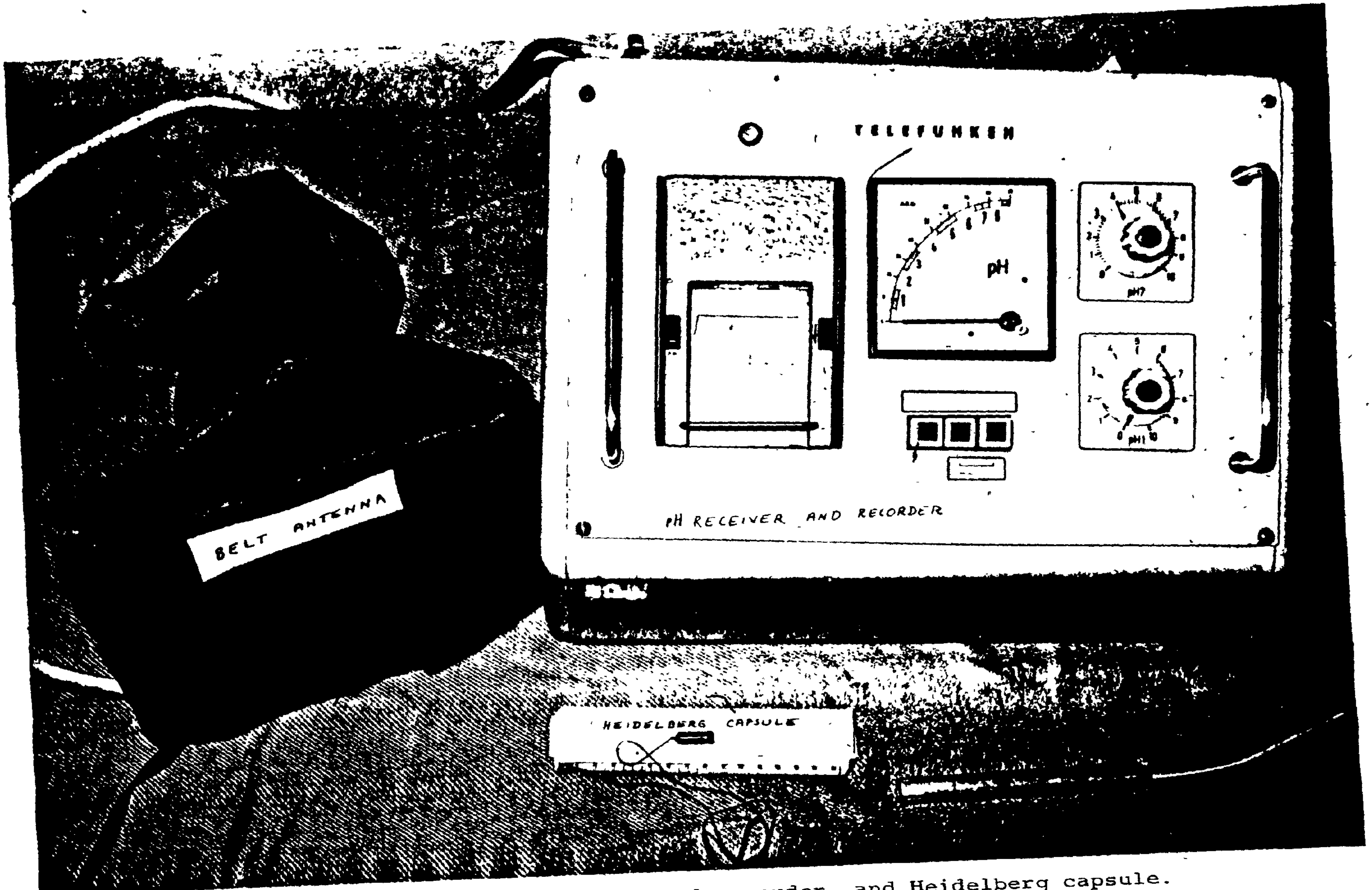

Figure 1. Belt antenna, pH receiver and recorder, and Heidelberg capsule.

frequency transmitted by the capsule: the frequency is dependent on the voltage changes in the transmitter caused by changes in pH. The frequency change is about 16 kilocycles per second (KCPS) per pH unit (Note 5).

A new battery was activated by immersion in .9% saline solution just before each test. It was then calibrated in buffer solution of pH 1 and 7. Buffers and rinse waters were heated to body temperature 37° C. Silk thread (4-0) was used to tether the capsule to polyethylene tubing (Silastic medical grade, by Dow Corning Cat. No. 602-135 H010986). Inner diameter of the tubing was .05 cm; outer diameter .09 cm. Approximately 167 cm of tubing was used for each subject, 57 cm from the capsule in the stomach to a taped marker around the subject's chin, and 110 cm outside the subject's body (Figure 2). A small hole (approximately .5 cm in length) was cut on one side of the tubing near the capsule. The outer end of the tubing was connected to a sterile hypodermic needle (22G1). The needle screwed onto a disposable 30 ml syringe with luer-lok tip. The syringe was filled with 25 ml molar potassium bicarbonate ($KHCO_3$). Before the capsule was swallowed, the tubing was filled with $KHCO_3$. Once the capsule and tubing were swallowed the syringe was taped to

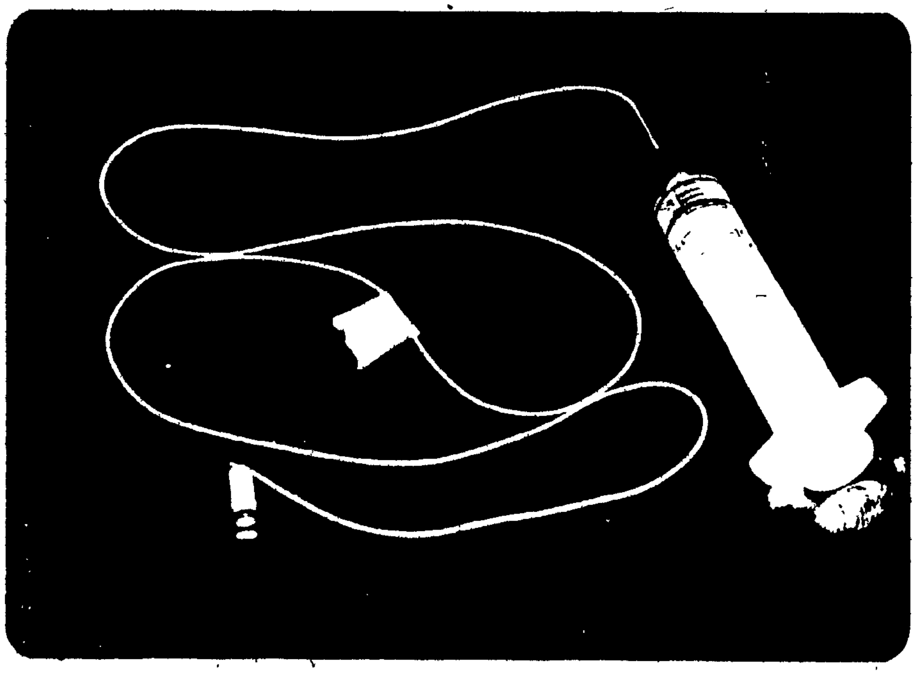

Figure 2. Capsule with attached tubing and syringe, showing taped marker 57 cm from capsule.

a table next to the pH meter. Signals emitted by the capsule were received by the belt antenna, amplified, and fed into the attached pH meter where they were continuously charted by a pen recorder incorporated in the pH meter. Additionally, another recording apparatus (Watanabe Servo-recorder SR6254) was connected to the pH meter and received signals, This second recording, in addition to amplifying the scale, allowed for notes of subjects' behavior and statements to be written by the experimenter alongside the pH.

Procedure and Design

Prior to the first session, the experimenter met each subject in the laboratory and explained that the purpose of the experiment was to study the effects of relaxation training on gastric acid output. He was told that effects on other physiological systems had already been studied but that there were as yet no data on the acidity response. The equipment was explained to the subject. He was asked to read and sign a consent form (Appendix B). He then sat in a recliner chair and listened to a taped explanation of the relaxation procedure (Behavior-Media-Relaxation-Exercises, Note 6). Any questions he had were then answered. Muscle tensing and relaxation instructions were given on tape at that time in order to assure the experimenter that the subjects understood and could accurately follow the instructions (Appendix C). Subjects were instructed to practise the exercises in their own homes eight times before returning to the laboratory. Duration of practice was twenty minutes daily. The time of day was left to the subjects' preference. Appointments were made for two morning sessions. Subjects were told that one session was to measure the effects of doing the exercises in the laboratory and the other was a control session. In fact, the control session included a reading period. Subjects received a telephone call the night before each session to confirm the session and to remind them to fast after midnight. If the session the next day was to be a reading session, it was suggested that the subject bring some reading material that interested him as "there may be some time in the session when you can read." The experimenter always had the daily newspaper and other magazines in case a subject neglected to bring reading material.

Sessions were designed to last between seventy-five and ninety minutes: seventy-five for the reading session and ninety for the relaxation exercise session. It had been decided in advance that each session would start with a basal period of pH measurement lasting a minimum twelve minutes or until the pH returned to the end-point of 3.5 after .5 ml $KHCO_3$ had been infused into the stomach. The pH was allowed to stabilize for 3-5 minutes after the capsule was swallowed. A volume of 0.5 ml $KHCO_3$ was then infused through the tubing. If the pH returned to 3.5 before twelve minutes had elapsed, another .5 ml $KHCO_3$ was infused. Occasionally subjects were producing much acid and required several infusions during the basal period. The control or experimental period started when the pH returned to 3.5 as long as a minimum of twelve minutes had passed after the capsule had been swallowed. Thus the basal period served two purposes: one to allow any effects of swallowing the capsule and tubing to subside, and the other, to allow the same pH starting point for each subject.

The length of time that a control, reading or post-exercise period lasted varied somewhat because it was necessary that each period end and start at the pH end-point of 3.5. Generally, the periods lasted approximately thirty minutes. A minimum of a twenty-minute sample of acid output was required for subjects in control, reading or post-exercise periods. Again, the maximum time depended on how long it took for the pH to return to the end-point of 3.5 after the twenty-minute minimum had elapsed. In the case of one subject, there was outside interference that influenced the transmission of signals at the start of his session. This necessitated prolonging his basal period to thirty-seven minutes. It was decided at that time to accept a shorter time sample for his control period prior to the relaxation exercises in order not to unduly prolong his session.

The experimental procedure is described in Table 1.

Each post-exercise period was preceded by the subject performing the relaxation exercises according to the instructions on the tape which he had practised at home.

The study consisted of an incomplete crossover design for twelve subjects. Table 1 shows the four possible paradigms that a subject could undergo. The first volunteer got paradigm A, the second--B, the third--C, the fourth--D, the fifth--A, etc. It was designed in this way to counterbalance any possible order effects between or within sessions. Neither temporal nor habituation effects had been noted in previous studies (e.g. Demling <u>et al.</u>, 1970; Sigman, Note 1).

Following each session, subjects were asked a standard series of questions by the experimenter (Appendix D). Of particular interest in the self-report data were the subjects' reported degree of interest in their reading material and their mental and physical state following the relaxation exercises. Subjects were also asked about their mood in the other half of each session. In addition, they were asked whether they were worried at any time about swallowing the capsule, how the first half of the session compared to the second half in terms of ease or any other dimension on which they wished to comment. It was hoped that if a subject were undergoing any particularly stressful or exciting activity this would be reflected in his answers to the above questions.

The experimenter recorded behaviors exhibited by the subject such as stretching or other body movements, rapid page turning, closing a book, etc., in an attempt to corroborate the subject's answers to the questionnaire.

Table 1

<u>Experimental Procedure</u>

Group	Session	Period 1 ~15 mins.	Period 2 ~30-45 mins.	Period 3 ~30-45 mins.
$A_{n=3}$	1	Basal	Reading	Control
	2	Basal	Exercises, Post-Exercises	Control
$B_{n=3}$	1	Basal	Control	Reading
	2	Basal	Control	Exercises, Post-Exercises
$C_{n=3}$	1	Basal	Exercises, Post-Exercises	Control
	2	Basal	Reading	Control
$D_{n=3}$	1	Basal	Control	Exercises, Post-Exercises
	2	Basal	Control	Reading

RESULTS

An individual's acid output has been shown to vary from day to day (e.g. Whitehead et al., 1975; Sigman, Note 1; Gorman, Note 2). It would not be meaningful, therefore, to compare the acidity of a subject on one day while he was reading with his acidity on another day in the post-exercise state. It is only meaningful to compare acid output of individuals within the same experimental session, i.e. to compare a control with an experimental period on the same day.

However, before collapsing the data of all subjects across either reading sessions or relaxation sessions, it was necessary to examine whether temporal effects existed within sessions or whether habituation effects resulted from the first to the second session. Neither temporal nor habituation effects could be examined using the control period data because these data are confounded by the experimental periods that preceded them. Therefore, in the reading sessions, it was decided to search for temporal effects by comparing the reading periods following basal periods with reading periods following basal and control periods. Habituation effects were explored by comparing the reading data of subjects who had reading sessions first with the reading data of subjects who had their reading sessions second. It was decided that if an analysis of variance carried out on such reading data did not reveal significant differences at a liberal alpha level, the reading and control periods of all subjects could then be collapsed and compared using a correlated _t_ test. A similar approach was taken with the relaxation session data. Acid output data were based on mEq acid per hour.

There were technical problems involved in one of the two sessions of two subjects--a reading session in the case of one, and an exercise session in the case of the other (Appendix E). An attempt was made to replace these sessions by offering a third session to each of these subjects. The subject who was to repeat his reading session could not swallow the capsule that day due to a sore throat. In the case of the subject who was repeating his exercise session, technical problems again necessitated deleting the session from the experiment. It was decided not to offer a fourth session to these subjects although they offered themselves for same. A third subject, age sixteen, was unable to secure his parent's signature for his second session, a reading session. These three subjects were replaced to comply with the original design of the study.

Reading Results

Analysis of variance on the reading periods between and within sessions revealed no significant differences even at the .18 alpha level (Table 2). This suggested that it made no difference if the reading was done in the first or second session regardless of whether it preceded or followed the control period.

Because no temporal effects were revealed (within sessions) and no habituation effects were revealed (between sessions), it was decided to collapse the data and, as well, to add the data of the extra subject. The mean acid output for the thirteen subjects in the control period was 11.2 mEq per hour compared to 7.54 mEq per hour in the reading condition (Figure 3).

A 2-tailed correlated t test comparing the mean acid output during the reading and control periods approached significance, t (12) = 2.162, $p < .0515$. It was felt that if this difference were not due to chance it could have been due to either the effect of inhibition of acid release during reading or to some rebound phenomenon following reading in the control period. It was important to explore if there were significantly more acid output in the control periods that followed, compared to those that preceded the reading condition. If so, a rebound effect could be contributing to the difference

Table 2

Analysis of Variance of Temporal and Habituation Effects on Acid Output in Reading Sessions

Source	df	SS	MS	F	p
Rows (sessions)	1	69.84	69.84	1.53	.251
Columns (periods)	1	96.96	96.96	2.13	.182
R x C	1	5.43	5.43	.11	.748

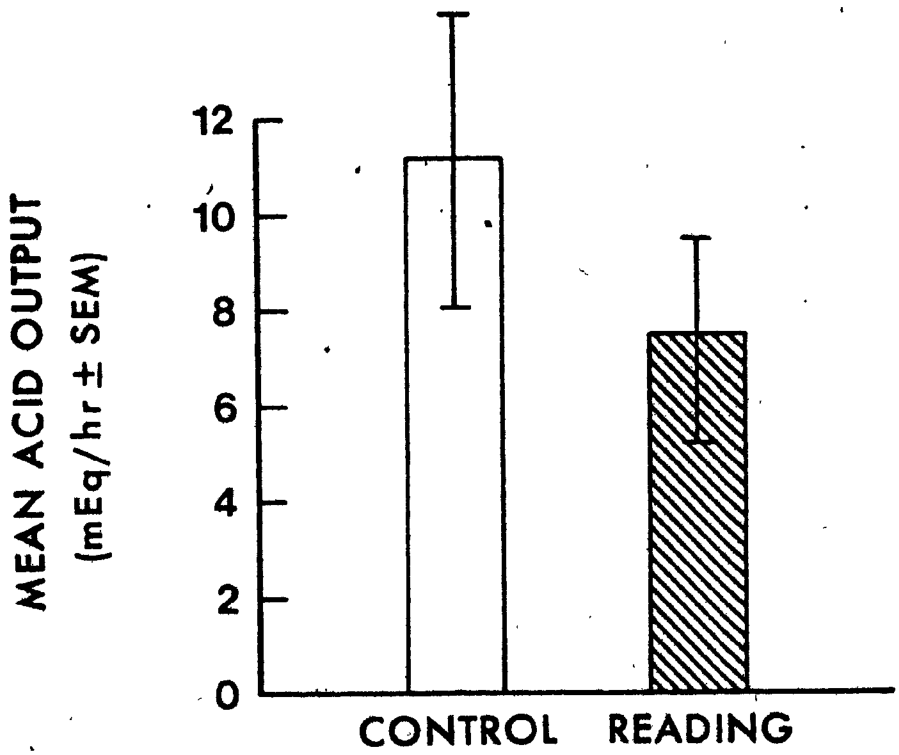

Figure 3. Mean acid output (mEq/hr ± SEM) in control and reading.

demonstrated in the two conditions. Therefore, a t test was performed comparing the differences in mean acid output between the control and reading periods of the seven subjects who had their control period first, with the differences of the six subjects whose control period followed the reading. No significant difference was noted at the liberal .2 alpha level ($t(11) = .23$). This suggested that the difference between control and reading conditions was due to the inhibitory effect of reading on acid output rather than to a possible rebound phenomenon in a control period.

The individual data are presented graphically in Appendix F.

Nine of the thirteen subjects decreased acid output during reading periods. The self-report reading period data revealed that twelve subjects were either mildly or very interested in what they were reading. Eight of those twelve decreased acid. The ninth subject whose acid decreased while reading reported he was bored with his book and, in fact, closed it before his pH returned to 3.5. He was given more reading material which he read.

A Chi square (χ^2) test with Yates continuity correction, performed to see if there was a relationship between reported interest in reading and decrease in acid, was not significant (2.26, 1 df).

Exercise Results

Analysis of variance performed on the post-relaxation exercise periods between and within sessions revealed no significant differences at the .8 alpha level (Table 3). This suggested, as in the reading experiment, that it made no difference if the post-exercise period was held in the first or second session regardless of whether it preceded or followed the control period.

Because no temporal effects were revealed within sessions and no habituation effects were noted between sessions on these twelve subjects in the original design, it was decided to collapse the data and, as well, to add the data of the extra two subjects. Mean acid output for the fourteen subjects was 5.47 in the control period compared to 5.33 in the post-exercise period. A two-tailed correlated _t_ test comparing the mean acid output during these periods revealed no significant differences, $t(13) = .783$ (Figure 4).

The individual data are presented in Appendix G. Eight subjects increased and six decreased acid output following the relaxation exercises.

A χ^2 test, performed to determine if there were a relationship between reported mental relaxation and decreased acid output following the performance of the

Table 3

Analysis of Variance of Temporal and Habituation Effects on Acid Output in Relaxation Exercise Sessions

Source	df	SS	MS	F	p
Rows (sessions)	1	.94	.94	.04	.84
Columns (periods)	1	.75	.75	.03	.86
R x C	1	9.5	9.5	.43	.53

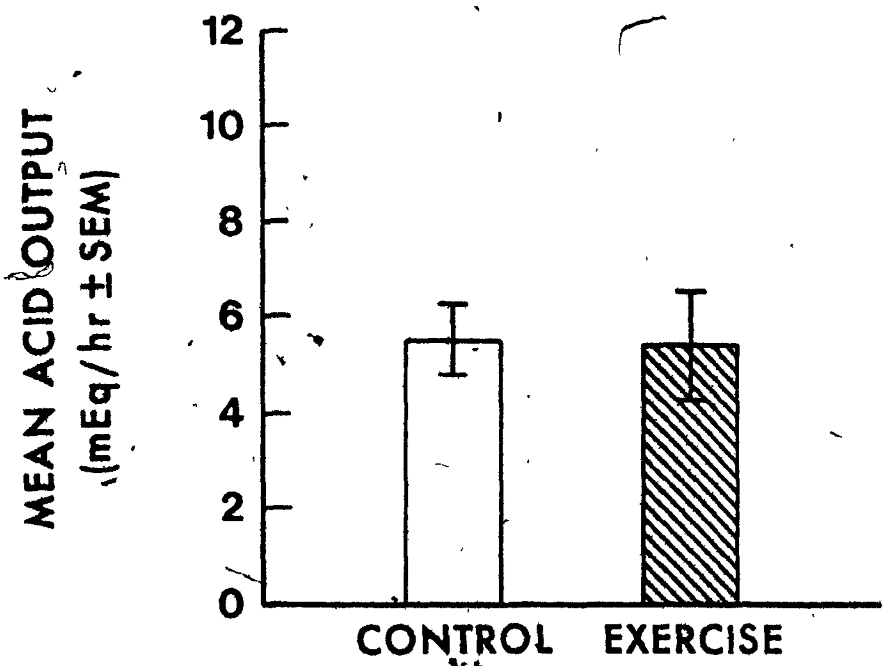

Figure 4. Mean acid output (mEq/hr ± SEM) in control and post-relaxation exercise conditions.

exercises, revealed no significance (1.5, 1 df). A χ^2 test to search for a relationship between reported physical relaxation and decreased acid output following the exercises was also not significant (.44, 1 df).

DISCUSSION

It was hypothesized that the mean acid output of subjects would be less when they were reading compared to control conditions within the same session. If the results of this study do not reflect a chance finding, they may support that hypothesis. Subjects produced a mean of 48.8% more acid in the control period compared to the mean acid output while they were reading.

It was further expected that if subjects reported interest in their reading, this would be associated with a decrease in acid output. The statistical analysis of these data does not support a relationship between reported interest in reading and decreased acid. Other factors that may be relevant to the rejection of this hypothesis will be discussed recognizing that they are clinical observations that were not systematically gathered.

The experimenter had assumed that a reported interest in reading would imply a degree of active cognitive involvement on the part of subjects and that this would be the key factor associated with decreased acidity. Although twelve of the thirteen subjects reported mild or much interest in their reading, observations of these twelve subjects did not always corroborate their self-report. In the case of one subject who reported much interest in his book, he was observed to have put his book away before his pH returned to the end-point 3.5, i.e. before the end of his reading period. This suggested that he may not have been as interested as he had reported. A second subject was observed to be either very involved or very tense and physically restless at different times during his reading period. However, he simply reported that he had been very interested in his reading. A third subject who reported that he had been very interested in his reading appeared indeed to be so involved. However, this subject was seen within an hour after the session rushing along the street returning to the university. He said, in passing, that he had to change his clothes for his impending graduation that afternoon, a fact he had not mentioned to the experimenter earlier. It is possible that he had been feeling the pressure of time and had perhaps not been fully concentrating during his reading period. This period had occurred in the latter portion of his session. His acid increased to almost double during that period. These observations suggest the possibility that the questionnaire may not have been adequate to elicit the necessary information. Further questioning may have resulted in more accurate information with regard to the degree of active cognitive involvement that the subject was experiencing in his reading material. It may have been important to have asked the subject, for example, if his mind had wandered during the period in which he was reading and, if so, to which areas. Subjects were asked only one question about the reading because it was felt that if more emphasis had been placed on this part of the study, they may have suspected that this was in fact the area of the researcher's interest. Because of the possibility of subjects within the same university speaking with each other about the study, the focus on the effects of relaxation exercises was maintained both in the questionnaire and in any conversation held with the subject before or after the sessions.

Perhaps as important as the reported or actual degree of interest in the reading period is what the subjects were doing or thinking during the control period. In the case of two subjects whose acid did not decrease during their reading period, it appears from their self-report that they were equally or more cognitively involved during their control period. One subject, a music student, reported that he had been composing tunes during his control period. His fingers were observed to be moving as if playing a piano during that time. The other subject, a psychology student, reported that he had "used the silence of the period to play with . . . (his) perception." His hands were also observed to be moving. His eyes followed these movements as if he were figuring out angles or indeed "playing with his perception."

The observations corroborated the self-reports of the above two subjects' control periods. These were associated with decreased acid. Most of the subjects whose self-reports confirmed their demonstrated involvement in reading also decreased acidity. This suggests that active cognitive involvement rather than "looking at words" or reading per se may be the factor leading to the decrease in secretion.

The third hypothesis stated that the mean acid output would be unaffected by the relaxation exercises when the control periods would be compared with the post-exercise periods. This was supported by the data as there was no significant difference in the acid of the two periods. Six subjects decreased acid in the post-exercise period while eight subjects increased acid. Any changes in acid output were not significantly related either to the degree of physical relaxation or mental relaxation reported by the subjects as predicted by the fourth hypothesis. It is interesting to note, however, that three of the four subjects whose acid increased in the post-exercise period by more than 3 mEq per hour (which represented a doubling of acidity) also indicated that they were not mentally relaxed at that time. The fourth subject appeared vigilant and said "time was going slower" compared to his control period when "time went fast." One of the three reported he had been thinking of "relationship problems." The other two were not more specific in their reports other than to say that they were not mentally relaxed. All four reported feeling physically relaxed in the post-exercise period.

The only subject whose acid increased more than 3 mEq per hour in the control period was looking at his watch throughout that period which was in the latter portion of his session. As noted earlier, studies have linked non-acute anxiety with increased acid secretion (e.g. Mahl, 1950; Heller _et al._, 1953). Perhaps some form of non-acute anxiety was experienced by those four subjects whose increased acid was associated with indications that they were not mentally relaxed.

Davidson and Schwartz (1976) discuss relaxation on two dimensions--the cognitive/somatic dimension and the activity/passivity dimension. The progressive relaxation exercises themselves involved both active and passive elements and primarily somatic rather than cognitive elements. The post-exercise period, during which acidity was measured and compared to the control period, likely involved lowered somatic activity. Eleven of the fourteen subjects reported physical relaxation. It is interesting that only one-half the subjects reported feeling mentally relaxed during the thirty minutes following the exercises. Davidson and Schwartz (1976) suggest that the reduction in somatic activity seen after deep muscle relaxation may lead to an increase in spontaneous thoughts. As some of the subjects in this study have indicated, these thoughts need not be relaxing ones. This may have played some role in the increase in acid secretion. However, as noted above, the self-reports of mental relaxation on the questionnaire were not significantly related overall to the changes in acid output.

An additional factor that may be important is that decreased somatic activity probably involved some decrease in sympathetic arousal (Jacobson, 1938; Paul, 1969; Reinking & Kohl, 1975; Fey & Lindholm, 1978). The decrease in sympathetic activity could be associated with increased parasympathetic activity (Benson, Beary & Carol, 1974), hence more acid. This physiological effect could have countered any of the relaxing cognitive effects some of the subjects may have experienced from the lowered somatic activity. Attempts had been made in pilot work prior to this study to measure the pulse pressure of subjects during the sessions in an attempt to replicate the finding that relaxation exercises result in decreased sympathetic activity.

The additional equipment necessary to do this, however, interfered to some extent with subjects' reading and performing relaxation exercises.

In summary, the lowered somatic activity in the post-exercise period was not associated with decreased acid. Eleven of fourteen subjects reported feeling physically relaxed, yet seven of these increased acid output at that time. This may have been due to the spontaneous generation of anxious thoughts which some subjects indicated in their self-report. Another factor which may have played a role is the possibility of increased parasympathetic arousal concomitant with sympathetic lowering which is postulated to occur following the relaxation exercises. The data suggest that relaxation training is not an effective method of lowering acid output of healthy subjects.

In the reading study, mean acid output was decreased 32% when subjects were reading relative to the control period. Furthermore, when subjects appeared to be absorbed in the externally generated task of reading or self-generated tasks, such as composing tunes or "playing with perception," acid output was generally decreased. This suggested that the decreased acid was associated with active cognitive involvement rather than the act of reading itself.

In conclusion, the data of Study I suggest

(1) that an acid-reducing activity may be one that involves subjects cognitively in a non-anxiety stimulating situation and (2) that an activity which relaxes subjects physically is not associated with decreased acid output.

INTRODUCTION TO STUDY II

Study I was designed to explore the effects of cognitive involvement on gastric acid output. The mean acid output while subjects were reading was 32.5% less than during their control periods. Further analysis of subjects' activities during reading and control periods, strengthened the speculation that active cognitive involvement was an important factor contributing to the decrease in acid output.

In order to further test this hypothesis, it was important that the experimenter be able to assess that subjects were, in fact, involved in cognitive activity. In the reading study, the extent of subjects' involvement in their reading could not easily be measured. Their reported interest in the material was not always corroborated by the experimenter's observations. In the case of two subjects, the possibility existed that they were more cognitively involved in their control periods than while reading. Furthermore, the experimenter did not provide a standard stimulus for all subjects. Because of the nature of the study, subjects were free to bring reading material of their choice to the laboratory, e.g. newspaper, TV guide, career journal, textbook, novel. Additionally, they were not required to read for the entire reading period although most chose to.

In Study II, an attempt was made to control for the above factors, i.e. to provide a standard stimulus in which the subjects' continuous active involvement could be confirmed by observation. A maze-solving task was chosen as the stimulus activity because subjects' involvement in it could be readily observed by the experimenter. In order to encourage continuous involvement in the task, the element of competition and possibility of reward were added to the activity.

In pilot work using the maze, subjects continuously involved themselves in the task until it was removed from them. They later reported it had challenged them and maintained their interest. Four of the five pilot subjects required a minimum of fifteen minutes to solve the maze. The fifth subject solved it in nine minutes and then required an additional six minutes to solve it in reverse. Thus, the pilot work suggested that the task was an engrossing one that would require approximately fifteen minutes of laboratory time. It had the additional advantage that it could be reversed as many times as necessary until a minimum of fifteen minutes had passed or until pH returned to the endpoint 3.5. As discussed in Study I, the measure of acid output was arrived at by observing the volume of alkali ($KHCO_3$) required to neutralize the acid in the stomach to pH 3.5 within a designated period of time.

In contrast to the reading study, the subjects' active involvement in maze-solving could be readily observed continuously throughout the task portion of the session. Cognitive involvement could be safely inferred because of the nature of the task. It was felt that the subject was more likely to continue to involve himself in this activity because of the possibility of reward. Furthermore, the maze-solving task was a more standard activity for each subject than reading.

In view of the above factors and the results of the reading study, it was hypothesized that the subjects' active involvement in the maze-solving task would result in significantly less mean acid output compared to control periods.

METHOD

Subjects

Six male subjects volunteered to participate in the study. They responded to the same advertisement used in Study I (Appendix A). They ranged in age from seventeen to twenty-five years and were all students at the post-high school or university level. They were paid $10 for the session. When asked, none reported a history of ulcer disease. Subjects fasted for eight hours prior to the session.

Apparatus

The acid measuring and recording equipment was the same as that used in Study I.

A Bolt Head Maze (Milner, 1965) was used as the maze-solving task (Figure 5). It consists of 100 bolt heads screwed into a board 33 x 33 cm. The maze is electrically wired so that when the bolt heads are touched by a rod attached to the wiring, a click is heard and the trial is registered on an automatic counter. There is only one "correct" path of unwired bolt heads from the bottom left bolt head (START) to the top right bolt head (STOP) through which the heads can be touched without the sound of a click. The rules as set for this study were that subjects had to

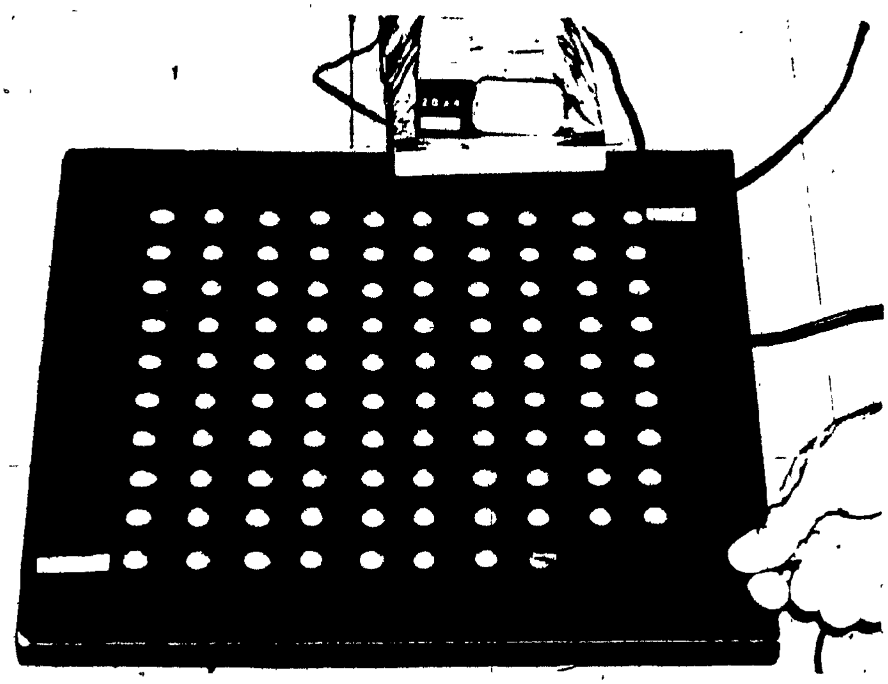

Figure 5. Bolt Head maze, showing attached rod and counter.

return to the START position each time they heard a click. In order to successfully complete the maze, subjects had to remember which bolt heads produced clicks on previous trials. Scores were calculated by recording the number on the automatic counter at the start and completion of the maze.

Procedure and Design

Prior to the session, the experimenter spoke to each subject on the telephone and described the equipment and acid-measuring technique. Subjects were told that a study had already been carried out to examine the effects of relaxation training on gastric acid output and that now "attention control" sessions were required to complete the study. The subjects were informed that following the session, which would last one hour, they would be trained in the technique of progressive relaxation. They were told that if they wished to practise it further, the relaxation tape would be loaned to them for a period of two weeks.

When each subject came to the laboratory, the equipment was explained and he was asked to read and sign the consent form (Appendix B).

Sessions were designed to last approximately forty-five minutes. It had been decided in advance, as in

Study I, that sessions would start with a basal period lasting approximately fifteen minutes, with a minimum of twelve minutes. Each session also had a minimum fifteen-minute control period, and a minimum fifteen-minute period during which subjects would attempt to solve the maze. Each control or experimental period started when the pH was at the end-point 3.5 and lasted until the pH returned to 3.5 after a minimum of fifteen minutes had elapsed. The procedure of the study is summarized in Table 4.

Those subjects (1, 3, 5) whose experimental period preceded their control period were told: "In about fifteen minutes, when your acid stabilizes after you swallow the capsule, I will give you a task that will involve your attention for the next fifteen minutes. Then for another fifteen minutes you will simply remain in the chair for another control measure."

Subjects 2, 4 and 6, whose experimental period followed their control period, were told: "After you swallow the capsule we will let your acid stabilize for about thirty minutes and then I will give you a task that will involve your attention for the last fifteen minutes."

At the start of the experimental period, each subject was given task instructions to read while the experimenter set up the maze on the desk in front of the subject

Table 4

Procedure of Maze-solving Study

Subject	Time ~ 15 minutes	~ 15 minutes	~ 15 minutes
1	basal	maze	control
2	basal	control	maze
3	basal	maze	control
4	basal	control	maze
5	basal	maze	control
6	basal	control	maze

(Appendix H). Any questions were then answered and the subjects started maze-solving.

The experimenter recorded behaviors exhibited by subjects, such as body movements, comments during the task, etc. After each session, subjects were given a questionnaire to complete (Appendix I).

RESULTS

It was necessary to assess whether temporal effects existed within sessions before collapsing the data of the six subjects in order to compare their acid output under task and control conditions. These effects were explored by comparing the acid output of the task conditions that followed basal periods (after fifteen minutes) with the acid output of the task conditions that followed basal and control periods (after thirty minutes). The control period data could not be used to assess temporal effects because these data were confounded by the experimental periods that preceded them. It was decided that if the differences were not significant at a liberal alpha level, the data of the six subjects could be collapsed and compared using a correlated t test.

A t test comparing acid output in the task period of the three subjects in the basal-task-control paradigm with acid output of the three subjects in the basal-control-task paradigm was not significant even at the .2 alpha level.

Because no temporal effects were revealed within sessions, the data were collapsed.

Mean acid output for the six subjects in the control period was 9.5 mEq/hour compared to 4.5 mEq/hour in the task period (Figure 6). A two-tailed correlated t test comparing acid output in task and control periods was significant ($t(5) = 2.82$, $p < .0371$).

The individual data are presented in Appendix J. One of the six subjects increased acid output while maze-solving. The other five decreased acid between 51% and 71% from the amount they were producing in the control period.

All subjects solved the maze within the task period. The maze was reversed for all subjects so they could work until their pH returned to the end-point 3.5.

Five of the six subjects solved the maze in 12-15 minutes; the sixth required eighteen minutes. The number of trials required to solve it ranged from 48 to 113. The Pearson product moment correlation (r) between the number of minutes and the number of trials required to solve the maze was +.689 ($p < .01$). The percentage decrease in acid output, however, did not appear to be related to the subjects' ability to find the correct path. The correlation between number of trials and percentage decrease in acid output was -.3 (N.S.). The correlation between the time required to solve the maze and the percentage decrease in acid output was +.02 (N.S.).

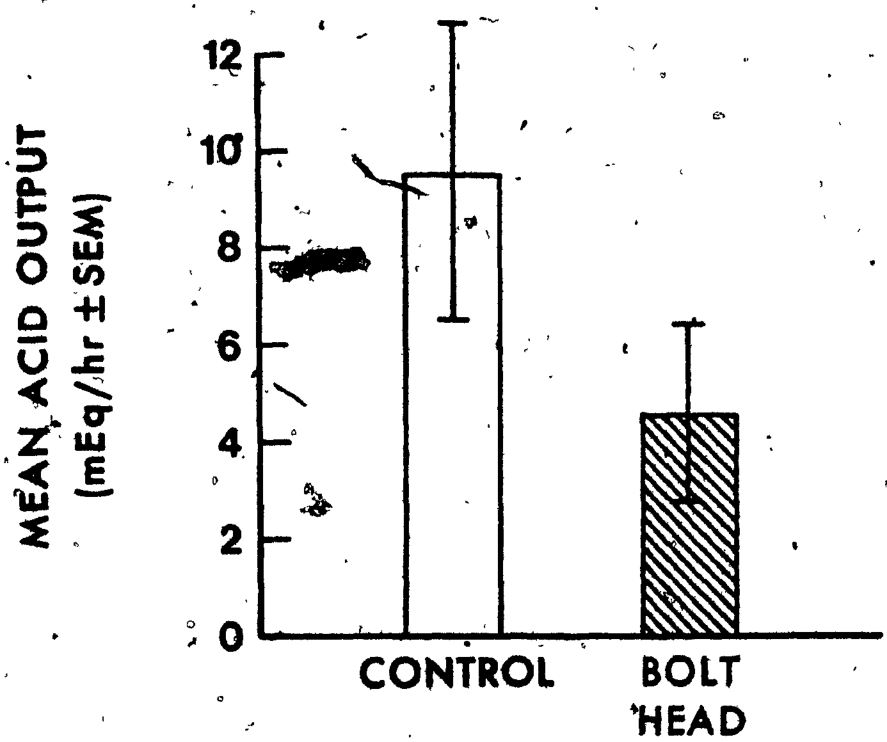

Figure 6. Mean acid output (± SEM) in control and maze-solving conditions.

Self-report data revealed that all subjects described the task as either very or moderately: involving, difficult, enjoyable and competitive. The self-report answers regarding degree of stress experienced varied more widely. Four subjects described the task as marginally, moderately or very stressful, two as not at all stressful. Allowing a score of three points for a report of "very stressful," two for "moderately," one for "marginally" and zero for "not at all," the Spearman rank coefficient (r_s) between self-report of stress and percentage decrease in acid output while maze-solving was -.95 ($p < .01$). This suggested that subjects who reported experiencing more stress while maze-solving had a lesser decrease in acid during the task period. All subjects reported feeling that they had done "moderately well" on the task except the single subject whose acid increased while maze-solving. He reported feeling he had done "very well" on the task.

Self-report data from the control period revealed that five of six subjects described their thoughts as moderately or very involving. One of these five also described his thoughts as moderately stressful and further reported he had been thinking of an argument with a friend at times. He was one of two subjects who produced a substantial amount of acid (more than the other subjects) during the control period. Two of the remaining four subjects described their thoughts as both moderately stressful and moderately enjoyable but did not elaborate further. One of these two subjects was the second subject who produced a substantial amount of acid in the control period. The other two subjects described their thoughts only as moderately enjoyable. One subject reported that his thoughts were not at all involving or stressful. Statistical analysis comparing the acid output of the control period with the self-reports of stress was not carried out because some subjects reported a mixture of thoughts within that period, i.e. stressful and enjoyable.

The verbal and motor behavior of subjects while solving the maze appeared to confirm the self-reports that the task was experienced as involving. Subjects were observed to have worked continuously during the task period without losing interest in it. One subject exhibited an additional behavior while maze-solving: he tapped his foot throughout the task period. He was the subject whose acid had increased somewhat during that time compared to his control period.

DISCUSSION

The results of Study II appear to support the hypothesis that subjects' active involvement in maze-solving would result in significantly less mean acid output than in the control condition. As noted in the results, five of the six subjects decreased acid 51%-71% relative to control periods. The observed behaviors corroborated the self-reports of subjects suggesting that they were all actively involved cognitively throughout the task period. There appeared to be no relationship between ability to solve the maze and acid output. It seemed rather that the involvement in the task itself was the acid-reducing factor.

The maze-solving task so obviously involved all the subjects that it appeared to have served as a more standard experimental condition than the reading task of Study I. Furthermore, the motor and verbal behavior observed suggested that subjects were more actively involved cognitively in the task periods of this study than in the reading study relative to the control periods of each study respectively. Under maze-solving conditions, the percentage mean decrease of acid output relative to the control period was 52.6%. This compares with a percentage decrease in mean acid output in Study I of 32.2% when the subjects were reading, and virtually no decrease in acid output following the relaxation exercises (2.5%). These results support the hypothesis that active cognitive involvement may be a contributing factor to the decrease in acid output.

Two lines of evidence will be discussed in an attempt to explain why this phenomenon may exist. The first suggests that there is less likelihood that subjects would experience intrusive stressful thoughts or feelings of anxiety when they are actively involved cognitively in reading or maze-solving. The other explanation invokes some data from the attention literature to speculate that active cognitive involvement may ultimately lead to decreased parasympathetic arousal and hence less acid.

The first explanation is based on observations that particular kinds of stress situations in humans with or without ulcer disease are associated with increased acidity. These situations include chronic fear (Hoelzel, 1942); stressful interviews (Mittleman & Wolff, 1942; Shay et al., 1958); situations that induced reported feelings of resentment and humiliation (Wolf & Wolff, 1943); anxiety of hospitalized patients over repeat routine gastric intubation tests (Heller et al., 1953). Mahl (1950) interviewed six high and two low-anxious subjects on the morning of a difficult examination during their final examination period.

The discussion emphasized the importance of the examinations in regard to the subjects' entrance to graduate school. Five of his six high-anxious subjects increased acid during the interview compared to their control condition, while the low-anxious subjects showed no change.

The above studies suggest that certain anxiety or stress situations may be associated with increased acid output. If we now begin to examine the reading, relaxation training and maze-solving studies on the basis of individuals' statements and behaviors in their control and experimental periods, we note that when subjects reported disturbing or intrusive thoughts, these periods were associated with increased acid secretion. The current studies, however, were not designed to examine such effects on acid output, but rather to explore the effects of cognitive involvement in reading and maze-solving. Detailed questioning of the content of subjects' cognitions was not carried out as this could have been stressful to subjects and influenced the subsequent measure. We have as data some observations noted by the experimenter and those statements that were volunteered by the subjects in answer to the questions they were asked after each session. For these reasons, the links between stressful thoughts and acid increases in the present studies are to be noted merely as observations since they were not systematically examined.

In the relaxation study we have already noted that no statistically significant relationship existed between subjects' reports of mental relaxation and acid output. However, of the seven subjects who reported not feeling mentally relaxed following the exercises, five increased acid output and two decreased acidity relative to their control periods. Three of the four subjects whose acid had doubled in the post-exercise period were those who reported not feeling mentally relaxed and the fourth stated "time went slowly." One of these subjects was more specific in describing his thoughts as having centred on problems in relationships. The others did not offer more detail.

In the reading study we noted a substantial increase in acid in the latter half of the session of the subject who was graduating that day. His behavior later suggested he had been pressed for time during that part of the session. A subject whose reading preceded his control period reported that during his control period he was anxious to get back to his newspaper reading. He had been reading the classified section as he was in the process of job-hunting. His acid increased 61.2% in his control period compared to when he had been reading.

Three subjects whose paradigm was control-reading reported having felt other than relaxed in their control periods. One said he felt tense at times and added that he had been thinking of personal problems. His acid decreased 80.4% when he was reading. The other subject reported having felt "blue" and "reflecting on all sorts of things" in his control period. It was noted that he appeared concerned and serious during that time. He said the reading period was easier for him as it filled his time better. His acid decreased 39.6% when he was reading. The third subject reported "feeling a little anxious" in his control period. His acid decreased 45.1% while reading career planning material. This subject is particularly interesting in that his acid output was not large in either part of his reading session or his relaxation training session. The largest amount he produced in any of those four segments was 4.7 mEq/hour. He seemed to have much on his mind after the latter part of his second session (exercise). He began to speak of problems he was experiencing in his home. The tubing and capsule were still in place. The experimenter continued to titrate the acid produced while the subject continued to talk about issues that were on his mind, e.g. his desire to move out of his family home, the pressure he felt his mother placed on him to get good university grades, the difficulties his parents demonstrated in their own relationship, and his own difficulty in establishing any relationship, etc. He continued to talk for an hour during which time he produced 10.3 mEq acid per hour, more than twice the amount he had produced in any of the other four periods. The results of this subject's session support the data of Mittleman and Wolff (1942), Mahl (1950), and Shay et al. (1958) who reported stressful interviews to have been associated with increased acid output.

As noted in the Results section of Study II, the subject who secreted the most acid in the control period was the individual who, in addition to describing his thoughts as moderately stressful, further detailed that he had been thinking of an argument with a friend that had occurred the day before. His acid output decreased 54.5% in the task period that followed those cognitions. Two other subjects also reported some amount of stressful thoughts in their control period. It is suggested that the active cognitive involvement in the task contributed to the decrease in acid output in part by inhibiting stressful cognitions at least in the case of these three subjects.

These observations from Studies I and II lend some support to the explanation that acid output decreased when subjects were actively involved cognitively in part because stressful or disturbing thoughts were inhibited at those times. When subjects were reading, they were assumed to be more cognitively involved than in their control periods. When they were maze-solving, they were clearly very involved in the task. The mean acid output decreases were larger as the degree of cognitive involvement increased from Study I to Study II. This further supports the association of active cognitive involvement with decreased acidity.

Davidson and Schwartz (1976) recommended different activities for people, depending on whether they have high or low somatic or cognitive anxiety. If we speculate, on the basis of the above reported observations and earlier reported studies, that high cognitive anxiety is associated with increased acid output, the appropriate activities to decrease acid output would be reading, watching television or playing chess, according to Davidson and Schwartz. These are their proposed activities for high cognitive anxiety. They prescribe progressive relaxation for those individuals high in somatic and low in cognitive anxiety. We noted that progressive relaxation exercises had virtually no inhibiting effect on mean acid output, even though eleven of the fourteen subjects reported feeling physically relaxed after the exercises. This further supports the notion that stomach acid is more related to cognitive than to somatic activity.

It is particularly interesting to note that although the Bolt Head maze was regarded as competitive and difficult by each of the six subjects, it nevertheless was associated with decreased acid output in the case of five of them. Four of the six subjects reported that the task was experienced as stressful to some degree. However, there was a significant negative correlation between degree of subjective stress reported during maze-solving and percentage decrease of acid output relative to control periods. Thus, those subjects who reported experiencing more stress had a lesser decrease in acid. However, the subjects' mean acid output during the task period was significantly less than during the control period. It is possible that the anxiety the subjects may have experienced because of the task's difficult and competitive nature was diffused by the opportunity they had to cope with it, i.e. to solve it. The single subject whose acid increased during maze-solving demonstrated the additional behavior of foot-tapping throughout the task period. It is conceivable that this signified the task was more stressful for him than for the other five subjects, even though his self-report indicated that he found the task only moderately stressful. The rest of his self-report was not different from the other subjects except that he was the only one who expressed the feeling that he had done very well. It is likely that the task and its competitive and reward components held somewhat different meanings for each subject. The significance of a stimulus for a particular individual is difficult to measure (Wolf & Welsh, 1972). It is possible that this subject experienced more anxiety or stress than the others compared to his reported "enjoyable" thoughts of his control period. His constant foot-tapping may have been an indication that the task or the competitive aspect of it was more stressful for him than for the other subjects. If foot-tapping can be construed as manifest anxiety, it can be noted that manifest anxiety was reported to be associated with increased acidity by Mahl (1950) and Heller et al. (1953).

The other line of evidence that may contribute to explaining the data of Studies I and II relates to the way in which the sympathetic and parasympathetic nervous systems operate at times. As noted earlier, the antagonistic interaction of the adrenergic and cholinergic systems has been demonstrated at the neurotransmitter level (Vizi, 1974). Other researchers have demonstrated that chemical or surgical sympathectomy is associated with increased acid output in rats (Moraes, Nyhus, Kalahanis, Bombeck & Das Gupta, 1978). They have theorized that sympathetic arousal may have an anti-cholinergic effect, i.e. the parasympathetic system may be inhibited when the sympathetic system is aroused.

A decrease in parasympathetic functioning would mean decreased vagal activity, i.e. less acid secretion.

A review of reported influences on the cephalic phase of acid secretion supports the view that the sympathetic and parasympathetic nervous systems often operate antagonistically. Many of the situations associated with decreased acid secretion are described by the experimenters as sympathetically arousing. Some of these involve acute fear or overwhelming situations, e.g. Cannon (1934), Wolf and Wolff (1943), Polish et al. (1962), Weiss (1977). Music of concert hall intensity was associated with decreased acid secretion compared to control periods; the experimenters suggested that the music may have been perceived as noisy and stressful and thus could have been sympathetically activating (Demling et al., 1970). The effect of sleep on gastric acid secretion was studied by Moore and Englert (1970) and Hall et al. (1977). Both reported a reduction of secretion in the morning. Hall et al. suggested that the decrease in acid seen on awakening could be an anti-cholinergic effect occurring when an individual adapts to changes in his environment. Perhaps this decrease in acid was a result of sympathetic activation during the adaptation arousal period. Kahneman et al. (1969) report sympathetic-like responses during attentive observation to external stimuli.

Badgeley _et al._ (1969) postulated a sympathetic activation mechanism to explain the decreased acid secretion of their subjects during mental arithmetic hours. These experimental hours were counterbalanced with control hours and no order effects were noted. They had hypothesized that mental arithmetic would be associated with sympathetic discharge and a shift of blood flow from the viscera to the periphery resulting in gastric vasoconstriction and lowered secretory rate. Brod (1963) had shown increased heart rate and muscular blood flow when subjects were mentally solving difficult arithmetic problems. Kahneman _et al._ (1969) as well reported increased sympathetic arousal during mental arithmetic tasks, albeit very brief ones.

In 1974, Lacey and Lacey reported that attentional tasks, such as detecting a signal tone, were associated with lowered heart rate (bradycardia), whereas mental arithmetic or "cognitive work" was associated with increased heart rate. They also reported that a "divided set" task requiring both tone detection and mental arithmetic resulted in more heart rate increase than the latter task alone. The components of the "divided set" task are somewhat akin to the Bolt Head Maze task in which subjects had to listen for the shock (detect a signal) while remembering the previous paths taken in the maze.

Elliott (1974) reported that when subjects were reading a transcript of a counselling interview with the knowledge that they were required to summarize it, suggest solutions, etc. later, their heart rate increased. In a similar study, Adamowicz and Gibson (1970) demonstrated that when subjects were listening to easy or difficult text recordings with intent to verbally summarize them, heart rate increased over baseline values. When there was no summary required of subjects, heart rate decreased. In order to reduce the "motor set" associated with the task while still maintaining the cognitive component, Adamowicz and Gibson (1970) required subjects in a second study to listen to the text with the knowledge that they would later provide a written summary. They still found cardiac increases were greatest when there was a high "cognitive task energy demand." They reported a gradient of cardiac increase from least to most cognitive involvement. Dengerink (1971) also demonstrated that heart rate levels were high when subjects were listening to instructions for a task in which they had to compete with an opponent. Thus, we note that sympathetic arousal has been demonstrated under conditions of mental arithmetic (Brod, 1963), other cognitive tasks (Lacey & Lacey, 1974; Kahneman et al., 1969), listening to texts or reading transcripts with intent to summarize (Adamowicz & Gibson, 1970; Elliott, 1974), and listening to task instructions with the requirement of later performance (Dangerink, 1971). All these tasks have an element of cognitive involvement which is similar to the involvement required by the maze-solving task of Study II, and to a lesser degree, the reading task of Study I.

At the physiological level, active cognitive involvement is associated with sympathetic arousal. We noted previously reports of the antagonistic interaction of the sympathetic and parasympathetic nervous systems. We noted, as well, studies in which sympathetic arousal was associated with decreased acid secretion, i.e. decreased parasympathetic vagal activity. It would appear that the decrease in acid output under the reading and maze-solving conditions may be partially explained by the sympathetically arousing nature of the tasks and the concomitant decrease in parasympathetic activity.

As noted earlier, an attempt was made in pilot work for Study I to measure sympathetic activity while measuring acid output. However, it was decided that the additional equipment interfered with the subjects' ability to carry out the relaxation exercises and reading tasks in comfort. It would also have interfered with performance of the Bolt Head maze task of Study II.

The two explanations offered above to account for the decrease in acid output under reading and maze-solving conditions were (a) the inhibition of stressful cognitions and (b) the sympathetically arousing nature of the tasks. One does not exclude the other. Indeed, they may interact under certain conditions to augment the decrease in acid output. This could be tested in future research by measuring the acid secretion of stressed and non-stressed subjects under control, maze-solving and, perhaps, tone detection (bradycardial) conditions. This would help determine the relative roles played by stressful thoughts, active cognitive involvement and sympathetic activity in acid output.

More importantly, however, the question should first be asked whether maze-solving or reading interesting material would systematically decrease acid secretion in subjects who were under stress. It would then be of interest to study these questions in subjects with peptic ulcer disease or hyperacidity. It would seem unlikely that relaxation exercises would serve to decrease acid secretion in subjects under stress. Not only does the post-exercise condition allow for the re-introduction of stressful cognitions but, in addition, it is reported that the relaxation exercises result in a decrease of sympathetic arousal (e.g. Jacobson, 1938; Paul, 1969; Chinnian <u>et al.</u>, 1975; Reinking

& Kohl, 1975; Fey & Lindholm, 1978). Thus, if any change in autonomic functioning were to occur, it would likely be in the direction of an increase in parasympathetic functioning, i.e. increased acid output.

The implication of the current set of studies is that, at least for healthy subjects, active cognitive involvement rather than physical relaxation would be more likely to reduce gastric acid output. The data indirectly support the research of Chappell and Stevenson (1936) who gave daily "group psychological training" for six weeks to thirty-two subjects with ulcer disease. There were twenty control subjects who did not receive this training. It should be noted, however, that the authors did not report giving the control subjects any form of attention. The experimental group was trained to learn the negative influence of worry on the healing process of the gastrointestinal tract. To prevent worry, the patients were instructed to select a period of life to which not many unpleasant thoughts were associated. They were then trained to direct their thoughts to this period. Patients were also told to seek the cooperation of their families in eliminating the discussion of their disorder and diet. At the end of three weeks, all but one of the experimental subjects were free of subjective symptoms. At the end of eight months only one subject experienced recurrence of disease compared to the control group in which all suffered ulcer recurrence. Chappell and Stevenson (1936) used thought substitution training as part of the treatment in their study. The reading and maze-solving tasks could also be considered as redirecting cognitions, albeit these stimuli were external to the subjects. The implications of both sets of studies, however, are that elimination of stressful cognitions benefit the gastrointestinal tract.

An additional implication of the maze-solving study is that the presentation of a difficult task need not result in increased acid output if there is an opportunity to cope with the task. The possibility of reward in this study may have contributed to the subjects' motivation to continue to solve the maze and to maintain interest in it. It is suggested that the necessity of remembering past moves, i.e. the cognitive involvement or energy requirement, helped to eliminate what may otherwise have been a "stress" reaction of increased acid output. In fact, the result was decreased acidity.

We learned further that reading was not as effective as maze-solving in decreasing acid output, again implying that cognitive involvement or the cognitive energy required by a situation may play an important role in the acid response. As discussed above, this may be associated indirectly with sympathetic arousal, or the inhibition of worries, or an interaction of the two factors.

Twenty-one subjects in the two studies swallowed the Heidelberg capsule and tubing. Most did this without difficulty. A total of thirty-three sessions were held, exclusive of pilot work and sessions eliminated due to technical problems. On six occasions the subjects required several tries to successfully swallow the capsule. This occurred on the first occasion for five of the subjects and on the second session of the sixth subject. The five subjects did not find it aversive to the degree that it would prevent them from participating in the next session.

There were two other subjects who had volunteered for the study but were unable to swallow the capsule. One later described himself as a "gagger." The other reported after several attempts that he had experienced difficulty in swallowing since the age of six when an oesophageal fistula had been repaired. In future research with this equipment, subjects should be asked specifically if they have ever had difficulties in swallowing before engaging them in the study. The capsules are costly and must be used on the day they are calibrated.

In both sessions of Study I, subjects were asked if they were worried about swallowing the capsule. Worry, either prior to or while swallowing, was reported in fourteen of the twenty-seven sessions. A Chi square test revealed, however, that these reports bore no relation to the subsequent control period acid output measure which directly followed the basal period (during which no measure could be taken), $\chi^2(1) = 1.45$, $p < .3$.

The telemetering equipment seems to be less aversive than other acid measuring procedures. Two subjects in the first study offered themselves for a fourth session when technical problems made it necessary to eliminate their second and third sessions. Their offers were not accepted but they do indicate the relatively non-aversive nature of the technique.

In conclusion, these studies suggest the following:

1. The modification of the Heidelberg acid measuring equipment as described in this thesis renders it useful for measuring gastric acid output. This measure can be made continuously throughout sessions while subjects undergo various experimental conditions. This is accomplished without discomfort to the subjects. The method minimizes the risk of either cephalic or gastric phase effects on acidity due to the measuring technique.

2. Cognitive activity in tasks such as reading and

maze-solving may be associated with decreased acid output. Because maze-solving was more acid-reducing than reading, it is suggested that the degree of cognitive involvement is a key factor in the acid response.

3. The presentation of a difficult task, even if it is perceived as stressful, need not result in increased acid output if there is an opportunity to cope with the task.

4. Progressive relaxation exercises inducing physical relaxation effect no significant change in acid output.

5. Cognitive activity appears to influence gut activity in the form of acid output changes. Future research should examine the implications of these studies in subjects under stress and in subjects suffering ulcer disease.

If research on subjects with hyperacidity or peptic ulcer disease demonstrated similar results, this would suggest that a treatment for such problems include not physical relaxation but rather an activity with a large cognitive component. The results suggest that a difficult cognitive activity need not result in increased acid output if the opportunity exists to cope with it. It might follow, therefore, that the more involving the activity, the more likely it would be that acid output would be decreased at that time. It may well be, for example, that the hypersecretor should holiday not by relaxing on a sandy beach, but rather by engaging himself in a challenging activity such as underwater photography or scrabble.

The method developed to measure acid output as described in this thesis is recommended for use in future psychological research. It could be a valuable adjunct for behavioral approaches to lowering gastric acidity.

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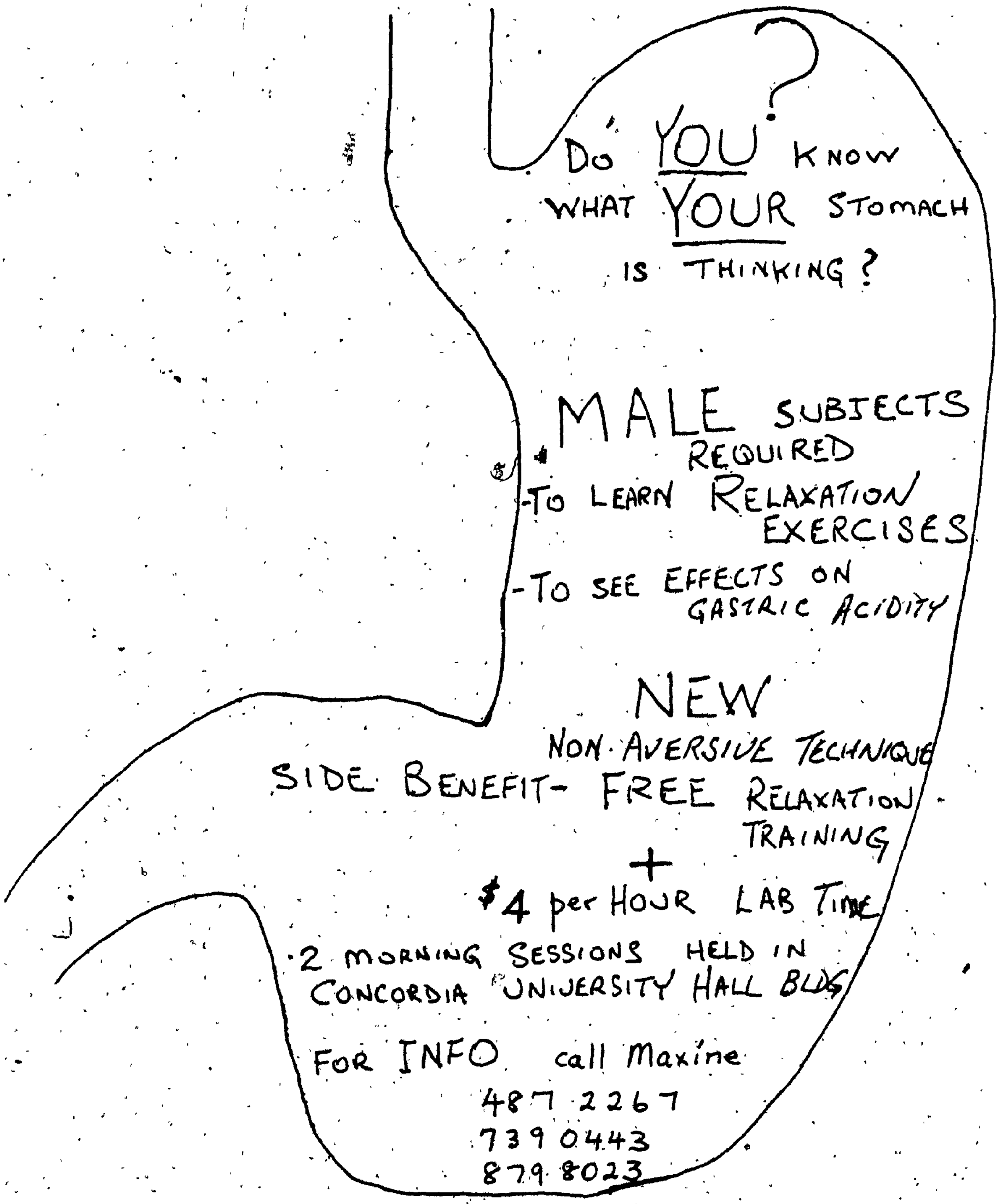
APPENDIX A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APPENDIX B

INFORMED CONSENT

I, the undersigned declare that I agreed to participate as a subject in a study conducted by Maxine Sigman and supervised by Dr. Z. Amit.

I declare that the nature of the study was explained to me prior to my participation. I also declare that I agreed to allow the investigators to withhold from me, should they need to, some information which is necessary for the success of the study. The investigators undertook to provide me with all pertinent information upon completion of the study.

Signed this _____ day of the _______

month _______ year

in the city of Montreal

____

Signature

APPENDIX C

Modified Jacobsonian Instructions

For Progressive Relaxation

I want you to lie as comfortably as you can on the chair with your arms straight at your sides and your legs straight. First, I want you to take a slow, deep breath. ...Take a slow deep breath and hold it....Then relax and let go.

In the first exercise, I want you to focus on the muscles across the forehead. I want you to tighten these muscles by raising your eyebrows as high as you can. Raise your eyebrows as high as you can...as if you were trying to force them right into your hairline. Now concentrate on the tension that builds up across your forehead. Focus on the discomfort you're feeling....Allow this discomfort to build up...and then relax, and let go. Smooth the muscles across your forehead. Try and let these muscles go more and more completely limp.

********(10-second pause)

Now I want you to lower your eyebrows and force them together as if you were frowning. Lower your eyebrows and force them together and, at the same time, I want you to clench your eyes tightly shut. Focus on the buildup of tension around your eyes, across the bridge of your nose, and all along your eyebrows. Again, concentrate on the feeling of tension and feeling of discomfort. Hold this tension...and now, let go and relax. Feel the relaxation along your eyebrows and across the bridge of your nose.

********(10-second pause)

In the next exercise, I want you to press your tongue against the roof of your mouth. Press your tongue against the roof of your mouth. Concentrate now on the pressure building up along your jaw and along your tongue. Concentrate on this feeling. Focus on the tension. Focus on the discomfort....Now, let go and relax. Let your tongue go into your lower jaw without touching the roof of your mouth at all. And let your jaw go slack.

********(10-second pause)

Breathe easily and deeply...and regularly. Each time that you exhale, I want you to concentrate on relaxing more and more completely.

********(10-second pause)

Now focus on the muscles around your mouth. To tense these muscles, I want you to press your lips tightly together. Press your lips together as if you were trying to press your upper lip down into your lower lip. Tense these muscles and feel the tension all across your upper lip and around the corners of your mouth, and along your lower lip. Press...and now relax. As you relax, let your lips part and let your jaw go slack. Concentrate on the pleasurable sensation of the muscles becoming more and more relaxed.

********(10-second pause)

We're now going to shift our focus to the muscles around your neck. The first thing I want you to do is to turn your cheek so it's pressing against the pillow. Press your left cheek against the pillow and, with your shoulders flat, I want you to twist your head as if you were twisting it around on a pivot. Again, keep your shoulders flat and press your left cheek into the pillow as if you were twisting your head around on a pivot. Concentrate now on the buildup of tension along the right side of your neck and the right shoulder. Concentrate on this tension. Focus on the discomfort. And now, let go and relax.

Breathe easily and deeply. And now just let your head go back to its original position.

********(10-second pause)

Now do the same thing, but on the other side. Turn your head so that your right cheek is resting on the pillow and again, keeping your shoulders flat, press your cheek into the pillow as if you're twisting your head around on a pivot. Press your right cheek into the pillow and concentrate on the buildup of tension along the left side of your neck and left shoulder. Press and concentrate on the tension. And now relax...let go...enjoy the feeling of relaxation that spreads around your head and shoulder. Then let your head move back to its original position.

********(10-second pause)

In the last exercise of the set around your neck, I want you to keep your shoulders flat on the chair but raise your head so that your chin is pressing into your breastbone. Lift your head off the chair and press your chin into your breastbone. Again, hold the tension...hold this tension, and concentrate on the discomfort building up around your neck.

When I tell you to let go, I want you to let your head just drop back onto the pillow. All right, relax...your head's dropped down onto the pillow and I want you now to just concentrate on the feeling of relaxation spreading around your neck.

Enjoy this feeling of relaxation spreading around your neck.

Enjoy this feeling of relaxation and continue to breathe evenly and regularly, concentrating on relaxing as you exhale.

********(10-second pause)

Now shift the focus to the muscles along your arms and into your hands.

Keep your arms straight and make your hands into fists. Now slightly raise your arms off the chair, keeping your arms straight. Slightly raise your arms off the chair with your arms straight and your hands clenched into fists, and tighten the muscles all along your arms, your forearms, your upper arms, and right across your shoulders. Feel the tension building up in your arms. Concentrate on this feeling...and feel the vibration in the muscles as you keep these muscles tight. When I tell you to relax, I want you to just let your arms flop down onto the chair.

All right, relax....Your arms have dropped down onto the chair, and now I want you to focus on the wave of relaxation and the wave of warmth that travels along your arms and across your shoulders. Just focus on this release...on this pleasant feeling of relaxation...and let your arms become more and more limp and more and more relaxed.

********(10-second pause)

Now concentrate on the muscles of your stomach and your diaphragm. In the first exercise, I want you to press your stomach slightly out, and tighten it, as if you're preparing to receive a blow. Tighten this muscle as if you were preparing to receive a blow....Hold this tension....Concentrate on the feeling that you're getting from these tensed muscles. ...Hold it....And now relax.

Relax, and let these muscles go limp. Feel the relaxation spreading across your stomach. Feel the pleasurable sensation of these muscles when they're relaxed. Just try to relax them more and more completely.

********(10-second pause)

Now I want you to pull in your stomach. Suck in your stomach as if you're trying to touch the back of your spine. At the same time, I want you to tighten the muscles in your diaphragm.

Again, concentrate on these muscles....Concentrate on the tension....Concentrate on the discomfort. Hold this tension...and now relax. Just breathe easily and deeply, allowing these muscles to relax more and more completely... again focusing on the pleasurable sensation of these muscles as they relax more and more completely.

********(10-second pause)

Now shift your focus to the muscles between your waist and your knees. . . . I want you to do two exercises at once. First, I want you to press your knees together. Press your knees together and, at the same time, I want you to tighten the muscles along your thighs, the upper parts of your thighs, and the lower parts of your thighs, and the muscles in your buttocks.

Tighten all these muscles between your waist and your knees and continue to keep the pressure going between your knees. Hold this tension....Feel the discomfort....And then relax. Let go and concentrate on the sensation of relaxation traveling along your legs.

Try and let these muscles relax more and more completely. Become more and more limp.

********(10-second pause)

Now focus on the lower parts of your legs. In order to tense these muscles, I want you to point your toes back toward your knees. Point your toes back toward your knees and tense the muscles in your calves and in your shins.

You should feel the tension flowing from the tips of your toes, around the backs of your heels, and right up into your calves and shins. Concentrate on holding this tension, focusing on it....And now, let go. Relax, and again concentrate on the feeling of warmth and relaxation that spreads along your legs.

********(10-second pause)

Now, take a slow, deep breath....Breathe easily and deeply and concentrate on letting your whole body relax more and more completely each time that you exhale.

********(10-second pause)

I want you now to imagine a wave of relaxation starting at the top of your head and traveling down your whole body to the tips of your toes. Concentrate first on the muscles across your forehead. Relax the muscles across your forehead and allow this relaxation to spread along your eyebrows and across the bridge of your nose. Relax the muscles across your eyebrows and across the bridge of your nose. Let this relaxation spread around your eyes, around the corners of your eyes, and across your eyelids....Let it continue to spread down along your nose to the corner of your nostrils...and spread out across your cheeks. Relax the muscles in your cheeks. Relax the muscles across your upper lip. Focus on relaxing just the muscles of the upper lip and around the corners of your mouth...then down around your lower lip.

Let your mouth go slightly open and let all these muscles go completely limp and heavy. Relax the muscles in your tongue...along your tongue and down underneath your tongue. Again, just let your tongue rest on your lower jaw without touching the roof of your mouth.

Continue to feel the relaxation spreading along your jaw. Let your jaw go slack, and let the muscles relax.

********(10-second pause)

Relax the muscles along your neck and down into your shoulders. Feel the muscles relaxing in your neck and down into your shoulders. Allow this relaxation to spread slowly down your arms right to the tips of your fingers. Feel the relaxation spreading down your arms and right to the tips of your fingers.

********(10-second pause)

Concentrate now on the contact between your back and the chair. Feel the contact between your back and the chair and try to maximize this contact. Just let your back sink down into the chair and feel the wave of relaxation starting across your shoulders and traveling down your back right to the tip of your spine. Concentrate on feeling the wave of relaxation going from across your shoulders down to the tip of your spine.

********(10-second pause)

Relax the muscles in your legs. First the muscles in your upper legs...all around your thighs...down around your knees...into your calves and shins...right down into your feet. If any tension remains in your legs, I want you to imagine the tension draining down your legs and out through the tips of your toes. Just feel the tension draining down your legs and out through the tips of your toes.

********(10-second pause)

Now concentrate on your whole body. Feel yourself being supported by the chair. You don't have to make any effort at all...you're being completely supported and you can just allow yourself to sink down into the chair. Allow your muscles to become more and more completely limp and heavy. Feel yourself sinking into the chair.

*********(10-second pause)

In a moment, I'm going to tell you to open your eyes. I want you to maintain this relaxation, this feeling of being refreshed. All right....Open your eyes...and continue to feel relaxed and refreshed.

(End of Instructions for Progressive Relaxation)

APPENDIX D

Questions Asked by Experimenter

After Sessions in Study I

Was your reading material: very interesting
mildly interesting
boring

Was your mood in the other half hour:
Session I--happy, tense, relaxed, blue, anxious, angry
Session II

Were you worried about swallowing the capsule:
Session I--before during
Session II--before during

Was the second half of the session:
Session I--easier same harder
Session II--easier same harder

After the exercises were you:
physically relaxed
mentally relaxed
physically and mentally relaxed
not relaxed

APPENDIX E

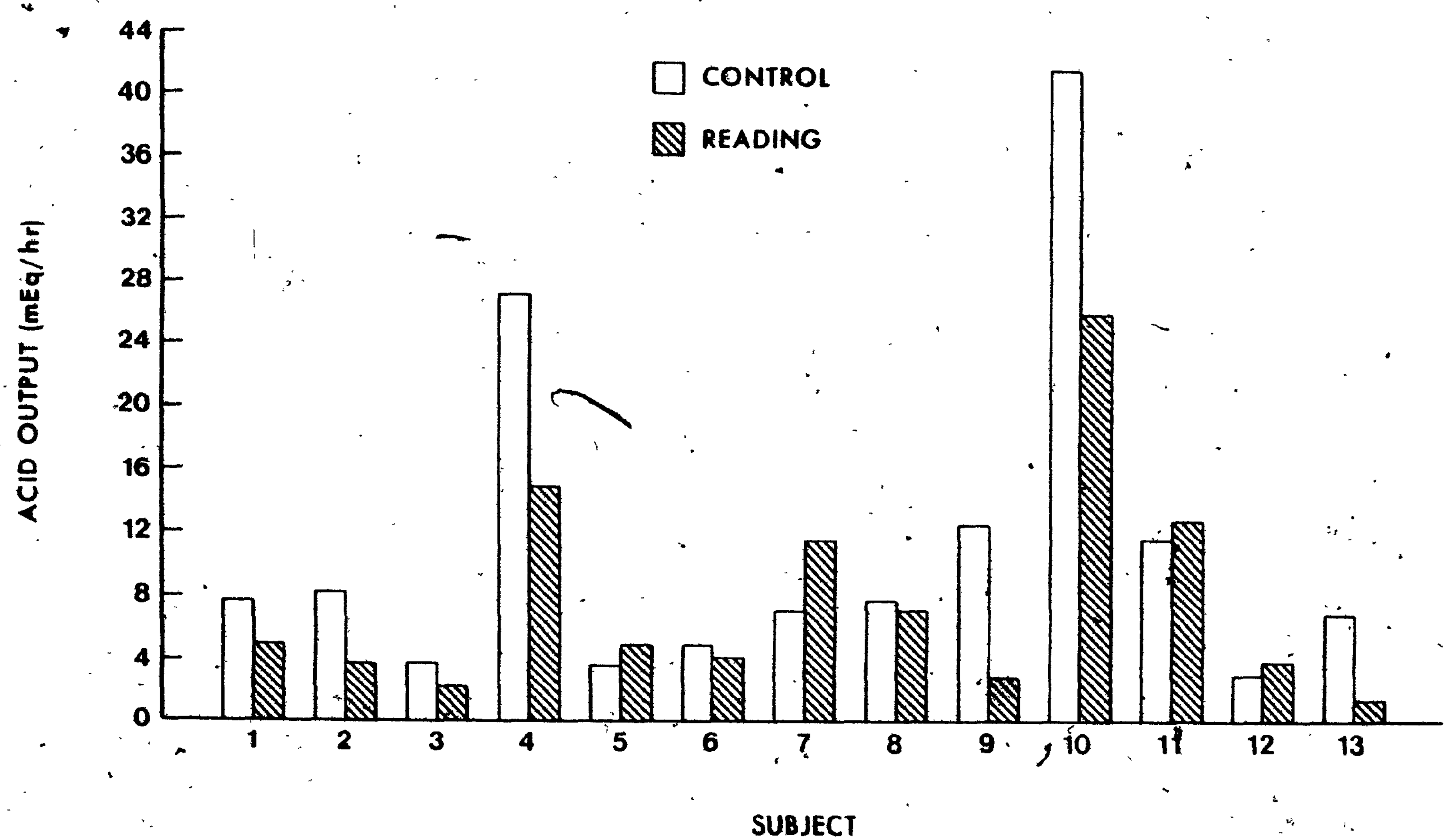
Technical Problems Necessitating Elimination of Sessions

1) Artifactual fluctuations of pH indicator to which the experimenter responded by infusing titrant. These were due to outside interference of unknown origin.

2) Capsule separated from tubing as it was swallowed.

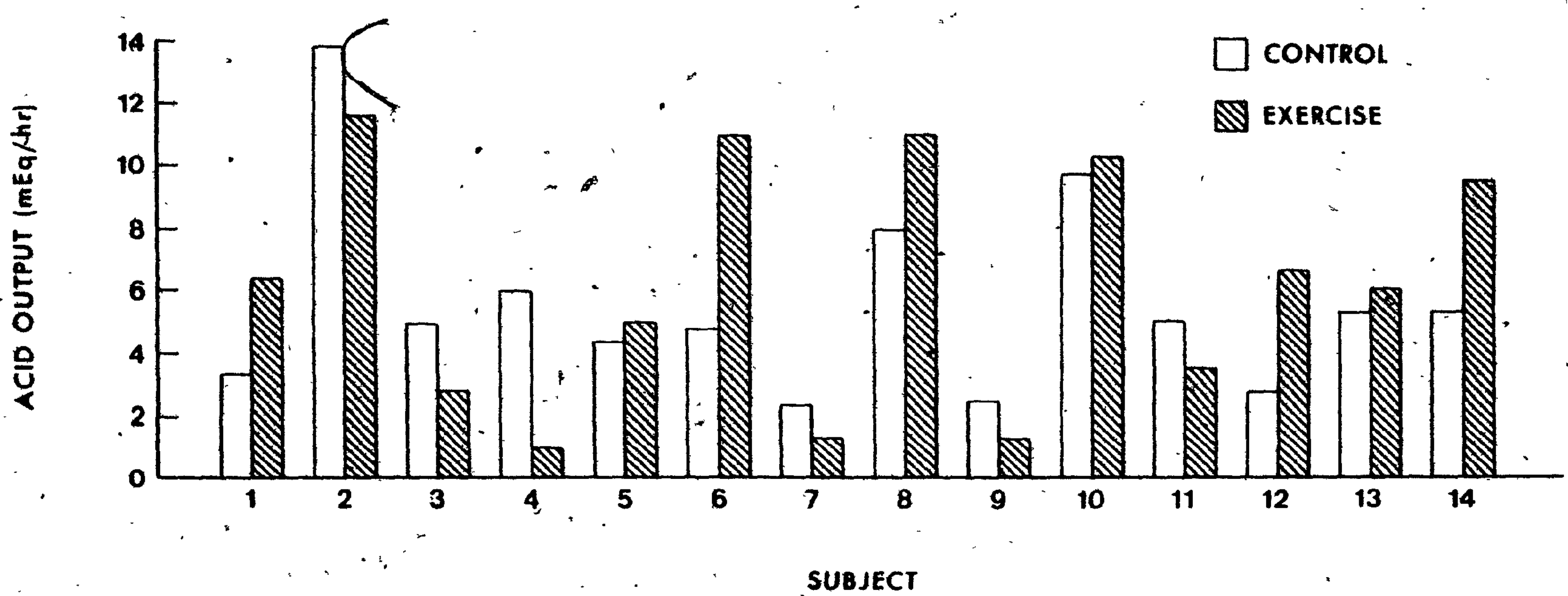
3) Capsule stayed in oesophagus. This occurred early in the study and stimulated the use of a marker taped to the tubing 57 cm from the capsule. Subjects then were required to swallow tubing up to the marker.

APPENDIX F



Individual subjects' acid output (mEq/hr) in control and reading conditions.

APPENDIX G



Acid output (mEq/hr) in control and post-relaxation exercise conditions for each subject.

APPENDIX H

Instructions to Bolt Head Maze

This is called a Bolt Head Maze. You are to trace a path through the maze from START to STOP using the rod to touch the heads of the bolts.

If you take the wrong path, you will hear a click and you then have to go back to START and begin again.

You start at the bottom left hand corner. You can travel only at right angles--vertically or horizontally but in any direction, i.e. forwards or backwards, up or down. You may not go diagonally.

You have approximately 15 minutes to work at this task--to find the correct path.

There are two aspects to scoring your performance--one is based on the speed at which you work and one based on the number of trials you require to solve it or to reach your closest point to STOP.

If you complete the maze you will be asked to start over. There will be a bonus of $10, over and above the $10 you receive for being a subject, if you surpass the standard of scoring. This standard will be calculated on the basis of the 6 subjects participating in this aspect of the study. Because you are competing against the other 5 subjects I will not know and hence will not be able to tell you if you have surpassed the standard until the study is completed.

APPENDIX I

PLEASE UNDERLINE THE ANSWER THAT BEST DESCRIBES YOUR RESPONSE.

Did you find the Bolt Head Maze task very involving, moderately involving or not involving at all?

Did you enjoy doing it very much, somewhat or not at all?

Did you find it very difficult, moderately difficult or not at all difficult?

How do you feel you performed? very well, moderately well, poorly.

Did you find this task very competitive, mildly competitive or not at all competitive?

Did you find this task very stressful, moderately stressful or not at all stressful?

What did you like most about the task?

What did you like least about the task?

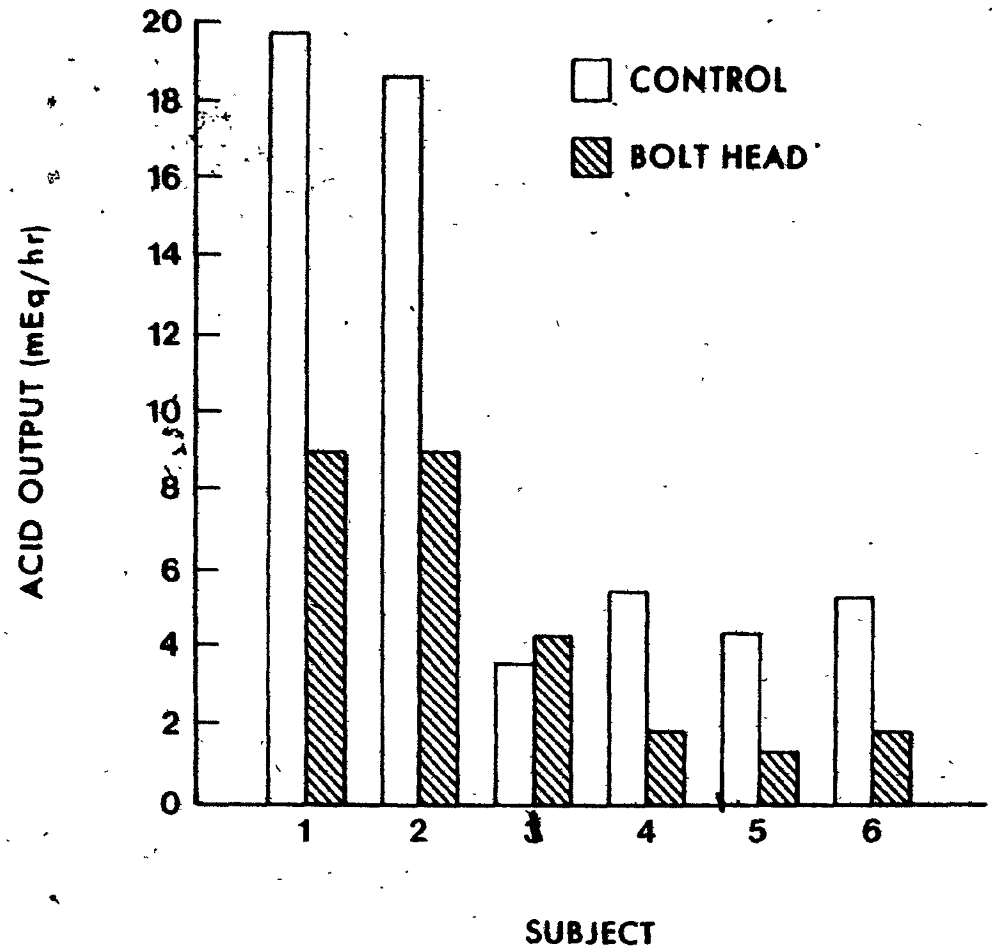
Were your thoughts when you were not maze-solving very involving, moderately involving or not at all involving?

If your thoughts were involving, were they very stressful, moderately stressful, not stressful, very enjoyable, moderately enjoyable or not enjoyable, or other ______________?

What did you like most about the period when you were not solving the maze?

What did you like least about that period?

APPENDIX J



Acid output (mEq/hr) of each subject in control and maze-solving conditions.