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Effects Of Relaxation, Stress And Gastrointestinal Symptomatology On Spontaneous Swallowing.

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EFFECTS OF RELAXATION, STRESS AND GASTROINTESTINAL SYMPTOMATOLOGY ON SPONTANEOUS SWALLOWING

by

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A DISSERTATION

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ABSTRACT OF DISSERTATION
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Aerophagia (excessive air-swallowing) has been postulated as a potential mechanism for the relationship between stress and gastrointestinal (GI) symptomatology. High rates of air swallowing have been associated with abdominal pain, heartburn, and bloating, and may contribute to disorders like functional dyspepsia (FD) and irritable bowel syndrome (IBS). Previous research with asymptomatic subjects found that experimental stressors increase swallowing rate and brief relaxation training decreases it. The present study attempted to replicate this relationship between emotional state and swallowing rate, and to determine whether it differed between persons with and without GI symptomatology. Symptomatic subjects (n=32) were selected to have consulted a physician due to symptoms consistent with IBS or FD within the past 2 years, whereas asymptomatic subjects (n=17) reported no GI symptoms. Groups were matched on age and gender. Each subject received both pleasant low arousal (i.e., relaxation) and aversive high arousal (i.e., stress) procedures, presented in separate sessions. The high arousal condition involved exposure to visual material and an auditory task that had been previously rated as unpleasant and arousing, whereas the low arousal condition involved exposure to a cascaded series of relaxation-inducing techniques. For both groups, spontaneous swallowing rates were significantly lower during the relaxation period than during the high aversive one (M = 7.53 ± 1.05 (SE) vs. 20.14 ± 2.03 swallows/30 min., respectively). Interestingly, symptomatic subjects compared to asymptomatic subjects reported a significantly larger change in GI-related symptomatology in response to arousal manipulations but only a parallel trend was observed in swallowing rate.

These findings provide further support for a relationship between emotional state and swallowing rate. Excessive rates of air swallowing might mediate the relationship between stress and GI symptoms only for those subjects who, due to a lower pain threshold, perceive normal levels of air accumulation as painful.

Edward Taub

Abstract Approved by: Committee Chairman [illegible]

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LIST OF ABBREVIATIONS

Ag/AgCl	Silver-Silver chloride
CT	computarized tomography
cf.	compare
cm	centimeter
dB	decibels
DFA	discriminant function analysis
e.g.	for example
EKG	electrocardiography
EMG	electromyography
et al.	and others
e.s.	effect size
F	F ratio
FD	functional dyspepsia
gi/GI	gastrointestinal
GSR	galvanic skin response
hr	hour
Hz	hertz
IBS	irritable bowel syndrome
i.e.	that is
LN	low neck
M	mean
min	minute

LIST OF ABBREVIATIONS (Continued)

ml	milliliter
mmHg	millimeters of mercury
ms	millisecond
N/n	number
p	probability value
PMR	progressive muscle relaxation
r	Pearson correlation coefficient
s	second
SBP	systolic blood pressure
SCL	skin conductance level
SD	standard deviation
SE	standard error
SM	submental
sw	swallow(s)
μV	microvolt
μS	microsiemens
VCR	videocassette recorder
vs.	versus

Introduction

The gastrointestinal literature contains suggestions concerning a relationship among affect, arousal level and gastrointestinal symptomatology (Maddock, Bell & Tremaine, 1949; Roth & Bockus, 1957; Whitehead & Schuster, 1985; Bradley, McDonald & Richter, 1990; Drossman et al, 1990). However, a clear mechanism for mediating this hypothesized relationship has never been conclusively demonstrated. The proposed study aims to produce further evidence that "aerophagia" (excessive air swallowing") might be one of the mediating mechanisms for some functional gastrointestinal disorders.

Gastrointestinal Disorders and Relationship to Stress

According to Whitehead and Schuster (1985) some confusion exists between the terms functional, psychosomatic and psychophysiological with respect to gastrointestinal disorders. The term functional is often used to designate a disorder or a symptom for which there is no known physical cause and for which no tissue changes or lesions have been found. Physiological changes (e.g., increased intestinal motility) may or may not be present. In this regard, "globus sensation" and irritable bowel syndrome (IBS) are functional disorders (Whitehead & Schuster, 1985). The term psychosomatic, on the other hand, is used to refer to disorders such as peptic ulcer in which there are lesions, but these lesions are believed to be caused or exacerbated by psychological factors such as stress, anxiety, grief, etc. However, for Whitehead and Schuster, distinguishing between functional and psychosomatic on the basis of the presence or absence of an observable lesion is artificial and questionable because the lesions in psychosomatic disorders result from the abnormal types or amounts of physiological activity seen in functional disorders. The term psychophysiological is preferable to functional or psychosomatic because it includes both; it implies only that there is abnormal physiological activity occurring in response to psychological factors, and it neither presumes nor precludes the occurrence of a lesion (Whitehead & Schuster, 1985).

Many gastrointestinal disorders seem to have psychophysiological factors interacting with their origin or influencing their course, in the sense that physiological response or symptoms are correlated with variations in the patient's exposure to environmental or cognitive stressors (Bradley, McDonald & Richter, 1990). The diagnosis of these stress-related disorders can be established by medical procedures, use of self-report instruments such as symptom diaries over an extended period of time and through psychophysiological evaluations using experimentally induced stressors in a laboratory situation.

The most appropriate treatments for stress-related disorders are either teaching the patient a technique for reducing his arousal response to stressors or attempting to modify the environment so that it is less stressful. The most commonly used arousal reduction techniques cited by Whitehead and Schuster (1985) are: (a) Biofeedback based on such parameters as forehead electromyograph, finger skin temperature or skin conductance level (SCL), (b) progressive muscle relaxation (PM), (c) autogenic training, and (d) meditation.

Gastrointestinal psychophysiological disorders can often be characterized as being based on classically conditioned responses, like in cases where physiological reactions to aspects of the environment that are neutral to most people elicit symptoms because of previous learning experiences (Whitehead & Schuster, 1985). In addition, some gastrointestinal symptoms can be reward-maintained because they have been followed by such positive reinforcement as attention from others, financial compensation or avoidance of aversive tasks (Whitehead & Schuster, 1985). Many gastrointestinal disorders can be treated successfully by biofeedback or other behavioral techniques even though their etiology is not related to psychological factors. An example is fecal incontinence secondary to pudendal nerve damage. This condition can often be alleviated using behavioral techniques that help the patient learn to use the neural pathways remaining after injury or that help them relearn alternative behaviors (Whitehead & Schuster, 1985; Bassotti & Whitehead, 1994).

Aerophagia

Whenever swallowing takes place, especially when there is no food or liquid in the mouth, air is ingested. Aerophagia is defined as swallowing excessive amounts of air; this term literally means "air eating". It may produce a sensation of upper gastrointestinal fullness that can be characterized as dyspepsia or it may result in excessive belching or flatus (Calloway, Fonagy, Pounder & Morgan, 1983). Because of the poor absorbability of the nitrogen content of swallowed air, it is either eructated from the stomach, expelled per rectum or retained in the gastrointestinal system (Roth & Bockus, 1957). In the past, aerophagia has usually been considered to be benign. Swallowed air is credited with contributing approximately 70% of gas in the gastrointestinal tract, diffusion of gases from the blood stream accounts for approximately 20%, and bacterial decomposition of food residues produces about 7 to 10% (Roth & Bockus, 1957).

The principal mechanism by which the stomach becomes distended with air is an excessive frequency of swallowing. Traditionally, it has been estimated that from 1 to 2 ml of air enters the gastrointestinal track with each swallow; in the absence of food or liquids, up to 5 ml of air accompanies saliva to the stomach with each dry swallow (Maddock, Bell, & Tremaine, 1949; Calloway, Fonagy & Pounder, 1982). Recently, however, researchers using ultrafast CT scanning have shown that the deglutitive pharyngeal chamber capacity is typically 14 ml greater than the bolus volume; consequently, this amount of air is swallowed every time swallowing occurs (Ergun, Kahrilas, Lin, Logenmann, & Harig, 1993). In addition, when dry swallowing occurs, up to 25 ml of air are ingested (Kahrilas P. J., personal communication, March 1994). These researchers also found that this value exhibited substantial variability among subjects, perhaps partially explaining differences among individuals in their degree of susceptibility to aerophagia (Ergun et al., 1993). The neurophysiological mechanism underlying swallowing is not yet completely understood. It is speculated that reflex swallowing is elicited by sensory input from the pharynx or larynx, being mediated via bilateral swallowing centers in the reticular formation of the medulla. In addition, the hypothalamus and limbic system have been shown to initiate or modify swallowing (Fonagy & Calloway, 1986). The possible involvement of limbic structures may account for the hypothesized association between spontaneous swallowing and high arousal states (Maddock, Bell & Tremaine, 1949; Roth & Bockus, 1957). Normally, while humans breathe, the closure of the superior esophageal constrictor prevents air from entering the esophagus. This sphincter opens up in the act of swallowing and permits air to pass into it. From there a secondary peristaltic movement often carries a bolus of air into the stomach (Roth & Bockus, 1957). Richter (J. E., personal communication, July 1992) reports that esophageal peristaltic activity does not always occur after swallowing, but the superior and inferior esophageal sphincters do relax allowing air into the stomach, even though there is no peristaltic activity. Usually, swallowing goes without awareness, but it can become clearly discriminable to the self-observer when attention is fixed on it. Air swallowing and particularly gulping of large amounts of air, may occur as a voluntary response.

A conscious and exaggerated maneuver used to facilitate air swallowing for inducing belching consists of slightly elevating the chin and extending the neck, which straightens the esophagus and tends to hold it open while at the same time the subject makes an inspiratory effort against a closed glottis (Roth & Bockus, 1957). With this maneuver, a negative pressure of 30 to 40 mmHg is created in the esophagus and as much as 170 ml of air can be drawn into the eso-phagus; upon swallowing a peristaltic esophageal contraction sweeps all that air into the stomach. If eructation occurs, much of this air will be expelled, but there is typically some residual air that remains in the stomach (Whitehead & Schuster, 1985).

The above mentioned behavior occurs largely in two groups of patients: retarded subjects who gulp large quantities of air and then belch or regurgitate in order to get attention, and clients whose aerophagia seems to be maintained by financial rewards through disability compensation (Whitehead & Schuster, 1985).

Several studies suggest that aerophagia is common in patients with other gastrointestinal symptoms (Maddock, Bell and Tremaine, 1949). It can also occur in asymptomatic patients under stressful conditions (Roth & Bockus, 1957).

Maddock, Bell and Tremaine (1949), observed a threefold increase in the amount of air mechanically aspirated from the stomach of nervous patients during pyelography, as compared to the amount aspirated from calm patients. Another example is found in instances of an acute dilation of the stomach, which can occur in a short period (5 to 15 minutes), as patients are observed to gulp air under a variety of conditions provoking anxiety, such as some operative procedures, gastrointestinal radiographic series and ureteral catheterization (Roth & Bockus, 1957).

Aerophagia is rarely diagnosed, probably because most physicians do not recognize it as a medical problem and perhaps because most gastroenterologists ignore the normal range of swallowing. Behavioral observation during the interview is the most common method used to detect aerophagia (Whitehead & Schuster, 1985). Obviously, this method is unlikely to provide an accurate assessment of the rate of swallowing.

<u>Studies of normal swallowing rates</u>. There are several reports in the literature providing estimates of normal swallowing rates. For example, Lear, Flanagan and Moorrees (1965) reported 36.5 sw/hour (6.08 sw/10 min) in normal subjects observed while reading quietly. Calloway, Fonagy and Pounder (1982) reported a frequency of 2.3 swallows per 15 minute period (1.52 sw/10 min) in normals subjects sitting quietly and listening to random noise (See Table 1). Fonagy

and Calloway (1986) observed a swallowing frequency of approximately 2 swallows during a 10 minute pre-treatment period. A comparison of these rates shows a large variability. Large intersubject variation within studies has also been reported (see Calloway et al, 1983, Table 3).

Whitehead and Schuster (1985) state that average values for swallowing frequency under normal and stressful conditions are not known as yet because of the few studies done and the rudimentary methods that have been used.

Aerophagia and other gastrointestinal disorders. Excessive air swallowing has been reported in some patients with hiatus hernia, peptic ulceration, cholelithiasis and myocardial ischemia (Roth & Bockus, 1957). There have been reports of massive gastric dilation due to air swallowing; this led to death in one case (Hackl, 1973). Besides the anecdotal evidence and case studies just cited, there has been only one experimental study that has examined the presence of aerophagia in gastrointestinal patients. In their work, Calloway, Fonagy and Pounder (1982) found a significantly elevated swallowing rate in hiatus hernia and duodenal ulceration patients. They compared four groups: (a) 20 patients with duodenal ulceration, (b) 20 with hiatus hernia, (c) 20 dyspepsia-free dermatology outpatients, and (d) 20 dyspepsia-free hospital staff members. Swallowing was measured by means of both a mercury-loop strain gauge around the neck and a throat micro-phone. Subjects were exposed to 10 minutes of random loud noise and 5 minutes of silence. It

Table 1

Swallowing Rates Reported in the Literature

Study	Subjects	Condition	Recording period (min)	sw/hr (*M*)	sw/hr (*SD*)	sw/10 min
Lear, Flanagan & Moorrees, 1965.	Normals	Sleeping	480	7.5	3.9	1.3
	N = 15	Lying	30	31.4	15.6	5.2
		Seated + reading silently	30	36.5	13.6	6.1
	Normals	Sleeping	480	5.3	1.7	0.9
	N = 20	Eating and drinking	10-20	180.0	55.0	30.0
		Other activities	720	23.5	11.4	4.0
Calloway, Fonagy & Pounder, 1982.	Normals N = 20	Random noise	15*	9.2	--	1.5
	Hiatus hernia N = 20	"	15*	52.8	--	8.8
	Duodenal ulcer N = 20	"	15*	39.2	--	6.5

Note * = 10 minutes random noise plus 5 minutes rest.

was found that swallowing rates were 3 to 4 times higher in both groups of gastrointestinal patients than in either control group. No correlation was found between swallowing rate and age, sex, salivary output or anxiety measured by self-report and electrodermal response. Calloway et al. (1982) speculated that aerophagia may contribute to the etiology of these gastrointestinal disorders: hiatus hernia perhaps by weakening the diaphragmatic muscle through abdominal distension, and in duodenal ulceration perhaps by stimulating gastric acid secretion and facilitating reflux of acid into the duodenum and esophagus. Moreover, these authors suggested that through the passage of large amounts of air into the intestines, air swallowing may also contribute to some of the symptoms of irritable bowel syndrome (IBS), such as increased motility and/or bloating.

Findings from a recent study by Whitehead, Chami, Crowell & Schuster (1992) support the relationship between excessive swallowing and IBS. In a sample of 373 patients complaining of upper gastrointestinal symptoms, these authors found that more than half of those considered aerophagics (defined as those who swallowed more than 3 times in 4 minutes) satisfied the Manning criteria for irritable bowel syndrome. These authors attributed bloating and pain relieved by defecation to excessive amounts of gas in the GI tract and proposed aerophagia as an identifiable cause of bowel symptoms in a subset of patients usually diagnosed with IBS (Whitehead, Chami, Crowell & Schuster, 1992).

In addition, Thompson (1984) has proposed aerophagia as a contributory factor in non-ulcer dyspepsia. This author argues that the abdominal distension, belching and epigastric pain which characterize the typical post-prandial discomfort, are mainly gas-related. When aerophagia is defined only as excessive belching and abdominal distension, Talley and Phillips (1988) have found it equally common among patients with non-ulcer dyspepsia, peptic ulcer disease, and cholelithiasis.

Treatment of swallowing disorders. Swallowing disorders seem to be an ideal area for the application of behavioral interventions. Swallowing is a discrete behavior and, in addition, some disorders of swallowing appear to be associated with stress, anxiety or aversive conditioning (Whitehead & Schuster, 1985). However, behavioral techniques have rarely been used as a therapeutic approach to this class of disorders.

Dysphagia is defined as difficulty in or an inability to swallow. Its occurrence can be associated with disease, accident, physiological malformation at birth or aversive conditioning after cleft palate surgery (DiScipio & Kaslon, 1982). Significant increases in air swallowing rate have been reported in a few studies done with dysphagic patients (Haynes, 1976; Solyom & Sookman, 1980; DiScipio & Kaslor, 1982; Lamm & Greer, 1988).

Several methods have been used to treat dysphagia successfully. These include: (a) 20 sessions of frontal EMG biofeedback plus home relaxation practices in a woman suffering chronic dysphagia spastica (Haynes, 1976); (b) aversion relief therapy, using an electric shock during food consumption with two adult patients suffering "fear of choking" (Solyom & Sookman, 1980); and (c) a treatment consisting of a light touch to the posterior portion of the tongue and the positive reinforcement of the consequent swallow in the form of hugs, praises or attention from the trainer, with two one-year old babies on gastrostomy feeding since birth (Lamm & Greer, 1988).

Detection of swallows. Different swallow detection techniques have been reported in the literature. One of the more common ways of doing it has been through the recording of thyroid cartilage movement (McNally, Kelly & Ingelfinger, 1964; Lear, Flanagan & Moorrees, 1965; Lamm & Greer, 1988). McNally et al. (1964) reported that swallowing was signaled by upward movement of the thyroid cartilage, as indicated by displacement of a tambour placed over the skin in that area. Neither validation nor accuracy of the technique was reported. Lear et al. (1965) placed two parallel thin-walled rubber tubes, one above and one below the thyroid cartilage. Change in air pressure within the tubes produced a record on a polygraph strip chart. These investigators also used an auditory method for swallow detection consisting of loose attachment of a miniature hearing-aid microphone around the neck; following amplification, the characteristic clicking sound produced by swallowing could be detected from a tape recording of the session. They attempted to validate the first method by comparing pneumatic detection with simultaneous direct visualization of skin movement on the throat, reporting a 98% rate of agreement. Work done in our laboratory, however, indicates that direct visualization is an extremely inaccurate method for detecting swallows (Cook, Cuevas, McCutcheon, Whitehead & Taub, 1990, unpublished data).

More recently, Calloway, Fonagy and coworkers have also employed a technique involving simultaneous use of two recording methods: (a) An Orwood mercury-in-rubber strain gauge loop arrangement placed around the neck just above the thyroid cartilage, being the change in neck circumference recorded as a pen deflection; and (b) a low impedance throat microphone used to detect the "characteristic sound" of a swallow (Calloway et al., 1982; Calloway et al. 1983; Fonagy & Calloway, 1986). Their detection technique was validated by comparing a subject's self-reported swallows (recorded by one observer) with the records over the same period from the above mentioned methods interpreted by another observer who could not see the subject. No disagreement between the two measurement approaches was reported (Calloway, Fonagy & Pounder, 1982). A question arises, however, as to the accuracy of self-report as a means of determining the frequency of swallows precisely, as noted above.

Finally, Lamm and Greer(1988) detected swallows by observation of the upward movement of the thyroid cartilage and the disappearance of a small quantity of food placed from the mouth of the child. This technique was validated using tapes of videofluoroscopic recording of swallows during one session of treatment; videofluoroscopy and the observation of overt behavior were consistent with one another (Lamm & Greer 1988). Obviously, disappearance of food from the mouth has limited application in studies of effects of emotional state on swallowing.

In summary, a number of techniques for detecting swallows has been employed in laboratory situations. For most of the techniques some form of concurrent validation has been reported. However, the account of the validation methods has been sketchy and they do not appear to have been quantitative or carried out with respect to specific criteria. As indicated above, there is considerable question concerning the accuracy of videofluoroscopic recording and direct observation as proper techniques used for validation purposes. Moreover, there has been no use of discriminant validation, such as differentiating swallowing from similar oropharingeal functions such as phonation, yawning, coughing, as well differentiating it from tongue, head and shoulder movements. In conclusion, determination of the validity of any technique to be used for detecting swallowing is clearly of great importance as a preliminary step to conducting studies in this area.

Recently Cook, Anshasi, McCutcheon, Whitehead and Taub (1989) described development of a two-channel EMG technique for swallow detection. It is suitable for noninvasive monitoring of swallowing and has also the potential for being embodied in a miniaturized device suitable for use in 24-hour ambulatory monitoring. Their method involves recording EMG from two pairs of surface electrodes, one pair placed in the submental region below the chin and the other low on the neck. In order to obtain an algorithm that could accurately and reliably discriminate between EMG signals produced by swallows and nonswallows, this group conducted a series of studies focusing on the reliability and validity of the method. They developed a database of EMG recordings for swallows and non-swallows by asking 15 subjects to engage on instruction in different maneuvers that included: (a) dry and wet swallows, (b) loud and moderate phonation, (c) moderate and vigorous head movements, (d) tongue movements, (e) jaw clenching, (f) yawning, and (e) coughing. Each subject was given five sessions and was instructed to carry out the same maneuvers in the same order in each one of the sessions (Limdi, McCutcheon, Taub, Whitehead & Cook, 1989; Limdi, 1990). From the EMG recordings, an event onset was taken to occur when a specified change of the EMG signal (dA) happened within a certain time period (dx). Two set of values were used, for window one, $dA = 2.00\ \mu V$ and $dx = 0.05$ s; for window two, $dA = 6.00\ \mu V$ and $dx = 0.15$ s. This research group applied a series of discriminant function analyses (DFA) to this data base in order to explore the possibility of obtaining greater detection accuracy than using sets of logical rules based upon six different EMG parameters (Cook, Cuevas, McCutcheon, Whitehead & Taub, 1990). Using these EMG parameters several preliminary

DFAs were performed and those parameters which were redundant ($r > .90$) were eliminated. The final set of 6 parameters were: absolute amplitude at the low neck electrode location, absolute amplitude-submental placement, relative amplitude-submental placement using window one, relative amplitude-low neck placement using window two and temporal asynchrony of onset of response at the two electrode placements using window two. Between seven and thirteen alternative values for each parameter were explored in all possible combinations with each other. The analysis was done in a stepwise fashion, after each "search", those parameter values that yielded more accurate detection were retained, and the others were eliminated. The best algorithm yielded hit and false positive rates of 92.83% and 5.24%, respectively (Cook, Cuevas, McCutcheon, Whitehead & Taub, 1990).

A subsequent study was conducted by the same research group to determine the validity of the two-channel EMG detection technique. This was done by correlating the frequency and time of occurrence of swallows identified by this technique and swallows identified by examination of concurrent videotaped records of the movement of the thyroid cartilage. Normal subjects were asked to carry out the following activities: (a) Reading silently from an academic text, (b) reading aloud from the same academic text, and (c) difficult mental arithmetic operations made more stressful by error correction and instruction to proceed more rapidly. Each phase lasted 10 minutes and two orders of conditions were used during a session. Although data analysis is still in progress, preliminary inspection indicated that, surprisingly, swallowing rate was not different across conditions and, in general, it was higher than the average rate reported in the literature. The lack of difference between the high arousal and the two presumably low arousal conditions could be explained by the generally stressful nature of the validation technique used. To obtain a clear image of the neck area, subjects were asked to maintain an unnatural posture (chin up), to restrict their movements and to observe themselves on a video monitor (to keep their image on screen) under bright illumination. After a preliminary data analysis, it was speculated that this might have imparted a strong stressful element to the experimental situation that overrode any difference in arousal produced by the different conditions. A further factor tending to inflate swallowing rates could have been that overt verbalization while reading aloud and subvocal verbalization while reading silently, resulted in an increase in swallowing above normal resting rates.

To test this possibility, an extension of this study focused on the effects of more relaxed surroundings on swallowing rate. The two trainers in this experiment spent 10 to 15 minutes before each session establishing rapport with the subjects and making them feel at ease. A strong emphasis was placed on maintaining a relaxed and informal atmosphere throughout the session. In addition, videotaping with the prolonged maintenance of body position, bright lights and self-observation on video monitor were eliminated. Using the same two-channel EMG detection technique as employed before plus direct visual detection of swallows, 10 subjects were asked to carry out the following activities: (a) sitting quietly, (b) listening to music self-chosen from among a set of non-arousing selections, (c) reading silently from a self-selected textbook and, (d) mental arithmetic with negative feedback. Each condition lasted 10 minutes. Preliminary data analysis has been done using the swallowing rates obtained through visual observation. As indicated in Table 2, both sitting quietly and listening to music had lower swallowing rates (4.3 sw/10 min. and 3.6 sw/10 min., respectively) than activities involving a higher level of arousal, such as reading silently and reading aloud (6.0 sw/10 min. and 10.1 sw/10 min., respectively; data for mental arithmetic is not yet available). As expected, by providing a more relaxed environment, the mean rate of swallowing during the reading silently condition was half the rate observed during the same procedure in the previous study (6.0 sw/10 min. vs. 13.9 sw/10 min., respectively); but mean swallowing rate for reading silently in this study was higher than sitting quietly (6.0 vs. 4.3 sw/10 min.). As noted before, the latter could be due to subvocal verbalization during the reading silently condition, which might be expected to increase swallowing rate. This finding revealed that any activity involving subvocal verbalization, such as reading silently or mental arithmetic, could increase swallowing rate independently of arousal level.

In general, these results suggested that arousal level, as reflected in the different experimental conditions, can have a marked effect on swallowing rate. Consequently, this experiment thus provided useful pilot data and preliminary support for the first hypothesis explored by this group in a subsequent experiment (Cuevas, Cook, Richter, McCutcheon & Taub, 1994).

Previous Studies on Swallowing Rate and Arousal Level

Calloway, Fonagy and Pounder (1982) found that patients with hiatus hernia and duodenal ulcer have a significantly higher swallowing rate than unaffected persons under experimentally induced stress (See Table 1). In this study, 20 patients with hiatus hernia, 20 with duodenal ulceration, 20 dyspepsia-free dermatological outpatients and 20 dyspepsia-free hospital staff members were exposed to 10 minutes of loud random noise and 5 minutes of silence. The authors found that swallowing rate was 3 to 4 times higher during the noise stress period in both groups of patients with gastrointestinal symptoms than in either control group. They did not find any correlation between swallowing rate and salivary output or anxiety measured by self-report and electrodermal response. Some of the strengths of the study were: (a) Use of hospital patients and staff members as controls, (b) measures of salivary output to control for the confounding possibility that increases in salivation were producing increases in swallowing, and (c) use of a self-report questionnaire and skin conductance levels to measure anxiety as a manipulation check.

Table 2

Swallowing Rates in the Validity Study

Subjects	Activity	Recording period (min)	sw/10 min ($\underline{M}$)	sw/10 min ($\underline{SD}$)
		Under original conditions		
Normals	Reading silently	20	13.96	7.18
N = 13	Reading aloud	20	13.57	6.20
	Mathematics	20	14.23	9.64
		Under modified conditions		
Normals	Sitting quietly	10	4.3	2.36
N = 10	Listening to music	10	3.6	1.89
	Reading silently	10	6.0	2.98
	Reading aloud	10	10.1	5.40

their detection technique was validated using only self-report of swallows as the criterion, however, subjects can swallow without noticing it. Second, swallowing rates were reported for a 15-minute period that included 10 minutes of noise exposure plus 5 minutes of silence; they were not reported for each period separately. Third, the stressor did not affect either the self-report level of anxiety or the electrodermal response recordings; this casted some doubt on the stressful effect of their ex-perimental manipulation. Fourth, they used only one passive stressor administered for a brief period of time (10 minutes). This was a short time for a function that has such a low frequency as swallowing, minimizing the potential effect of the manipulation due to the reduced recording period.

In a subsequent study, Calloway, Fonagy, Pounder and Morgan (1983) found evidence supporting the belief that a reduction in swallowing rate is associated with a significant decrement in symptomatology, at least among hiatus hernia patients (See Table 3). They treated 12 cases in which aerophagia had been demonstrated, half using relaxation training with GSR biofeedback, and half using auditory feedback of their swallowing with self-monitoring to detect cognitive and situational antecedents. Three 45-minute training sessions were employed at approximately weekly intervals and twice daily practice of these techniques was requested. At pre-treatment, post-treatment and nine months after the end of treatment, swallowing rate and electroder mal response levels were measured and the severity of symptoms was assessed by a consulting physician using a three-category scale (improved, same or worse). In the relaxation training treatment group, only 2 patients achieved significant decrements in swallowing rate at post-treatment. However, in the swallowing feedback group, 4 out of 6 exhibited significant decreases in swallowing. At follow-up, improvement was maintained in only 50% of those patients who had initially shown swallowing decreases. However, there were several serious weaknesses in this study. First, the authors used very small sample sizes in both groups, six subjects, and did not specify how the presence of aerophagia was determined. They also had a high dropout rate in the first group (two patients) at post-treatment and consequently a reduced sample at follow-up. Second, home practice amount and quality were not determined for either treatment modality. Third, a weak clinical outcome measure was employed: physician rating of the level of symptoms, with only three very broad categories. Fourth, the change in swallowing rate and symptoms was maintained at follow-up only in half of the subjects showing initial improvement. Fifth, no attention/placebo control was used, a very important consideration as Whitehead's work (W. E., personal communica-tion, March 1991) has shown.

In the most recent study carried out by the group including Fonagy and Calloway (1986), confirmatory evidence was found for previous anecdotal reports of elevated swal-lowing rates associated with emotional arousal in normal subjects (See Table 3). They exposed 14 dyspepsia-free subjects to 10 minutes of experimental arousal interventions consisting of difficult intellectual problems or a Velten-type mood-induction technique. The problems used as stressors included arithmetic operations, word association and digit symbol substitution. Swallowing rate, salivary output and skin conductance levels were measured during a 10-minute baseline period and a 10-minute arousal manipulation period. The order of presentation of type of stressor (mood-induction and intellectual) was counterbalanced. Both types of stressor had a comparable effect in increasing swallowing significantly above the initial baseline rate. Salivary production was not changed by the experimental manipulations, but skin conductance levels almost doubled with respect to an initial rest period. There were large individual differences in swallowing rate changes in response to stress.

This study was conducted more rigorously than the previous ones by this group. A larger sample of subjects was employed for the different conditions. Changes in both self-report measures of stressor-induced emotional changes and skin conductance levels were found to correlate with the arousal manipulation used. In addition, salivation was again excluded as a possible confounding factor by an appropriate procedure. However, there were several methodological weaknesses. First, the investigators used a short baseline (10 minutes) and a short exposure to the stressors (10 minutes). Second, the mood induction technique was partially self-induced (thoughts about a recent related experience); it was, therefore, not experimentally well controlled. Third, they used a swallowing detection technique that, as noted before (see section on swallowing detection), had weak validation and no proven accuracy. Fourth, only high levels of arousal were explored; low and a neutral levels were not studied. A wider range of conditions could have shown the relationship between psychophysiological arousal and swallowing rate more clearly.

A recent study (Cuevas, Cook, Richter, McCutcheon & Taub, 1994) corrected most of the above mentioned shortcomings. These researchers: (a) used an accurate, recently developed

Table 3

Swallowing Rate Changes Induced by Different Methods

Study	Type of subjects	Condition	Recording period (min)	sw/hr (*M*)	sw/10 min (*M*)
Calloway et al., 1983.	Hiatus hernia.	Baseline	20	37.0	6.2
	N = 6	Relaxation[a]	20	28.7	4.8
	Hiatus hernia or aerophagia	Baseline	20	68.0	11.4
	N = 6	Biofeedback[b]	20	21.5	3.6
Fonagy and Calloway, 1986.	Normals	Baseline 1	10	17.6	1.8
		Arithmetic stressor	10	37.7	3.5
		Baseline 2	10	27.4	2.5
		Baseline 1	10	18.0	2.2
		Depression induction	10	30.5	3.1
		Baseline 2	10	24.4	3.4

Note: [a] GSR and PMR relaxation twice daily.
[b] Auditory feedback from swallows and self-monitoring

two-channel EMG swallow detection technique with an empirically determined hit and false positive rate; (b) investigated the effects of the whole spectrum of arousal levels on swallowing frequency (low, neutral and high); (c) used longer measurement intervals more suitable for a relatively low frequency event such as swallowing, (d) used arousal manipulations of documented effectiveness, and (e) employed several verbal and physiological indices as manipulation checks. Participants were 18 male and 20 female undergraduates assigned in a fixed irregular order to one of three arousal conditions (low, neutral or high). Subjects assigned to each condition were matched for gender and level of gastrointestinal symptomatology. Each experimental session was divided into a 30-minute neutral baseline period and a 30-minute arousal manipulation period. The low arousal condition involved four sessions of exposure to a cascaded series of relaxation-inducing procedures (EMG biofeedback was the main one). The neutral arousal condition consisted of two 15-minute subperiods, one each of viewing slides and listening to music, both previously rated by a panel of 40 judges as neutral. The high arousal condition involved sequential exposure for 15 minutes each to two stressors: slides previously rated by a panel of 20 judges as very unpleasant and arousing (e.g., burn and injury victims) and an auditory discrimination task that was both difficult and involved bursts of loud white noise (from 95 to 105 dB). Swallowing rate was measured during baseline and during all experimental periods. In addition, forehead and forearm EMG, heart rate and electrodermal response were measured as well as self-report of psychological arousal; these served as experimental manipulation checks. Mean values of all measures during the neutral baseline period were used as covariates to statistically remove the effect of pre-existing individual differences (mean swallowing rate during neutral baseline was 5.20 sw/10 min).

The main finding of this study was the existence of a large positive linear relationship between swallowing rate and emotional arousal level. An analysis of covariance revealed a significant main effect of arousal condition on swallowing rate, (F = 7.92, p <.01). Planned comparisons showed that during the arousal manipulation period, mean swallowing rate increased in a monotonic fashion from the low to the neutral arousal condition, and from the neutral to the high arousal condition (2.64, 4.84 and 7.83 sw/10 minutes, respectively). The effectiveness of the arousal manipulations was supported by the fact that most of the physiological and both of the verbal manipulation checks of arousal level varied appropriately with the experimental manipulations.

In the low arousal condition, there was a progressive decrement in swallowing rate across the four sessions (2.63, 2.52, 2.21, and 1.93 sw/10 min., respectively). However, a trend analysis yielded neither a significant linear or quadratic trend across sessions. In this regard, it should be noted that both forehead and forearm average EMG levels were quite low as early as the first session of training (M = 2.12

μV and 1.37 μV, respectively). These low values may therefore have constituted a floor below which further substantial decreases in subsequent sessions would have been difficult.

In summary, some tentative conclusions can be drawn from the available literature concerning the effect of arousal on swallowing rate:

1. There is anecdotal, clinical and some experimental evidence that swallowing rate is related to arousal states. However, this information comes from only a few studies and further experimental evidence would be valuable (See Table 3).

2. There is large between-subject variability in swallowing rate during rest and in reaction to experimental manipulations of arousal (See Tables 1 and 3).

3. The preliminary evidence suggests that it may be possible to increase or decrease swallowing rate through behavioral training, though a conclusive answer awaits the conduct of controlled studies.

4. There is little data available concerning the average rate of swallowing during different types of activities. Obtaining such data could be helpful for diagnostic and experimental purposes regarding the etiology and course of functional gastrointestinal disorders.

5. Work from our laboratory suggests that the methods employed in the past for detecting the frequency of swallowing may be inaccurate. The two-location EMG technique would appear to constitute a promising start in correcting this problem.

<u>Summary of the Research Plan</u>

Preliminary evidence suggested that swallowing rate increases under aversive high arousal conditions (Maddock, Bell & Tremaine, 1949; Roth & Bockus, 1957; Calloway et al., 1982, 1986; Cuevas et al., 1994) and also decreases under a pleasant low arousal condition (Cuevas et al., 1994). Similarly, there is preliminary evidence that increases in swallowing rate are larger among subjects with gastrointestinal symptomatology than among asymptomatics ones, under stressful circumstances (Calloway, Fonagy & Pounder, 1982). These considerations led to the following experimental questions:

1) Can the effect of emotional state on swallowing rate be replicated using a within-subject experimental design in which each subject will be exposed to each arousal condition rather than the less powerful between-subjects design employed previously (Cuevas et al., 1994)?

2) Does the effect of emotional state on swallowing rate and self-report of gastrointestinal symptomatology interact significantly with level of gastrointestinal symptomatology?

3) Is the effect of emotional state on swallowing rate different between subjects with predominantly upper gastrointestinal symptomatology and subjects with predominantly lower symptomatology?

In the absence of prior data on differential effects of type of gastrointestinal symptomatology, no specific predictions were made regarding this experimental question.

Main hypotheses. 1) There is a significant effect of emotional arousal manipulation on swallowing rate using a within-subject design. It was expected that a subject would exhibit a significantly higher swallowing rate under an aversive high arousal condition than under a pleasant low arousal condition.

2) There is a significant interaction between emotional state and levels of gastrointestinal symptomatology on swallowing rate. It was expected that swallowing rate change would be larger among subjects with high levels of gastrointestinal symptomatology than in asymptomatics (main contrast).

3) There is a significant interaction between level of emotional arousal and self-report of gastrointestinal symptomatology. It was expected that self-report of change in gastrointestinal symptomatology would be larger among subjects with high levels of gastrointestinal symptomatology than in asymptomatics (main contrast).

Overview of the experiment. Several improvements to the methodology used in the previous research (Fonagy, Calloway & Morgan, 1986; Calloway & Fonagy, 1983), were included in the present work. These were: (a) use of an accurate swallow detection technique with empirically identified hit and false positive rates, (b) use of a half-hour measurement interval, which is more appropriate than the previously used 10-minute period, for a low frequency event such as swallowing, (c) use of several arousal manipulations of documented effectiveness to prevent habituation; (d) reduction in the potential confound of verbal subvocalization (which may increase swallowing rate); and (e) use of a variety of objective and subjective indices of arousal as manipulation checks. A review of the literature on arousal manipulation methods aided in the selection of experimental stressors used to elicit aversive high arousal and techniques utilized to induce pleasant low arousal. The criteria employed were that the techniques: (a) engage experimental subjects actively, (b) involve minimal motoric activity, and (c) reliably affect the physiological and subjective measures used in this study in the intended direction (See Appendix A).

In addition, all subjects were exposed to both arousal manipulations (low and high), in a counterbalanced order. This type of experimental design was included to determine whether previous observations made by Cuevas et al. (1994) while exposing individual subjects to either a low or a high arousal manipulation could be reproduced using a more powerful within-subject design where the subjects are exposed to both of the conditions at different times.

In summary the experimental questions in this study were whether the effect of emotional arousal on spontaneous swallowing rate could be replicated and whether this effect differed with both level (presence vs. absence) and type (irritable bowel syndrome vs. functional dyspepsia) of gastrointestinal symptomatology.

Method

Subjects

Subjects were 49 adults selected for presence of either of two functional gastrointestinal disorders (irritable bowel syndrome or functional dyspepsia; *n*=32) or the absence of both disorders (*n*=17). The larger number of symptomatic subjects represented an attempt to develop distinct subgroups. For selection and classification purposes, all potential subjects completed an adaptation of the gastrointestinal symptom questionnaire of Whitehead, Bosmajian, Zonderman, Costa and Schuster (1988) (see Appendix C).

Symptomatic subjects were recruited from patients at a Family Medicine Clinic affiliated with the University of Alabama at Birmingham (UAB), from undergraduates who were fulfilling an introductory psychology course requirement and from members of the UAB community contacted through a student newspaper advertisement. Based on questionnaire responses, the functional dyspepsia (FD) subgroup (*n*=7) was defined as those reporting postprandial pain and/or bloating, associated with either indigestion, heartburn, belching of acid into mouth or excessive belching of gas, as suggested by the Rome Criteria (Drossman et al., 1990). The irritable bowel syndrome (IBS) subgroup (*n*=11) was defined as those reporting relief of pain after a bowel movement and/or more frequent bowel movements with onset of pain, associated with either bloating, passage of mucus by rectum, loose bowel movements with onset of pain or feelings of incomplete evacuation after a bowel movement as proposed by Manning, Thompson, Heaton & Morris, 1978). An additional 14 subjects had overlapping symptomatology. The symptomatic group was further restricted to those who had consulted a physician due to their gastrointestinal symptoms during the last 24 months. Since our interest was in functional gastrointestinal disorders, we excluded subjects with a history of organic gastrointestinal disorders (e.g., ulcerative colitis, Crohn's disease, ulcerative proctitis, gastric or duodenal ulcer, lactose intolerance). This information was obtained from the subjects during the telephone interview and confirmed by medical chart review in 18 of them. The final symptomatic group consisted of 7 undergraduates recruited from introductory psychology, 14 persons recruited through advertisement (including 9 additional undergraduates), and 11 patients from the Family Medicine Clinic. Overall, symptomatic subjects reported an average of 8.0 symptoms (SD = 3.0) on the Whitehead et al. (1988) questionnaire, and had consulted a physician for a mean of 3.0 symptoms (SD = 2.16).

Subjects who did not report any gastrointestinal symptoms on the questionnaire were considered eligible for the asymptomatic group. Each of these subjects was selected and recruited from the introductory psychology course to match a member of the symptomatic group on gender and age (within a 5-year range). Due to a larger number of female symptomatic subjects, matching of asymptomatic subjects resulted in an uneven gender distribution for the total sample.

Exclusionary criteria for both groups included factors considered likely to affect spontaneous swallowing rate and/or level of arousal: current psychotropic or gastrointestinal medication; and excessive consumption of alcohol, tobacco, or caffeinated beverages. Participation rate for remaining candidate subjects was 75%. After recruitment, a total of four subjects (2 asymptomatics and 2 symptomatics) were excluded from the study due to instrumentation breakdown or failure to return for a second session. The final sample included 37 females and 12 males, between 18-49 years of age ($M = 26.6$, $SD = 7.62$). There were no statistically reliable differences between symptomatics and asymptomatics in age, gender, height or weight (all $ps > .20$). All subjects received either credit toward a psychology research requirement or monetary compensation ($ 5.0 hr, $10 per each session) for their participation.

Measures

Submental and low neck EMG levels were recorded for swallow detection purposes (Cook et al., 1989). EMG was recorded from the forehead and lateral aspect of the forearm of the dominant arm as an indicator of general muscle tension and as the basis for biofeedback relaxation training. Heart rate and skin conductance levels (SCL) were also recorded.

Self-report of pleasantness-unpleasantness and emotional arousal were obtained using a variant of the semantic differential questionnaire of Mehrabian & Russell (1974). This measure consisted of a visual scale from 0 to 10, where zero represented either feeling "an extremely pleasant experience" or "absolutely relaxed" and ten represented feeling "an absolutely unhappy experience" or "absolutely, completely aroused or excited"

In addition, subjects reported perceived changes in gastrointestinal and stress or tension-related symptoms on a checklist, composed of 20 items (5 gastrointestinal-related, 15 tension-related). The gastrointestinal symptoms were: abdominal pain, indigestion or heartburn, visible distension of abdomen, belching of gas, and belching acid into mouth. Examples of stress or tension-related symptoms were: tension in forehead, heart beating, clenched jaw, feeling sweaty palms, feeling tension in upper back and neck, etc.
Subjects indicated whether a particular symptom increased, decreased or remained unchanged in comparison with the baseline period. The resulting summary score was the difference between the number of each type of symptoms that increased and the number of that type of symptoms that decreased, divided by the total of that type of symptoms on the checklist. This transformed both the measures of gastrointestinal and tension-related symptoms to the same scale, for comparative purposes. Copies of all self-report measures are presented in appendices C, D and F.

Apparatus and Physiological Recordings

For swallowing detection, EMG recordings from the submental and low neck areas were obtained using J & J (Poulsbo, WA) SE-40 Ag/AgCl electrodes. Surface electrodes were placed by using hard tissue landmarks adjacent to the neck. Following the technique developed by Cook, Anshasi, McCutcheon, Whitehead & Taub (1989), the upper landmarks were the intertragic notches of the pinnas of the two ears and the lower landmark was the sternal notch. These three landmarks defined a "V" along the sides of which distances were measured using an elastic tape divided into 10 equal spaces. Use of an elastic tape provided an adjustable measuring tool that enabled proportionally similar distances to be measured on necks of different sizes. The submental (SM) placements were determined by first locating points at 70% of the distance from the sternal notch to the intertragic notch on both sides of the neck and then placing electrodes at points on the diagonals intersecting an imaginary line connecting these two points. This location was approximately 2.0 cm above the thyroid cartilage and the distance from center to center of the electrodes was approximately 4.5 cm. The low neck (LN) placements were located directly on the sternal-intertragic notch diagonal lines, 20% above the sternal notch. Ground was located at the midline, 1 cm below the LN placement (see Appendix B). J & J Enterprises M-501 EMG amplifiers were used to amplify the EMG signals, filter them for 100-200 Hz activity and integrate them with a 220 ms time constant.

For the physiological manipulation checks and non-swallow-related biofeedback, Med Associates Ag/AgCl electrodes were used. For EMG, electrodes were placed at the standard forehead sites (Carlson, Basilio & Heaukulani, 1983), and 5 cm apart from one another on the middle third of the lateral aspect of the forearm. For SCL, electrodes were located on the thenar and hypothenar eminences of the nondominant hand. For heart rate detection, electrodes were placed at a left lower anterolateral position on the chest and close to the right collar bone. Coulbourn Instruments (Lehigh Valley, PA) modules amplified and filtered these signals.

Output from all amplifiers was fed to a Scientific Solutions Labmaster analog-to-digital converter installed in a PC/AT microcomputer. A computer program (Cook, Atkinson & Lang, 1987) was used to regulate the order and timing of experimental segments, average EMG signals, sample psychophysiological responses, and control additional Coulbourn modules that provided auditory information for the EMG biofeedback and noise discrimination tasks. A computer-controlled videocassette recorder (NEC PC-VCR) was used to present music and pictures to the subject in the neutral and aversive high arousal conditions.

<u>Procedure</u>

Potential subjects were contacted by phone and invited to participate in a two-session laboratory study of general physiological changes in relation to different types of activities; swallowing was not referred to specifically. The commitment to participate in two experimental sessions was emphasized and no specific information about the order of the sessions was given to the participants in advance.

Prior to sessions, subjects were asked to refrain from drinking alcohol or any caffeinated beverage for 24 and 2 hours, respectively, to avoid chemically-induced arousal changes. This precaution has been taken in several previous experiments involving alteration of arousal levels (Fridlund, Cottam, & Fowler, 1975; Turner & Carroll, 1985; Lovallo, Wilson, Pincomb, Edwards, Tompkins, & Brackett, 1985). The few subjects who smoked were asked not to do so for at least one hour before each session.

At the beginning of each session, electrodes were attached for physiological recording. Sites for EMG and EKG recording were cleaned with alcohol, and the skin surface was abraded with Omni Prep (Aurora, CO); sites for SCL recording were cleaned with distilled water.

Each session consisted of a neutral baseline followed by either an aversive high arousal manipulation or a pleasant low arousal manipulation. Each subject participated in both types of sessions (baseline-high arousal and baseline-low arousal), with the ordering of sessions approximately counterbalanced across subjects within level of symptomatology.

The baseline consisted of two 15-min periods separated by a 2-min break. During the first period, subjects viewed still pictures presented on a video monitor. Each picture was shown for 12 s followed by a blank screen for 6 s. During the second period, subjects listened to a series of musical segments, 2- to 3-min long. Both the pictures and music had been pre-viously rated as neutral by a panel of 40 judges and by sub-jects who participated in a similar experiment (Cuevas et al., 1994). Subjects were instructed to press a button every time a new picture was shown or a musical segment began, and to press a different button every time the screen went blank or the music stopped. The purpose of this procedure was to maintain subjects' alertness while minimizing movement and phonation, thereby reducing possible effects on heart rate due to large muscle involvements and eliminating a possible artifactual increase in swallowing due to subvocal verbalization. After the neutral baseline period, subjects completed the self-report measures of emotional arousal and pleasantness-unpleasantness of the experience.

The aversive high arousal condition consisted of the sequential presentation of two experimental stressors during 15-min periods separated by a two-min. time out period. The stressors were: exposure to aversive visual material and a difficult discrimination task between loud white noises. For the aversive visual task, pictures that were previously rated as highly aversive were presented for 12 s each, separated by an 8-s intertrial interval. Subjects were instructed to watch each picture closely; to ensure that they had done so, an audiotaped statement about the picture was presented during the intertrial interval, and subjects were requested to indicate whether this statement was true or false by pressing one of two buttons. The response component was included to prevent subjects from simply looking away from the aversive pictures or avoiding their disturbing details. For the noise task, subjects made difficult intensity or duration comparisons between sequential pairs of loud (80-105 dB) white noises. Subjects compared the duration or intensity of each new noise with that of the immediately preceding one; thus, the standard for comparison kept changing from trial to trial. Subjects responded via pushbuttons and were given feedback regarding the correctness of their choice through a message on the video screen. To increase the aversiveness of the task, there was time pressure (only 3 s/response) and a curt "Wrong" spoken over the intercom for every other incorrect response. In addition, the differences between the presented stimuli were small (between 10-20%), increasing the task difficulty.

The pleasant low arousal condition included a cascaded sequence of techniques documented to be effective for producing relaxation: abdominal breathing (Fried, 1987; Poppen, 1988; Stoyva & House, 1990), a shortened version of progressive muscular relaxation, including tense-relax and "letting go" phases (Goldfried & Davidson, 1976; Rimm & Masters, 1979), and multisite auditory EMG biofeedback (Shirley, Burish, & Rowe, 1982; Carlson, 1989) averaged over two sites (forehead and lateral aspect of forearm). Diaphragmatic breathing was modeled briefly and subjects practiced it while their technique was observed and corrected. After they had mastered the technique, they were requested to breathe "as slowly and deeply as you feel comfortable with" for 5 min. For progressive relaxation training, subjects were first instructed to tense (10 s) and relax (20 s) hand, arm and facial muscle groups separately for approximately 7 minutes. They were then instructed to "let the tension go" from the body's main muscle groups in a guided sequence for an additional 10 minutes. Finally, during multisite EMG auditory biofeedback, subjects listened to a signal whose pitch was directly related to the average level of muscle tension at the two recording sites during a 30-minute period; they were instructed to use the pitch of the tone, as well as the previously instructed abdominal breathing technique, to lower their muscle tension and deepen their level of relaxation. Because instruction in the various techniques involved training and interaction with the experimenter, recording of swallowing was restricted to the final 30-min biofeedback period, comparable to the same data collection interval during the high arousal condition. Preliminary observations indicated that muscle activity involved in swallowing spuriously increased forehead EMG levels. To avoid this potential confound from influencing the biofeedback signals, whenever EMG levels in the SM channel increased above 20 μV, modifications to the pitch of the feedback signal were suspended for a 3-s period.

At the end of each of the arousal manipulation periods (pleasant low arousal or aversive high arousal) subjects completed the checklist of perceived changes in tension- and gastrointestinal-related symptoms (See measures). They also again completed the self-report measure of arousal and pleasantness-unpleasantness. All procedures in this study were approved by the Institutional Review Board for Human Use of this university and all subjects gave informed consent prior to participation.

Data Reduction

Mean swallowing rates were detected offline from the recordings of submental and low neck EMG channels, using the methodology developed in our laboratory by Cook, Cuevas, McCutcheon, Whitehead and Taub (1990). The digitized EMG record was scanned by computer for an event onset, defined as an increase of 2 μV or more within .05 s. Once an event was detected, a set of 6 parameters was calculated and an algorithm based on these parameters was used to classify the event as either a swallow or a non-swallow. In an initial validation study, the algorithm for detecting swallows and differentiating them from other maneuvers had hit and false positive rates of approximately 93% and 5%, respectively (Cook et al., 1990). Swallow frequency was expressed as the mean number of swallows per 30 minute period.

Cardiac interbeat intervals were converted offline to rate-per-minute format, with each interval weighted proportionally to the period of time that it occupied (Graham, 1978). Mean heart rate, SCL and forearm and forehead EMG levels were computed for neutral baseline and emotional arousal manipulation periods of each session (30 min each).

Data Analysis

Baseline measures (swallowing rate, and the verbal and physiological manipulation checks) were analyzed first, using univariate and multivariate analyses of variance, to examine possible differences in tonic swallowing rate related to level of symptomatology, to select the proper covariate(s) for the main analyses of responses to arousal manipulations, and to test for possible carryover effects. For the main dependent variable (swallowing rate) there were no significant preexisting differences related to level of symptomatology (symptomatics vs. asymptomatics), gender, or order of arousal manipulation (low-high vs. high-low), all $ps > .23$. The presence of possible carryover effects was examined by analyzing the interaction between order and session type (pleasant low arousal vs. aversive high arousal). Neither for swallowing rate nor for any of the other measures was this interaction significant, all $ps > .12$. Consequently, since no preexisting group differences or carryover effects were found, the individual session baselines were used as covariates in the main analyses of responses to the arousal manipulations. In addition, since there was no evidence of carry-over effects, order of arousal manipulations was excluded from the main analyses.

Univariate and multivariate analyses of covariance (ANCOVAs and MANCOVAs) were used to test the hypotheses regarding the effect of the arousal manipulations on the symptomatology groups. For the analysis of the main dependent variable (swallowing rate), level of symptomatology (symptomatic vs. asymptomatic) was the main between-subjects contrast, and type of gastrointestinal symptomatology (functional dyspepsia vs. irritable bowel syndrome) was a secondary contrast. Gender (male vs. female) was an additional between-subjects factor. Arousal manipulation (pleasant low vs. aversive high) was the only within-subject factor. The analysis included all possible two- and three-way interactions between factors and contrasts except for the interaction of gender with type of gastrointestinal symptomatology, due to small number of subjects with exclusively FD or IBS symptomatology.

Similar MANCOVAs were used for verbal (emotional arousal and pleasantness-unpleasantness) and physiological (forehead and forearm EMG, heart rate and skin conductance) manipulation checks. A parallel MANOVA was used for the analysis of self-reported symptom (gastrointestinal- and tension-related) data.

Neither the contrast between FD and IBS group nor the interaction between this additional contrast and arousal manipulation had a significant effect on swallowing rate ($ps > .49$), perhaps due to small cell sizes for pure FD and IBS groups. Results related to this secondary contrast will therefore not be reported further in the interest of brevity.

Results

Neutral Baseline Period

Table 4 presents a summary of baseline values for all measures before each arousal manipulation period (pleasant low and aversive high arousal). During the neutral baseline periods, no significant differences in swallowing rate or self-report manipulation checks (pleasantness-unpleasantness and emotional arousal ratings) were found between genders, groups (symptomatic vs. asymptomatics), orders (low-high vs. high-low) or session types (pleasant low arousal vs. aversive high arousal); all $\underline{p}$s $> .22$. In addition, no significant two- or three-way interactions involving these factors were found; all $\underline{p}$s $> .10$. Regarding the physiological manipulation checks (forehead and forearm EMG, heart rate and skin conductance) a significant multivariate effect for gender was found, $\underline{F}$ (4, 38) = 9.75, $\underline{p} < .00005$. As in Cuevas et al. (1994), univariate tests on individual measures indicated that baseline forehead EMG was higher for females than for males (5.42 vs. 3.21 μV) whereas baseline skin conductance was higher for males (6.48 vs. 3.40 μS), $\underline{F}$s (1, 41) = 12.13 and 18.30, $\underline{p}$s $< .001$ and .001, respectively. However, paralleling the findings for swallowing rate, gender did not interact with symptomatology group, order or session type, all $\underline{p}$s $> .15$.

Table 4

Neutral Baseline Values for Swallowing Rate and all Manipulation Checks before High-and Low-arousal Sessions

Measure	Session type: Low arousal	Session type: High arousal
Swallowing rate	17.2 ± 1.6	17.7 ± 2.3
Arousal ratings	3.6 ± 0.2	3.4 ± 0.2
Unpleasantness	4.5 ± 0.2	4.6 ± 0.2
Forehead EMG	4.8 ± 0.3	4.9 ± 0.4
Forearm EMG	2.9 ± 0.3	2.6 ± 0.2
Heart rate	73.9 ± 1.3	72.9 ± 1.5
Skin conductance	3.8 ± 0.4	4.3 ± 0.5

Note: Table entries are means ± standard errors.

Arousal Manipulation Periods

Swallowing rate. Figure 1 shows the mean swallowing rates across all subjects for the baseline period and for the pleasant low arousal and aversive high arousal conditions. As expected, swallowing rate was markedly lower during the relaxation period than during the aversive high arousal period (*Ms* = 7.53 ± 1.05 (SEs) vs. 20.14 ± 2.03 swallows/30 min., respectively). The reliability of this difference between the pleasant low arousal and the aversive high arousal conditions was supported by the overall ANCOVA, F (1, 43) = 31.53, $p <$ .00005.

The hypothesized interaction between the affect manipulation and the contrast between symptomatics and asymptomatic subjects did not achieve statistical significance, (*F* (1, 43) = 2.31, *p* = .14). However, when mean swallowing rates among symptomatics (*M*s = 6.28 ± 1.1, and 20.88 ± 2.6 swallows/30 minutes, for low and high respectively) were compared with those among asymptomatic subjects (*M*s = 9.88 ± 2.2, and 18.76 ± 3.3 swallows/30 minutes, for low and high respectively) these values suggested a trend. As shown in Figure 2, although the effect of the arousal manipulation on swallowing rate was reliable for both groups of subjects, it was more pronounced for the symptomatic than for the asymptomatic subjects, *F*s (1, 44) = 27.61 and 5.01, respectively, *p*s < .03.

As expected, there were no statistically significant effects involving gender in the analysis of swallowing rate data, all *p*s > .36.

Verbal manipulation checks. During the arousal manipulation, all verbal measures showed the expected pattern. Subjective ratings of emotional response differed significantly between the relaxation and aversive high arousal conditions, multivariate *F* (2, 41) = 140.14, *p* < .00005. As anticipated, the aversive high arousal period was rated as more arousing than the relaxation period *F* (1, 42) = 286.87, *p* < .00005, (see Figure 3, panel a); in addition, the aversive high arousal condition was rated in the unpleasant part of the scale, whereas the relaxation condition was rated in the pleasant end of the respective scale, *F* (1, 42) = 118.38, *p* < .00005, (Figure 3b).

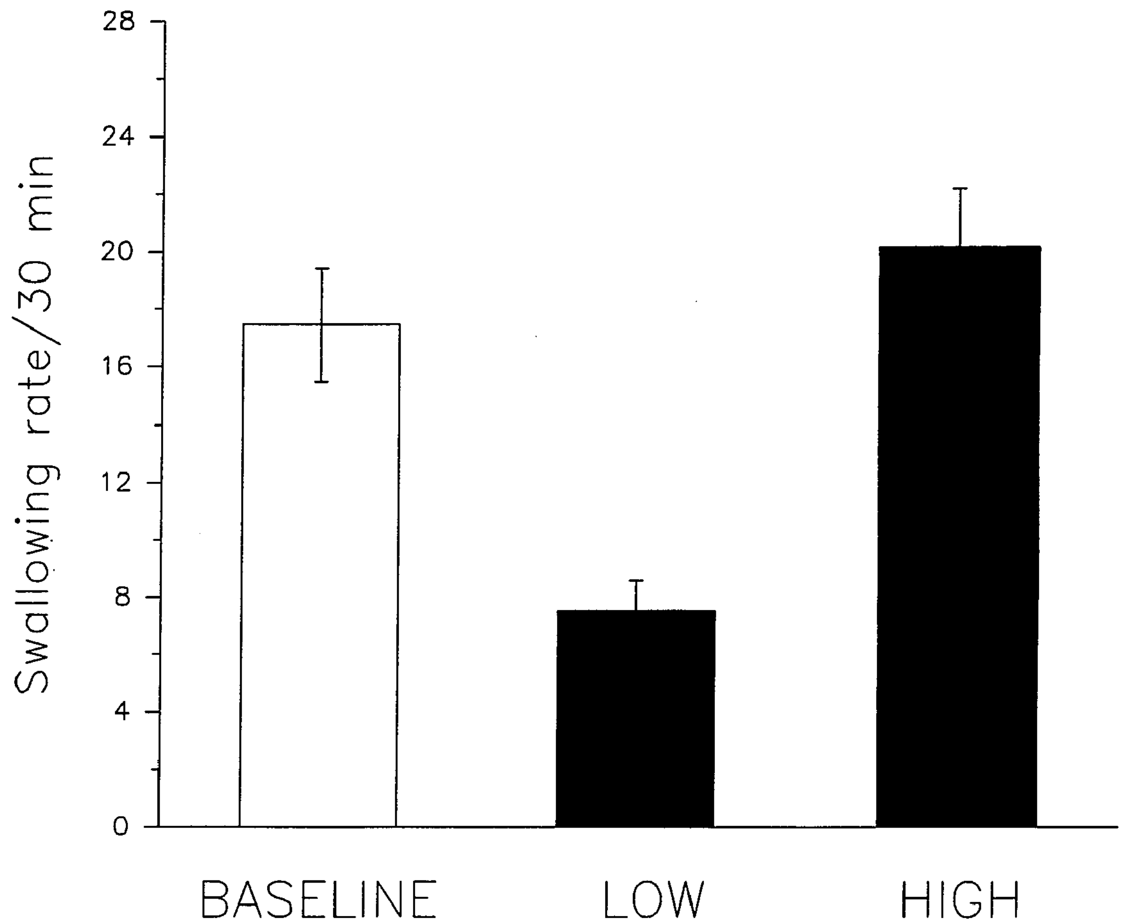

Fig. 1 Mean swallowing rates (± SE's) for the neutral baseline periods (averaged across both sessions) and for the pleasant low arousal and aversive high arousal periods.

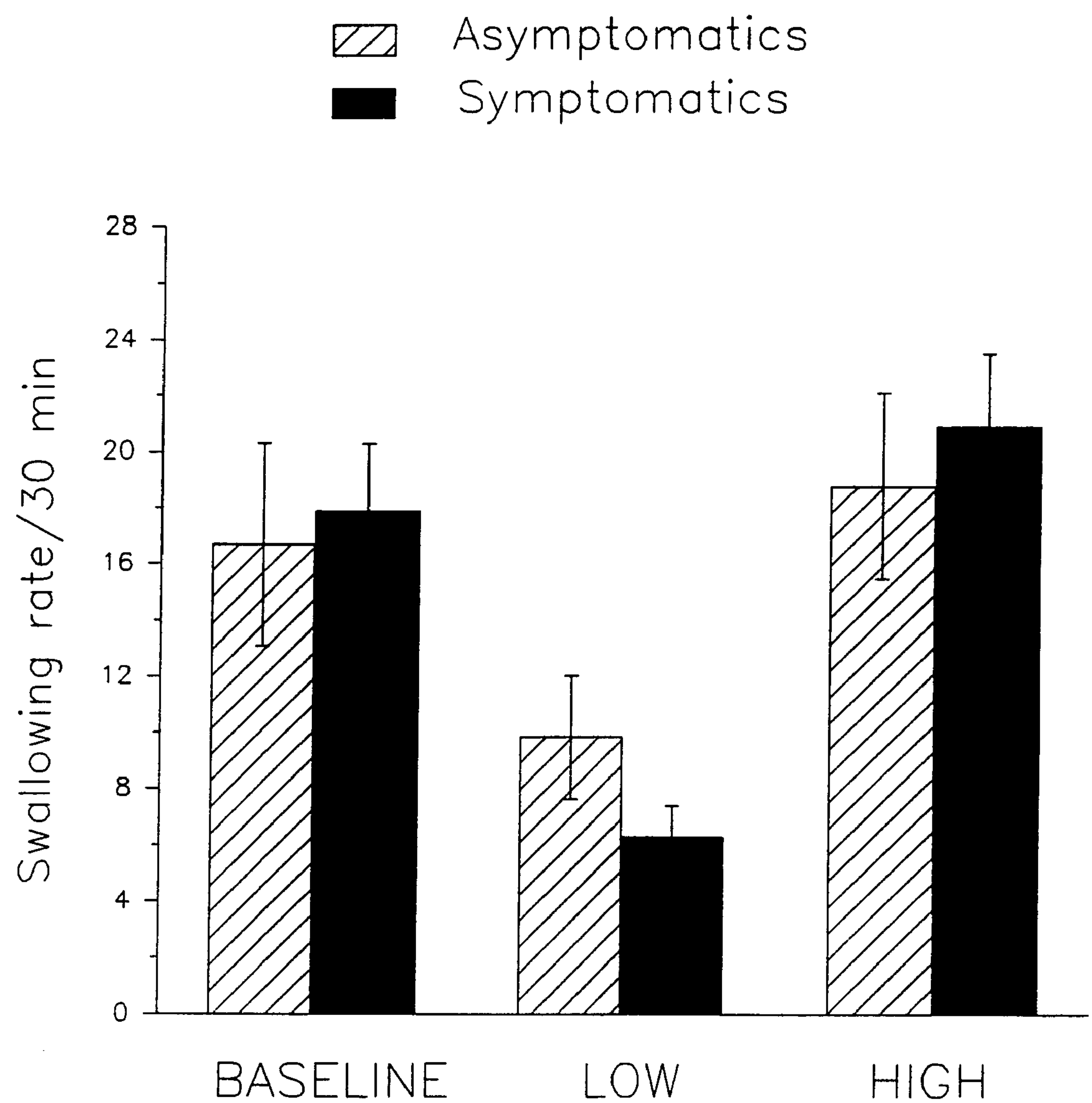

Fig. 2 Mean swallowing rates (± SE's) for the neutral baseline and for both emotional arousal conditions among symptomatic and asymptomatic subjects.

Similarly, ratings of gastrointestinal-related and tension-related symptomatology were significantly lower during the pleasant low arousal than the aversive high arousal condition (see Figure 3, panels c and d), multivariate $\underline{F}$ (2, 43) = 140.69, $\underline{p}$ < .00005. Univariate tests supported the reliability of these differences for gastrointestinal-and tension-related symptoms, $\underline{F}$s (1, 44) = 19.38 and 284.00, respectively, $\underline{p}$s < .0001. Reported changes in symptoms due to the arousal manipulation also varied between symptomatics and asymptomatics, multivariate $\underline{F}$ (2, 43) = 4.09, $\underline{p}$ < .02; for gastrointestinal-related and tension-related symptoms separately, univariate $\underline{F}$s (1, 44) = 4.60 and 4.97, respectively, $\underline{p}$s < .03. As shown in Figure 4, the effect of the arousal manipulation on both gastrointestinal- and tension-related symptom change was greer for symptomatic than for asymptomatic subjects, paralleling a pattern previously observed for swallowing rate (cf. Figure 2). Followup analyses revealed that mean ratings of gastrointestinal-related symptom changes in response to arousal manipulation were significant for the symptomatic subjects but not for the asymptomatics, $\underline{F}$ (1, 45) = 20.28, $\underline{p}$ < .0005 vs. $\underline{F}$ (1, 45) = .6, $\underline{p}$ > .43. Similar tests of the arousal effect on tension-related symptoms were significant for both symptomatic and asymptomatic subjects, $\underline{F}$s (1, 45) = 213.18 and 79.48, respectively, $\underline{p}$s < .00005.

<u>Physiological manipulation checks</u>. Figure 5 presents means for all physiological manipulation checks (forehead and forearm EMG, heart rate and skin conductance) during the

neutral baselines and during the low and high arousal manipulation periods. The physiological manipulation checks were all significantly lower during the pleasant low arousal period than during the aversive high arousal period. The reliability of these differences between arousal manipulation conditions was supported by the statistical analysis, multivariate $\underline{F}$ (4, 37) = 66.04, $\underline{p}$ < .00005. Separate univariate tests for the effect of arousal manipulation on each physiological measure were all statistically significant, $\underline{F}$s (1, 40) = 54.7, 44.95, 106.87 and 32.5, all $\underline{p}$s < .00005. The MANCOVA again did not reveal any significant effects involving gender, all $\underline{p}$s > .5.

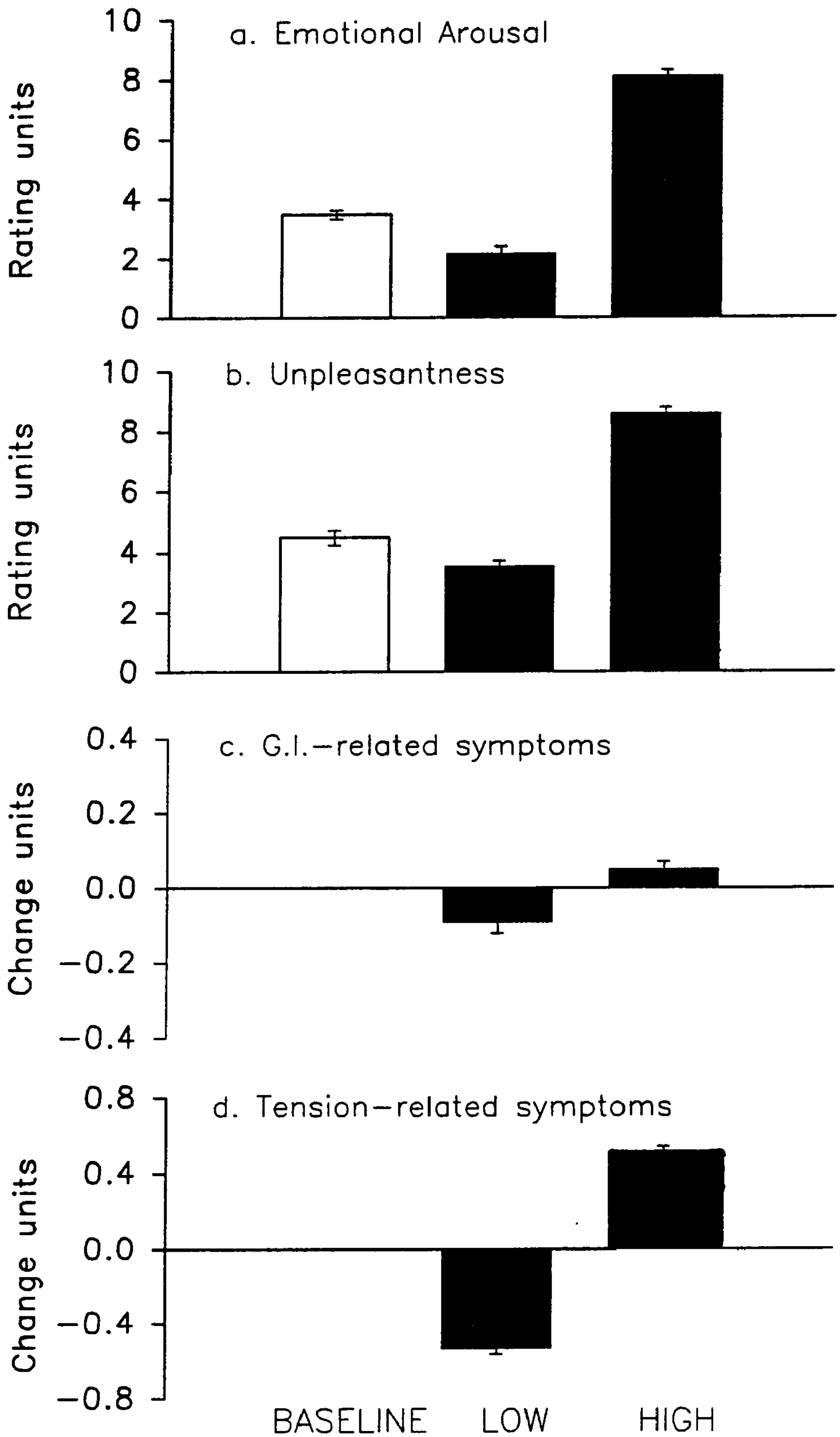

Fig. 3 Mean values (± SE's) for all verbal manipulation checks during neutral baseline, pleasant low arousal and aversive high arousal conditions.

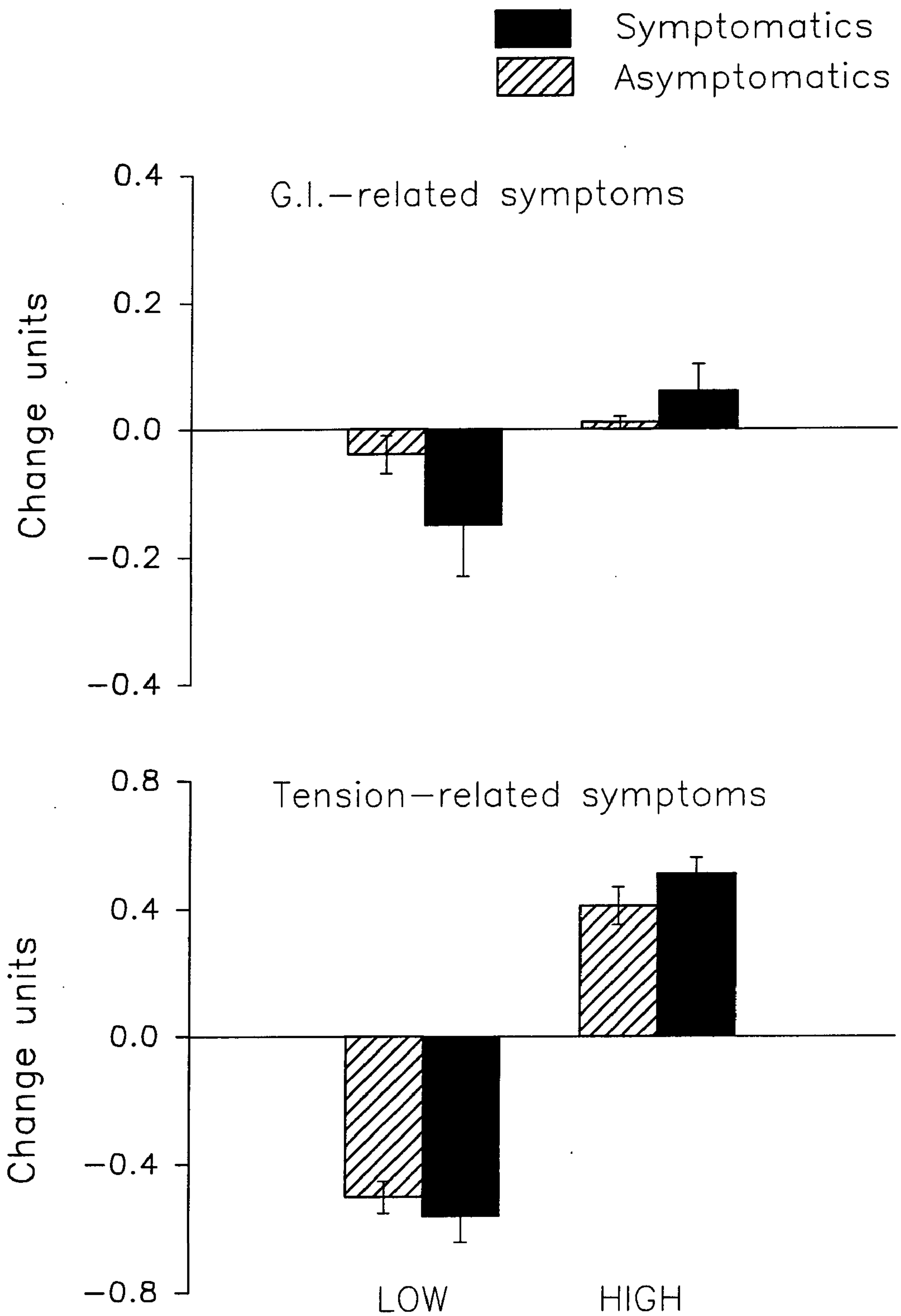

Fig. 4 Mean values (± SE's) for gastrointestinal-related and tension-related symptomatology for both emotional arousal conditions among symptomatic and asymptomatic subjects.

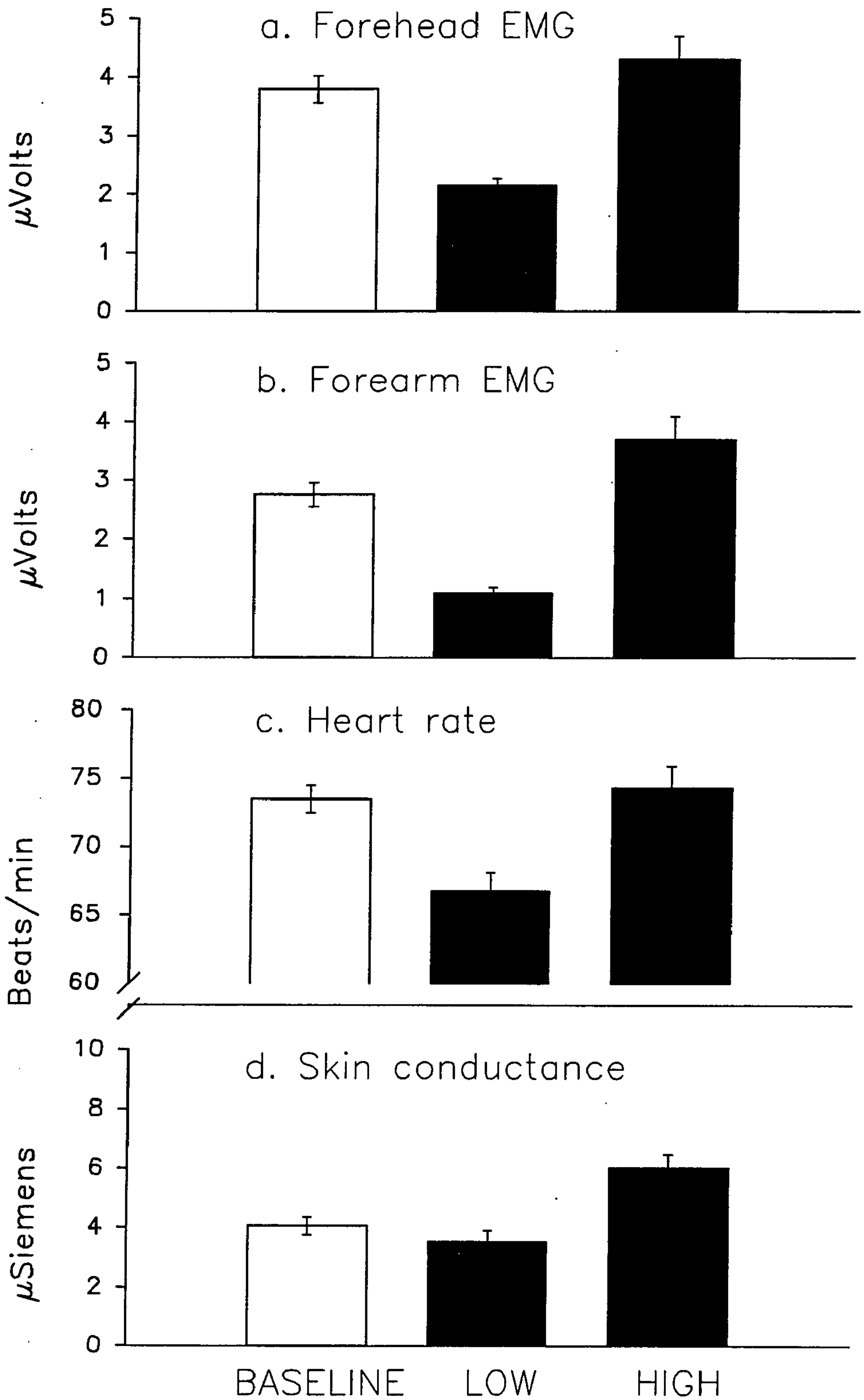

Fig. 5 Mean values (± SE's) for all physiological manipulation checks during neutral baseline, pleasant low arousal and aversive high arousal conditions.

Discussion

The results indicate that there is a positive relationship between level of emotional arousal and swallowing rate among asymptomatic subjects and symptomatic subjects with functional gastrointestinal disorders (irritable bowel syndrome and functional dyspepsia). There was approximately a threefold difference in swallowing rate between aversive high arousal and pleasant low arousal conditions. The success of the intended changes in emotional state was indicated by significantly higher values for the physiological manipulation checks (forehead and forearm EMG, heart rate and skin conductance) during the aversive high arousal condition than during the pleasant low arousal.

In this experiment, the observation previously made by Cuevas et al. (1994) and Fonagy and Calloway (1986) regarding an increase in swallowing rate with increased emotional arousal was replicated. In addition, the observation that a decrease in emotional arousal reduces swallowing rate (Cuevas et al., 1994), was also replicated. Moreover, similar swallowing rates during baseline periods were found in this study as previously (Cuevas et al., 1994) and there was also a very similar quantitative difference in rate of swallowing between high and low arousal conditions.

The effect of the affect manipulation on swallowing rate was more pronounced for the symptomatic (3:1 ratio for high/low conditions) than for the asymptomatic subjects (2:1 ratio), but the hypothesized larger difference for symptomatic subjects in swallowing rate did not achieve statistical significance. Calloway, Fonagy and Pounder (1982) found that patients with hiatus hernia and duodenal ulcer have a significantly higher swallowing rate than unaffected persons under experimentally induced stress. However, they used a swallowing detection technique only validated by self-report (making the validity of the detection questionable), their stressors did not affect either self-report of anxiety or electrodermal response recordings (raising questions about the effectiveness of the interventions), and their clinical sample consisted of patients with two disorders known to have an organic origin, rather than subjects with functional gastrointestinal disorders.

Though swallowing rate differences between symptomatic and asymptomatic subjects were modest, there were more robust differences in self-reported symptom changes. Symptomatic subjects reported larger changes in gastrointestinal-related symptomatology due to arousal manipulations than did asymptomatic subjects, and this difference between symptomatic and asymptomatic subjects for gastrointestinal symptoms changes was larger than the difference between the two groups for self-reported changes in tension-related symptoms. These observations regarding group differences were made using a checklist consisting of only a few gastrointestinal symptoms and no pre-intervention measurements were taken. Thus, further documentation of these observations would be of value using an expanded and standardized measure of gastrointestinal symptomatology administered both during a baseline period and after intervention.

Taken together, the findings of this experiment could tentatively be explained by the "hypersensitive gut" hypothesis. The present results indicate that swallowing rates are not excessive among symptomatic subjects, at least among those recruited from the general population. However, if these subjects have a lower pain threshold than asymptomatic subjects, the distension associated with more air in the gut could create pain and gas-related symptomatology in response only to moderate amounts of excessive air in these subjects but not in those not reporting discomfort. In support of this hypothesis, it has been reported that patients with IBS have significantly lower tolerance to rectal balloon distension (Ritchie, 1973; Kullman & Fielding, 1981; Whitehead et al., 1990), and to esophageal balloon distension (Constantini et al., 1993) than normals. However, this is not the case when the comparison is made based on tolerance to cold water applied to the hand, such as in a cold pressor test (Whitehead et al., 1990). In addition, other researchers have observed that patients with functional dyspepsia, have lower pain or discomfort threshold than normals (Mearin, Cucala, Aspiroz, & Malagelada, 1991; Bradette, Pare, Douvilee, & Morin, 1991).

Furthermore, Richter, Barish and Castell (1986) have found a similar "enhanced sensitivity to distention" due to lower visceral pain thresholds in patients with esophageal chest pain undergoing a balloon distension test.

The presently observed decrease in swallowing rate and self-reported gastrointestinal symptoms suggest the potential value of low-arousal-inducing techniques, such as biofeedback and relaxation training, to treat aerophagia and other stress-related gastrointestinal symptoms. These methods have been proposed previously (Whitehead, 1992; Bassotti & Whitehead, 1994) and their efficacy has been documented by Blanchard et al. (1993) in irritable bowel patients.

Contemporary research on emotion and physiological response (e.g., Lang, Bradley, & Cuthbert, 1990; Cook, Hawk, Davis, & Stevenson, 1991) has adopted a multidimensional conceptualization of affect based on results from factor analytic studies of responses on rating scales. Two independent factors have consistently emerged: (a) valence, a distinction between positive (happiness, pleasantness) and negative (unhappiness, unpleasantness) emotions; and (b) arousal, a distinction between excitement and activity versus calmness and inactivity (Osgood, Suci, & Tannenbaum, 1957). Since only an aversive high arousal condition and a pleasant low arousal condition were used in the present experiment, these two dimensions of affect were confounded. Thus, at present both emotional arousal and affective valence are equally credible explanations of the observed effect of emotional state on spontaneous swallowing.

Further research regarding the relationship among emotional state, gastrointestinal symptomatology and swallowing rate may benefit from selecting a more homogenous sample of patients. Although patients with overlapping symptomatology reflect a common fact in clinical practice, restricting study patients only to those with mostly gas-related symptoms might increase the likelihood of observing the hypothesized differential effect of excessive swallowing in gastrointestinal symptomatology; for example one might work only with the subset of IBS patients who appear to have predominantly gas-related symptomatology.

In summary, the present findings provide further support for a relationship between emotional state and swallowing rate. Subjects from a community sample with two common functional gastrointestinal disorders (irritable bowel syndrome and functional dyspepsia) showed greater effects of emotional state on self-reported gastrointestinal symptoms, than asymptomatic subjects. A similar pattern was observed for swallowing rate, though the group difference was not reliable.

Further research is needed to determine the affective dimensions that modulate swallowing rate and symptom reports, and to determine the mechanism of the relationship between them. In addition, use of an homogeneous sample of clinical patients with severe levels of symptomatology, particularly gas-related symptomatology, may increase the likelihood of detecting more marked differences between symptomatic and asymptomatic subjects.

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APPENDIX A

Review of Arousal Manipulation Methods

Low Arousal Inducing Techniques

Poppen (1988) has recently proposed an interesting conceptualization of relaxation. According to this author, relaxation may be defined as a response class consisting of members which covary. According to Poppen's idea, relaxation involves responding in four behavioral domains: motoric, verbal, visceral and observational. The first component of relaxation involves relaxed motoric behavior, which is characterized by low levels of muscle tension. The second component, relaxed verbal behavior, includes self-reports of calm and well being. The third component is relaxed visceral behavior, such as decreased heart rate, peripheral vasodilation, etc. The final component is relaxed observational behavior which is characterized by steady attending to repetitive, relatively invariant, low intensity stimuli usually enhanced in most relaxation training by restricting external stimulation. The occurrence of one behavior is associated with the likelihood of increased occurrence of other behaviors in that response class. Response covariation may occur both within a domain (from one muscle group to another) and across domains (decreased muscle tension in the face may covary with the verbal report of calmness). In the case of relaxation, the nature and support of such interbehavioral covariation is not well understood and awaits further research for elucidation (Poppen, 1988).

There are many similarities among the different methods for inducing relaxation. According to Benson, Beary and Carol (1974), these are:

1. A mental or behavioral device, such as a constant stimulus (sound, word, etc.) repeated silently or audibly or fixed gazing at an object.
2. A passive attitude; attention is focused on the technique but without worrying about performance.
3. A decreased muscular tone, achieved by adopting a comfortable posture.
4. A quiet environment, with decreased environmental stimuli and eyes closed.

Specifically, a mental device refers to observational behavior. In one way or another, it is included in most procedures; the subject is usually instructed to attend only to some low intensity stimuli, such as: (a) His own breathing, as in some forms of meditation, including Benson's technique (Benson, Beary & Carol, 1974; Stoyva & House, 1990); (b) proprioceptive sensation as in progressive muscle relaxation or autogenic training (interoceptive sensation is also attended to), (c) biofeedback signal (e.g., auditory or visual feedback), (d) a verbal instruction(s) from the respective instructor, and (e) a mantra or repeated sound, as in some forms of meditation (Poppen, 1988).

The second element, a passive attitude, is usually facilitated by verbal instructions to ignore distractions, to focus on a constant stimulus, to avoid evaluation of performance and to let the process go by itself (Goldfried &

Davidson, 1976; Rimm & Masters, 1979; Poppen, 1988).

The third component, low muscle tone, is the explicit goal in such methods as progressive muscle relaxation training (PMR) and EMG biofeedback. In other relaxation techniques, muscular relaxation is promoted by adopting a comfortable posture.

The fourth element is fairly constant, all training modalities emphasize a quiet, dimly lit environment. This enhances subject's attention to whatever constant stimulus may be present and minimizes attention to distracting stimuli (Goldfried & Davidson, 1976; Rimm & Masters, 1979; Poppen, 1988; Bernstein & Carlson, 1993).

A further common feature of relaxation techniques is the early explanation provided to the participant about the calm inducing effects of the procedure being learned. In addition, the trainer usually functions as a potent social reinforcing agent for participant compliance with the instructions and progress in the procedure (Goldfried & Davidson, 1966; Poppen, 1988). Another aspect in any relaxation procedure, is the relationship between instructor and trainee. It is critical to develop a cordial and comfortable relationship, to achieve an optimal result (Bernstein & Carlson, 1993). Finally another feature common to most relaxation methods is the use of self-report; this can clearly be influenced not only by covert feelings of relaxation but also by the social contingencies of the training situation (Poppen, 1988). In this regard, the inclusion of covert measures in the motoric (EMG recording) or visceral domain (SCL, heart rate, finger pulse volume, etc.) provides a more objective evaluation of the changes induced by relaxation.

Progressive Muscular Relaxation

This method for inducing relaxation involves the successive tensing and relaxing of voluntary muscles followed by a "letting go" phase. Both phases are done in an orderly sequence until all the main muscle groups of the body have been "worked through" (Rimm & Masters, 1979; Bernstein & Carlson, 1993). The first phase of the training, according to Jacobson, tends to make the individual increasingly observant of muscular tension in various parts of the body (Jacobson, 1938).

Most of the "motoric" oriented relaxation techniques are based on the premise that muscle tension is closely related to high arousal, and that the subject will experience a marked reduction in arousal if the tense muscles can be made to relax (Rimm & Masters, 1979; Bernstein & Carlson, 1993). In this connection it is important to consider that the striate musculature makes up at least 50% of the body mass in humans (Budzynski, Stoyva, Adler & Mullaney, 1973).

There is considerable evidence that reaching a low level of muscular tone is associated with reduced anxiety, other types of negative affect and reduced intensity or frequency of various symptoms, such as tensional and migraine headaches

(Blanchard & Andrasik, 1985; Bernstein & Carlson, 1993), snake phobias (Rimm & Masters, 1979), and sexual anxiety (Bernstein & Carlson, 1993).

The general procedure of the first phase of progressive muscle relaxation (PMR) includes two tension-relaxation cycles for each muscle group, holding the tension for 5 to 10 s and slowly releasing the tension for 20 s (Goldfried & Davidson, 1976). Subjects are instructed to notice the contrast in sensations between these two phases (tense and relax) which is an important discriminative learning for further use (Rimm & Masters, 1979; Bernstein & Carlson, 1993). This first phase is usually followed by a "letting go" phase. In this one, subjects are instructed to focus on the feelings from a specific part of the body and exhorted to relax it even further by letting go of any remaining sensation of tension. The order used is usually the same as the one for the tense-relax phase (Goldfried & Davidson, 1976).

One of the most common sequences used includes:

1. Hands: fist tensed and relaxed, fingers extended and relaxed.
2. Arms: biceps tensed and relaxed; triceps, extended and relaxed.
3. Shoulders: pulled up in a shrug, relaxed; shoulders pulled forward, relaxed.
4. Neck: head bent forward against the chest, relaxed; head pressed backward against what is resting on, relaxed.
5. Lower face: mouth open as wide as possible, relaxed; lips pursed in an exaggerated pout, relaxed.
6. Ocular area: eyes closed very tightly, relaxed.
7. Forehead : forehead and brows wrinkled, relaxed.
8. Back: entire back arched, relaxed.
9. Midsection: raised (tensing gluteus muscles), relaxed.
10. Abdominal area: tightened up, relaxed; pulled in toward spine, relaxed.
11. Thighs: legs stretched out and raised slightly, relaxed; heels dug into the couch or floor, relaxed.
12. Calves and feet: toes pointed toward head, relaxed; feet bent in opposite direction, relaxed.
13. Toes: toes flexed into the bottom of shoes, relaxed; toes extended, relaxed (Goldfried & Davidson, 1976; Rimm & Masters, 1979; Poppen, 1988; Bernstein & Carlson, 1993).

Diaphragmatic Breathing

Rate and pattern of breathing are partly under the control of the autonomic nervous system, but also partly under control of the somatic nervous system; consequently, both are potentially subject to instructional control. Control of rate and pattern of breathing is an important aspect of a number of relaxation training procedures (Fried, 1987; Poppen, 1988; Stoyva & House, 1990; Fried, 1993).

The diaphragm is a large, flat muscle which stretches like a layer across the body below the lungs and just above the stomach. According to Poppen (1988) and Stoyva & House

(1990), diaphragmatic breathing is a method that involves use of the diaphragm, rather than chest muscles, to draw air into the lungs. This allows deeper breathing and more efficient respiration with less muscular work. Also, the subject is able to relax neck and shoulder muscles while breathing. Focusing one's attention on slow, rhythmic breathing can have a general calming effect (Fried, 1987; Poppen, 1988; Stoyva & House, 1990; Fried, 1993) and it is an important part of a number of meditation techniques.

In diaphragmatic breathing training, the subject learns to be aware of his abdominal and chest movements by either placing his right hand or a light book on the upper abdomen and the left hand on the upper chest (Poppen, 1988; Stoyva & House, 1990; Fried, 1993). Subjects are instructed to breathe slowly and rhythmically through the nose and to try to produce a large movement of the right hand (on the upper abdominal area) as they inhale (upward displacement) and as they exhale (downward displacement), while the left hand (on the upper chest) remains relatively still (Poppen, 1988; Stoyva & House, 1990; Fried, 1993). Participants are instructed to breathe smoothly, gently and regularly. This training can take place while the subject is lying down (Poppen, 1988; Fried, 1993) or seated upright with shoulders relaxed, back straight and hands resting on the thighs (Stoyva & House, 1990).

<u>EMG Biofeedback</u>

A substantial number of studies have found that frontal EMG biofeedback is effective for training subjects in deep-muscle relaxation. Single site EMG biofeedback has been proved equal to other relaxation techniques in producing muscular relaxation in normal subjects (Alexander, 1975; Coursey, 1975; Haynes, Moseley & McGowan, 1975; Reinking & Kohl, 1975; Alexander, White & Wallace, 1977; Carlson et al., 1983) and with subjects suffering from chronic tensional headaches (Budzynski et al., 1973; Cox, Freundlich & Meyer, 1975; Hutchings & Reinking, 1976; Blanchard & Andrasik, 1985). The main reported advantage of single site EMG biofeedback over relaxation techniques is that it appears to produce its effect more rapidly (Reinking & Kohl, 1975). It also allows the researcher or practitioner to monitor the subject or patient progress closely and quantitatively.

The rationale behind EMG biofeedback training has been that relaxation of the forehead region should effect a lowering of general tension throughout the body and induce a state of "wakeful relaxation" (Carlson, 1989). In relationship to this assumption, headache patients treated with frontal EMG biofeedback have reported that they learned to relax and were able to do so when they felt themselves becoming tense. However, once the headache started they were unable to stop it (Budzynski et al., 1973); moreover, they reduced the frequency of headaches but not their duration (Haynes et al., 1975).

Sharpley and Rogers (1984) reviewed 20 studies comparing the therapeutic efficacy of EMG frontal biofeedback with other tension-reduction procedures such as progressive relaxation, cognitive intervention and meditation. Effect size (e.s.) was defined as: pre-intervention forehead EMG level minus post-intervention forehead EMG level divided by pre-intervention forehead EMG level. They found no difference between clinical and normal samples in effect size. Frontal EMG biofeedback was found to be significantly superior to a control procedure involving a simple instruction to relax ($\underline{M}$ e.s = 0.426 vs. 0.210), but not significantly different from the other alternative relaxation procedures (0.310). Interestingly, length of EMG biofeedback session was significantly correlated with effect size ($r = .33$, $\underline{p} <.01$). A related finding was that the larger the number of sessions attended, the larger the reported reduction in frequency of symptoms (Smith, 1987).

However, the traditional belief that the effects of frontal EMG biofeedback based relaxation generalize to muscle groups other than those for which biofeedback is provided appears to be incorrect, despite a few positive early reports (Budzynski et al., 1973; Coursey, 1975). Studies in which the muscles of the forearm and leg (Alexander, 1975; Schandler & Grings, 1976; Whatmore, et al., 1981) and neck (Shedivy & Kleinman, 1977) were monitored during frontal EMG training revealed no evidence than any muscles other than those associated with frontal potentials were influenced by the procedure.

Also, neither frontal nor forearm EMG biofeedback training appears to facilitate subsequent acquisition of the ability to reduce levels of muscular tension during training on the alternative site; that is, there is no apparent transfer of training (Alexander et al, 1977, White & Wallace, 1977; Carlson, Basilio & Heaukulani, 1983). Similarly, Whatmore et al. (1981) recorded EMG from four regions in alert and awake subjects: forehead, jaw-throat, right forearm and left leg. They found that EMG level in these regions intercorrelated poorly with one another.

The great majority of studies that have attempted to assess the transfer of biofeedback training from the forehead to another anatomical region have failed to show generalization of lowered forehead EMG levels to muscle areas outside the face, including the forearm, the neck and the lower leg (Alexander, 1975; Schandler & Grings, 1976; Shedivy & Kleinman, 1977; Whatmore et al., 1981).

Since the effects of single site EMG biofeedback training are specific to the locus from which the feedback originates, it may be more suitable to describe that type of learning as a "discriminative motor skill model" rather than in terms of a centralized model (Alexander, 1975; Fridlund et al., 1987).

With regard to generalization of frontal EMG biofeedback to other physiological response systems, the evidence is more ambiguous. It has been reported that EMG biofeedback was more effective than parietal EEG feedback in reducing heart rate and respiration rate (De Good & Chisholm, 1977). However, in other studies, EMG biofeedback was not found to be a more effective modality than instructions to relax for reducing heart rate (Shirley et al., 1982), increasing skin resistance (Schandler & Grings, 1976; Carlson, 1989), increasing skin temperature (Alexander et al., 1977; Nielsen & Holmes, 1980; Shirley et al., 1982; Carlson et al., 1983) or finger pulse volume (Shirley et al., 1982). It seems fair to conclude that frontal EMG biofeedback has a fairly localized effect in terms of both response system and anatomical location (Alexander et al., 1977; Nielsen & Holmes, 1980; Carlson et al., 1983), particularly when it is carried out from a single site (forehead), like in all the studies reviewed above.

The research done using multisite EMG biofeedback is more promising in terms of generalization effects across response systems and anatomical locations (Shirley et al., 1982; Carlson, 1989). Shirley et al. (1982) used multisite auditory EMG biofeedback integrated over the forehead, masseter, sternomastoid and forearm muscles. They found that multisite auditory EMG biofeedback was more effective than frontal-only EMG biofeedback in reducing: (1) EMG levels at the four different target muscle groups, (2) self-report of anxiety, and (3) autonomic arousal correlates (lowered finger pulse volume and raised skin temperature). This was true both during training periods and during stress induction trials when EMG biofeedback was not provided (Shirley et al., 1982).

In addition, Carlson (1989) compared a control group, a frontal-only group and a multisite EMG group for 3 sessions of 20 minutes each. Relative to baseline, there was no change in the control group; the frontal-only group showed reduced EMG potentials from the frontal region but not from the jaw (masseter) neck (sternomastoid) or forearm muscles. In contrast, the multisite trained group showed a 70 to 80% reduction of EMG levels at each of the sites mentioned above. They also exhibited a greater decrease in state anxiety than the other two groups.

Carlson (1989) has stated that the rationale for using multisite EMG biofeedback is that a general lowering of the average integrated EMG potentials from frontal, masseter, sternomastoid and forearm muscles is more likely to have an impact on the central nervous system and result in a generalized relaxation state than single site feedback. The same author has hypothesized that reduced proprioception from a substantial portion of the musculature could cause a direct reduction in hypothalamic/reticular activity with a "trophotropic" or generalized relaxation effect (Gelhorn, 1964), including autonomic and cognitive aspects (Carlson, 1989).

High Arousal Inducing Techniques

Before describing some of the most widely used experimental stressors, some methodological considerations derived from the psychophysiological literature should be examined as a basis for deciding on some of the procedural characteristics to be employed in the study of psychophysiological factors on gastrointestinal functions.

Active vs. Passive Tasks

It has been stated by Light and Obrist (1980) than an important feature of stressful tasks is whether they require subjects to cope actively or passively with stress. Sympathetic influences on the myocardium are most pronounced when subjects are exposed to tasks (such as shock avoidance or discriminative reaction time) that require them to exercise active instrumental control over aversive events or over the level of reward achieved (Krantz, Manuck & Wing, 1981). Thus, a task such as a challenging reaction-time test, where subjects have to respond to avoid a electric shock or earn money, produces greater systolic blood pressure (SBP) and heart rate (HR) increases than tasks involving passive exposure to stressors. In contrast, the passive tasks, such as the cold pressor test or exposure to a mutilation film (which subjects usually approach passively), results in lesser SBP and HR changes; however, there are greater increases in diastolic blood pressure (DBP) than in active coping tasks (Krantz et al., 1981).

Consistent with these results, it has been found that an increase in heart rate mediated by the beta-adrenergic system is characteristic of situations requiring active coping; the decrease in heart rate during passive coping, on the other hand, is associated with vagal and/or alpha-adrenergic control of the cardiovascular system (Hull, Young & Ziegler, 1984).

Controllability

A large body of psychophysiological and psychoendocrine research on stress supports the conclusion that the effectiveness of psychosocial factors in arousing the sympathetic and adrenocortical systems depends on the individual's evaluation of the balance between the demands of the situation and his personal ability to handle those demands (Krantz, Manuck & Wing, 1981). It can be generally stated that over the long term, controllability facilitates adjustment to stressors and enhances coping effectiveness, although the effort involved in exerting control may be associated with an increase in arousal in the short term (Krantz et al., 1981).

Vigilance vs. Problem-Solving Tasks

Since Lacey's initial observations concerning the influence of attentional demands upon cardiovascular response to experimental stressors, many investigators have noted that HR decreases during tasks requiring vigilance (sensory intake), but increases during cognitive problem-solving tasks requiring concentration and rejection of interfering sensory information (Krantz, Manuck & Wing, 1981). For cognitive tasks there is, in addition, a redistribution of blood flow from skin and viscera to skeletal muscle, along with increased motoric activity. Vigilance or sensory intake tasks are associated with decreased motoric activity in addition to decreased HR; they are also like cognitive tasks in that they are related to vasoconstriction in skin and viscera but are different in that they are also related to vasoconstriction in skeletal muscle (Manuck, Krantz & Polefrone, 1981).

Habituation

Habituation normally occurs to the repeated presentation of a stimulus. It is slower to develop with intense, unique and complex stimuli (Stern, Ray & Davis, 1980). This process is also affected by the rate of presentation of stimuli and the duration of each presentation. If the subject is required to make a behavioral response (e.g., rating the intensity of the stimuli), habituation will be somewhat inhibited. In general, orienting responses habituate rapidly whereas defensive responses habituate very slowly (Stern et al., 1980).

Motor Component

Another relevant issue is the motor response component of the experimental procedure. It should be minimal and standardized if cardiovascular parameters or muscular tension are being recorded (Steptoe & Ross, 1981). If a task involves extensive motor activity, this may of itself provoke cardiovascular and muscular adjustments independent of the psychological challenge. Moreover, if a task is not paced externally, the subject may produce different cardiovascular and muscle tension levels purely on the basis of their work rate (Steptoe & Ross, 1981). Another important consideration is that the task should actively engage mental and emotional resources of the experimental subject. For the task to have a sizable psychophysiological effect, either challenge or interest on positive tasks or threat on negative tasks should be elicited (Steptoe & Ross, 1981).

Experimental Stressors

Mental arithmetic. The use of mental arithmetic as an experimental stressor is widespread in the psychophysiological literature, including studies examining the association between emotional arousal and gastrointestinal dysfunction (Camilleri & Neri, 1989). There are several variations of this type of task but most of them include mathematical operations performed without paper and pencil, under time pressure and, in some cases, with punishment for error and slowness.

Steptoe and Ross (1981) used a prerecorded series of difficult mathematical problems. These required addition or subtraction of three to four digit numbers. The answers appeared on the problem sheet and the subject had to identify whether they were right or wrong. Problems were administrated at 10 s intervals. The task lasted three minutes and subjects were requested to respond as quickly as possible after the problem was presented, but at most two seconds before the next problem was presented. They found that this procedure induced large increases in heart rate (Steptoe & Ross, 1981).

Pomerleau and Pomerleau (1987) used with success a procedure involving 5 minutes of serial subtractions of the number 13 from a randomly chosen four-digit number, combined with competitive pressure to induce performance anxiety in a sample of smokers. Allen, Obrist, Sherwood and Crowell (1987) also used a task involving serial-13 subtractions from a four-digit number (5529) during a three minute period. Subjects were instructed to try to perform as quickly and as accurately as possible. A significant increase in heart rate was observed during the task (Allen et al., 1987). Tucker and Carroll (1985) utilized a mental arithmetic task composed of 56 addition or subtraction problems involving two- or three-digit numbers. Subjects had only two seconds to respond before a pre-recorded answer was presented to them. Half of the answers were correct while the other half were incorrect. Thus, correct answers were often indicated as being wrong and incorrect answers were often indicated as being right. This task produced a large increase in heart rate (Tucker & Carroll, 1985).

Unfortunately, when swallowing rate is the dependent variable, the inclusion of any kind of mental arithmetic task as one of the stressors is precluded by the findings of Fonagy & Calloway (1986) and confirmed in this laboratory. Swallowing rate seems to be responsive to subvocal verbalization, confounding the effects of arousal level substantially.

<u>Noise.</u> Loud white noise stimulation during a 5 minute period has been used effectively as an stressor in a number of EMG studies (Fridlund, Cottam & Fowler, 1982). In addition, Young et al. (1987) used 10 minutes of intermittent 100 dB white noise, presented on an unpredictable schedule, as one of the experimental stressors in studying the relationships between stressful stimulus conditions and esophageal motility. They found that amplitude of peristaltic esophageal contractions, velocity of the peristaltic esophageal wave and levels of self-reported state anxiety were significantly higher during periods of noise than during a quiet baseline period (Young et al., 1987). An interesting observation made in this study was that the esophagus appears to respond in healthy volunteers only when stressful stimuli are above a threshold value. This suggests the importance of using potent stressors in psychophysiological studies of the esophagus, and possibly any other gastrointestinal functions. These considerations could also apply to some other physiological response systems as well.

<u>Disturbing visual stimuli and visual conflict task.</u> Visual stressors have been used widely in psychophysiological research. A film of an industrial accident, "It Didn't Have to Happen" was used as an experimental stressor by Hull, Young and Ziegler (1984). Other investigators have used exposure to

graphic slides of automobile accidents (Waters et al., 1987; Lewis & Smith, 1987), or pictures of wounds and mutilated bodies (Cook, Davis, Hawk, Spence & Gautier, 1992). Most studies have found substantial effects on self-report and physiological measures, elicited by the exposure to these stimuli.

The Stroop word color task has been a commonly used procedure in psychophysiological research, including studies which have examined the association between emotional arousal and functional gastrointestinal disorders (Camilleri & Neri, 1989). This is a visual discrimination test in which input that elicits interference is employed (Hull et al., 1984). In this task, subjects are instructed to read three pages one after the other. The first page consists of the words "RED", "GREEN" and "BLUE" arranged randomly and printed in black. The second page is composed of 100 items, all written as "XXXX" but printed in either red, green or blue. The third page consists of the words on page one printed in the colors on page two, blended so that the word and the color of the word does not match for any of the items (Golden, 1978). The materials of this test create a high level of interference, forcing subjects to slow down processing speed which is incongruent with the standard instructions to read as fast as possible (Golden, 1978). This task can be made even harder by using conflicting auditory input, which consists of requiring the subjects to listen to color names while trying to read the stimuli (Golden, 1978; (Hull, Young & Siegler, 1984).

Unfortunately, this widely used task tends to induce subvocal verbalization in many subjects; the later precludes its inclusion in the study of the relationship between arousal level and swallowing rate.

Multiple stressors. Some researchers have used several consecutive stressors instead of only one with very encouraging results. For example, Hull et al. (1984), employed in sequence: a film of a severe industrial accident, the Stroop word color task with conflicting auditory input, the cold pressor test using the foot and exercise on an automated treadmill until exhaustion. They found significant initial increases in heart rate during the psychological stressors, but decrements back to baseline after three minutes of exposure (Hull et al., 1984). Young et al. (1987) successfully used a combination of an intermittent white noise plus solvable and unsolvable discrimination problems. Soffer, Scalabrini, Pope and Wingate (1988), included a "video game" delayed audiofeedback and a "cold pressor" test, to examine the effect of stress on esophageal motor function. Finally, Myrtek and Spital (1986) used several stressors simultaneously rather than in sequence; these included: (a) Mental arithmetic, (b) the cold pressor test, and (c) physical exercise. They found a synergistic effect for this stressor combination on heart rate, diastolic blood pressure and respiration rate. The authors argue that to combine stressors effectively requires that the stressors be suitable for repetition without undue adaptation effects. They also argue that the intensity of the different stimuli should not be too different in relative magnitude to avoid one canceling out the others.

In summary, use of stressors in sequence or a combination of several of them appears to have a stronger effect than the use of a single one. Furthermore, it is a practical option to prevent habituation when studying physiological responses with a low frequency, which demand prolonged experimental sessions, such as is the case with swallowing.

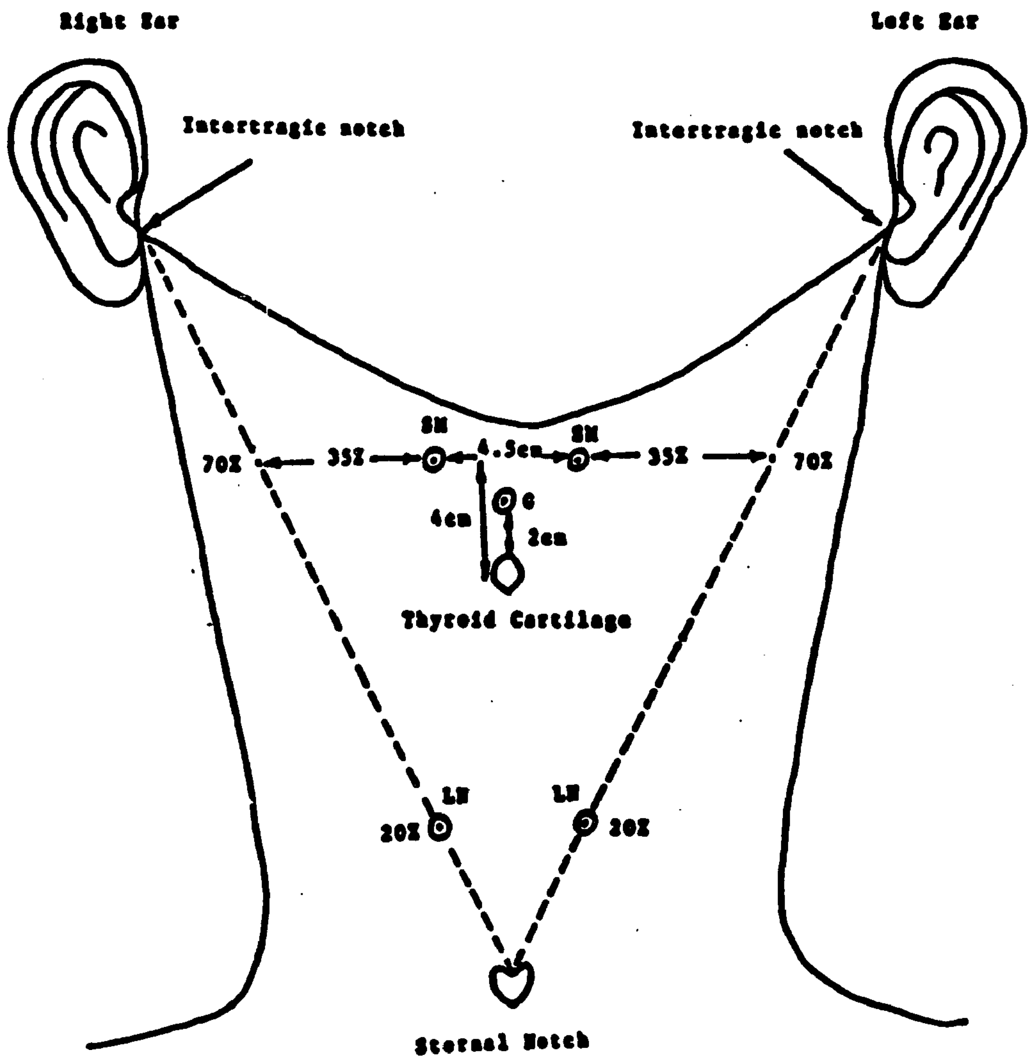
APPENDIX B

Diagram of Anatomical Landmarks and Electrode Placement for Swallowing Detection

SM: Submental placement

LN: Low neck placement

G: Ground electrode



APPENDIX C

Gastrointestinal Symptom Questionnaire (modified from Whitehead et al. (1988)

<u>WOMEN: Do not include symptoms that were ONLY experienced during premenstrual or menstrual periods</u>.

Please, circle <u>only one option</u> per symptom, if you choose C. be sure to answer how long ago you consulted a physician for that particular symptom.

1. ABDOMINAL PAIN. In the last 24 months:
   A. experienced/did not see doctor B. did not experience
   C. experienced/saw doctor......How long ago.............?

2. DIARRHEA. In the last 24 months:
   A. experienced/did not see doctor B. did not experience
   C. experienced/saw doctor......How long ago.............?

3. CONSTIPATION. In the last 24 months:
   A. experienced/did not see doctor B. did not experience
   C. experienced/saw doctor......How long ago.............?

4. NAUSEA. In the last 24 months:
   A. experienced/did not see doctor B. did not experience
   C. experienced/saw doctor......How long ago.............?

5. VOMITING. In the last 24 months:
   A. experienced/did not see doctor B. did not experience
   C. experienced/saw doctor......How long ago.............?

6. INDIGESTION OR HEARTBURN. In the last 24 months:
   A. experienced/did not see doctor B. did not experience
   C. experienced/saw doctor......How long ago.............?

7. BELCHING ACID INTO MOUTH. In the last 24 months:
   A. experienced/did not see doctor B. did not experience
   C. experienced/saw doctor......How long ago.............?

8. EXCESSIVE BELCHING OF GAS. In the last 24 months:
   A. experienced/did not see doctor B. did not experience
   C. experienced/saw doctor......How long ago.............?

10. VISIBLE DISTENTION OF ABDOMEN (BLOATING).
    In the last 24 months:
    A. experienced/did not see doctor B. did not experience
    C. experienced/saw doctor......How long ago.............?

14. PASSAGE OF MUCUS BY RECTUM. In the last 24 months:
    A. experienced/did not see doctor B. did not experience
    C. experienced/saw doctor......How long ago.............?

15. PASSAGE OF BLOOD BY RECTUM. In the last 24 months:
   A. experienced/did not see doctor B. did not experience
   C. experienced/saw doctor......How long ago.............?

18. FEELING OF INCOMPLETE EVACUATION AFTER A BOWEL MOVEMENT. In the last 24 months:
   A. experienced/did not see doctor B. did not experience
   C. experienced/saw doctor......How long ago.............?

19. GASTROINTESTINAL REACTIONS TO MILK PRODUCTS. In the last 24 months:
   A. experienced/did not see doctor B. did not experience
   C. experienced/saw doctor......How long ago.............?

21. LOOSE BOWEL MOVEMENTS WITH ONSET OF PAIN. In the last 24 months:
   A. experienced/did not see doctor B. did not experience
   C. experienced/saw doctor......How long ago.............?

22. RELIEF OF PAIN AFTER A BOWEL MOVEMENT. In the last 24 months:
   A. experienced/did not see doctor B. did not experience
   C. experienced/saw doctor......How long ago.............?

23. MORE FREQUENT BOWEL MOVEMENT WITH ONSET OF PAIN. In the last 24 months:
   A. experienced/did not see doctor B. did not experience
   C. experienced/saw doctor......How long ago.............?

24. PAIN IN THE UPPER ABDOMINAL AREA AFTER FINISHING A MEAL. In the last 24 months:
   A. experienced/did not see doctor B. did not experience
   C. experienced/saw doctor......How long ago.............?

25. VISIBLE DISTENTION OF ABDOMEN, AFTER FINISHING A MEAL. In the last 24 months:
   A. experienced/did not see doctor B. did not experience
   C. experienced/saw doctor......How long ago.............?

APPENDIX D

Rating Form (adapted from Mehrabian and Russell, 1974)

We would like you to rate your emotional reaction to this experience on two separate dimensions. The first dimension is how unhappy vs. happy what you just have experienced makes you feel:

Unhappy 0 1 2 3 4 5 6 7 8 9 10 Happy

Circle "0" at the "unhappy" end of this scale if the experience makes you feel **COMPLETELY** and **ABSOLUTELY** unhappy, annoyed, unsatisfied, melancholic, despairing, or bored--that is, 100% unhappy without any happy feelings--. Circle "10" at the "happy" end of this scale if this experience makes you feel **COMPLETELY** and **ABSOLUTELY** happy, pleased, satisfied, contented, or hopeful--in other words, 100% happy without any unhappy feelings. Use the ratings 1 through 9 for intermediate feelings, neither completely unhappy nor completely happy. If you feel **COMPLETELY NEUTRAL**, use a rating of 5.

The second dimension we would like you to rate is how unaroused vs. aroused this experience makes you feel:

Unaroused 0 1 2 3 4 5 6 7 8 9 10 Aroused

Circle "0" at the "unaroused" end of the scale if this experience makes you feel **COMPLETELY** and **ABSOLUTELY** relaxed, calm, sluggish, dull, sleepy, or unaroused--that is, 100% calm without any feelings of excitement--. Circle "10" at the "aroused" end of the scale if this experience makes you feel **COMPLETELY** and **ABSOLUTELY** stimulated, excited, frenzied, jittery, wide-awake, or aroused--in other words, 100% aroused without any calm feelings. Again, use the ratings 1 through 9 for intermediate feelings, neither completely aroused nor completely unaroused. Again, use a rating of 5 for the midpoint of the scale, which might correspond to a "normal" awake state.

YOUR RATINGS :

Happy 0 1 2 3 4 5 6 7 8 9 10 Unhappy

Unaroused 0 1 2 3 4 5 6 7 8 9 10 Aroused

APPENDIX E

Reactions Checklist

Listed below are various bodily sensations that subjects ordinarily experience in different situations. Read each one carefully and choose for each description <u>only ONE</u> of the three possible options. Base your judgement on how you have felt <u>OVER THE PAST 30 MINUTES</u> compared to how you were feeling <u>WHEN YOU ARRIVED FOR YOUR APPOINTMENT TODAY</u>.

DESCRIPTION	Increased	No change	Decreased
1) HEART BEATING.	( )	( )	( )
2) NAUSEA.	( )	( )	( )
3) FEELING SWEATY PALMS.	( )	( )	( )
4) BUTTERFLIES IN STOMACH.	( )	( )	( )
5) WANTING TO SCREAM.	( )	( )	( )
6) WHOLE BODY FEELS HEAVY.	( )	( )	( )
7) TENSION IN FOREHEAD.	( )	( )	( )
8) ABDOMINAL PAIN.	( )	( )	( )
9) BLOOD RUSHING TO FACE.	( )	( )	( )
10) CLENCHED JAW.	( )	( )	( )
11) BELCHING OF GAS.	( )	( )	( )
12) ARMS AND LEGS WARM AND RELAXED.	( )	( )	( )
13) FEELING RESTLESS AND JITTERY.	( )	( )	( )
14) BLOATING	( )	( )	( )
15) FEELING TENSE ALL OVER.	( )	( )	( )
16) BELCHING ACID INTO MOUTH.	( )	( )	( )
17) FEELING TENSION IN UPPER BACK AND NECK.	( )	( )	( )
18) BREATHING RATE.	( )	( )	( )
19) FIST CLENCHING.	( )	( )	( )
20) INDIGESTION OR HEARTBURN.	( )	( )	( )

APPENDIX F

Laboratory Set-Up and Common Protocol

SET-UP before subject arrives

1) Set up **ELECTRODES:**

1.1) Frontal EMG: a pair of large Ag/AgCl surface electrodes with conductive gel.
1.2) Forearm EMG: a pair of large Ag/AgCl surface electrodes with conductive gel.
1.3) Sub-mental EMG: a pair of J & J SE-40 Ag/AgCl surface electrodes with conductive gel.
1.4) Low-neck EMG: a pair of J & J SE-40 Ag/AgCl surface electrodes with conductive gel.
1.5) EKG: Two small electrodes with electrode gel
1.6) SCL: Two large "SC" electrodes filled with unibase
1.7) Ground electrode: is part of sub-mental EMG set.

2) Set up **EQUIPMENT and COMPUTER:**

2.1) TURN ON two power strips (POWER RACK and PC-VCR).
2.2) Set computer to the CORRECT DIRECTORY:
2.3) Set BATCH FILE for data acquisition and data storing.

Format for running the batch file is:
JCPH CONDITION SUBJECT # FIRST NAME LAST NAME
After typing all parameters type ENTER key to start the SET UP subroutine designed to check physiological signals.

2.3.1) FIRST PARAMETER will be either LOW or HIGH
After typing the NAME of the condition, a two-digit number will be assigned after the experiment code J1

FIRST DIGIT (condition): LOW = 1 or HIGH = 3
SECOND DIGIT (part of the session): BASELINE = 0
AROUSAL MANIPULATION = 1
2.3.2) SECOND PARAMETER codes gender, diagnostic group, order and subject progressive number within gender, diagnostic group and order (a FOUR-DIGIT number).

FIRST digit codes GENDER: MALE = 1 FEMALE = 2
SECOND digit codes DIAGNOSTIC group: IBS = 1 FD = 2
CONTROL = 3
THIRD digit codes ORDER: LOW-HIGH = 1 HIGH-LOW = 2
FOURTH digit codes SUBJECT NUMBER: from 1 to 4.

2.3.3) THIRD PARAMETER will be subject's FIRST NAME.

2.3.4) FOURTH PARAMETER will be subject's LAST NAME.

3) Set up **LABORATORY**

CONTROL ROOM:

3.1) **VISUAL and AUDITORY STIMULI:**
PC-VCR: power ON, JCMA tape inserted and rewinded.

3.2) VISUAL monitoring of subject:
PANASONIC NV-8420 VCR: power ON, CAMERA REMOTE on MANUAL MODE.
T.V. MONITOR: power ON, SELECTOR on channel THREE.
VIDEO SIGNAL SELECTOR: on the PANASONIC position TO WATCH CHAMBER. PC-VCR ON to MONITOR TAPE.
SWITCHBOX: all switches DOWN.

3.3) AUDIO MIXER:
CHANNELS: number ONE UP and ALL OTHER DOWN.
MODE SELECTOR: MONO position.
EQUALIZER: dials 1-3 on "0" and last four on " -12".

3.4) **COULBOURN equipment check-up:**
EMG bioamplifier ONE: LOCATION 1 A/D CHANNEL 6
(FOREHEAD) GAIN X 1000 = 5.0
COUPLING switch = 1 Hz.
GAIN switch = X 10 PERCENT of gain = 0.1 %
HI CUTOFF = 250 Hz. LO CUTOFF = 90 Hz.

3.5) COULBOURN equipment check-up:
EMG bioamplifier TWO: LOCATION 2 A/D CHANNEL 7
(FOREARM) GAIN X 1000 = 5.0
COUPLING switch = 1 Hz.
GAIN switch = X 10 PERCENT of gain = 0.1 %
HI CUTOFF = 250 Hz. LO CUTOFF = 90 Hz.
EKG bioamplifier FOUR: LOCATION 4 A/D CHANNEL 3
(HEART RATE) GAIN X 1000 = 5.0 *
COUPLING switch = 1 Hz.
GAIN switch = X 10 PERCENT of gain = 40 %
HI CUTOFF = 13 Hz. LO CUTOFF = 8 Hz.
SCL Coupler: LOCATION 2B A/D CHANNEL 0
CONDUCTANCE X 10 μmhos = 1.04 (locked)
EXCITATION = 0.5 DC COUPLING = DIRECT DC (SCL)
SENSITIVITY = 100 VERNIER = X 1 CAL.
VOLTAGE controller: LOCATION 1B
Oscillator FREQUENCY SWEEP RANGE = B, BIPOLAR
SHAPED rise/fall gate: LOCATION 1B
* adjustable for FB2 RISE/FALL TIME = 1.5 *
(base of 100, equal 150 ms)
Envelope shape = Nonlinear.
NOISE: LOCATION 1C AMPLITUDE RMS = 2V

4) Set up EXPERIMENTAL CHAMBER

4.1) **ILLUMINATION:** LIGHTS ON (outside switch, individual switches for each lamp).
4.2) **AUDIO:** HEADPHONES plugged in. TWO STATION INTERCOM close to subject's chair.
4.3) **VIDEOCAMERA:** AC POWER ADAPTOR: selector on VTR (DC OUT) position. (Green light ON). HANDYCAM POWER SWITCH: selector on CAMERA position.
4.4) **TV MONITOR:** INPUT selector on EXT MODE (use remote control).
VOLUME: set proper level with remote control, middle position).
4.5) **EMG-501 POWER:** Switch ON. CONNECT "E" and "F" cables
4.6) **EMG-501 J & J** amplifiers: GAIN (0-100) = LOW (SWITCH UP).
FILTER BAND = NARROW (SWITCH UP).

5) Set up MATERIALS

5.1) CONSENT, RELEASE and CONTACT forms. FACE and SESSION data sheets.
5.2) Symptoms CHECKLIST and two Rating forms.

6) HOOK-UP INSTRUCTIONS:

During this procedure, tell the subject that different types of physiological signals will be recorded. Emphasize to the subject that sensors will detect very small signals from his body and that no shock will be administered, answer any question about what is being measured by telling the subject that this will be explained at the end of the experiment. Before beginning tell subject that you will be attaching sensors to his forehead, forearm, neck, hand, collar bone and low side; tell subject that for most of the sensors, you will be rubbing the skin with different substances in order to get a good signal and invite him to tell you if you are rubbing too hard. Inform subject that he will be wearing the sensors for about the next 1 1/2 hours, if he thinks he might need to use the restroom, invite him to do so and also ask subject to remove his watch, as this can interfere with physiological recording.

CLEAN-UP:

6.1) **SCL:** RINSE the skin of the dominant hand with DISTILLED WATER on a tissue.
Wipe DRY. WIPE the skin with UNIBASE and then gently WIPE OFF the excess. APPLY electrodes to THENAR and HYPOTHENAR eminences of the hand.
PUT loops in the wires and TAPE DOWN over the wrist.

DO NOT CONNECT the short wires coming from the electrodes to the cable's DELAY HOOK-UP. (BE DONE LATER if all the OTHER SIGNALS are O.K.).

6.2) **FOREARM EMG:** CLEAN electrode placement sites on lateral aspect of DOMINANT forearm with ALCOHOL.
ABRADE skin with linear strokes using OMNI PREP, then WIPE it off.
RUB the areas with an small amount of GEL and REMOVE the excess.
ATTACH electrodes to the LATERAL SURFACE of the dominant forearm, one electrode TWO INCHES below the RADIAL EDGE of the cubital fossa and the other TWO INCHES BELOW the first one.

6.3) **FOREHEAD EMG:** CLEAN electrode placement sites on forehead with alcohol.
ABRADE skin slightly with OMNI PREP, then WIPE it off.
RUB the areas with an small amount of GEL and REMOVE the excess.
ATTACH electrodes on the forehead, approximately one inch over each eyebrow, centered on the pupil of each eye with gaze directed straight forward.

6.4) **EKG:** Prepare the skin by CLEANING the areas with ALCOHOL and RUBBING the areas briefly with a small amount of ELECTRODE GEL.
REMOVE excess of gel.
ATTACH electrodes to the skin over RIGHT COLLAR BONE and LEFT LOWER ANTEROLATERAL LOWER CHEST area over the lowest rib.
TAPE DOWN a loop of wire by each electrode as a STRAIN RELIEF.

6.5) **LOW NECK AND SUBMENTAL EMG:**
TELL subject and proceed to MEASURE neck circumference, distance between sternal notch and intertragic notch and distance between sternal notch and angle of the jaw as a percentage of the preceding measure.
CLEAN electrode placement sites with ALCOHOL including ground site.
GIVE subject a brief EXPLANATION regarding making small marks on his skin to help you place the sensors correctly. Inform him that they will be cleaned by the end of the session.

6.5.1) **SUBMENTAL:** Establish reference MARKS 70% of the distance form the sternal notch to the intertragic notch on both sides of the neck. Trisect the line connecting these two points and place marks on the points of trisection (approximately 4 cm above the thyroid cartilage and 4.5 cm apart from each other).

6.5.2) **LOW NECK:** Directly on the sternal notch-intertragic notch lines, 20% up from the sternal notch.
PLACE GEL on the skin at the placement marks.
RUB it in well and then WIPE it OFF completely.
ATTACH electrodes to skin carefully. (Total of FIVE).
INSPECT electrode configuration by checking that the electrode pairs are really CENTERED ON the MIDLINE and that the HEIGHT on the neck of both electrodes in each pair is EQUAL. If misplaced, replace them by lining them up both by remeasuring and by eye.
SNAP cables from J&J amplifier "E" (FOREHEAD).
SNAP cables from J&J amplifier "F" (FOREARM).
6.6) **IMPEDANCE CHECK-UP**
Before proceeding with session, CONNECT all EMG leads to the IMPEDOMETER.
TEST each channel and repeat site cleaning in any one that shows an electrical impedance larger than 10 kilohms.

7) <u>TESTING PHYSIOLOGICAL SIGNALS</u>

7.1) **INSTRUCTIONS:** TELL subject that you would like to TAKE a FEW MOMENTS to make sure that we are going to get a good recording.

7.1) **SIGNALS on VPM DISPLAY:**
USE LEFT shift key to change from one pair of signals to another (EKG-SCL, Forehead and Forearm EMG's, SUBMENTAL and LOW NECK EMG's). DO NOT PRESS the RIGHT shift (EXITS SET UP).

7.2) **EKG CHECK-UP**
In an acceptable EKG display, every R-WAVE appearing on the analog display has a MATCHING GAP in the event marker line. Also, the LAST TIME value remains fairly consistent, varying only within a few hundred points (usually between 250 and 650).
ADJUST according to this list:
Signal is a FLAT LINE : Are electrodes PLUGGED IN ?
Signal DOESN'T LOOK like EKG : Is SUBJECT STILL?
TOO FEW GAPS or TIMES TOO LONG........Turn GAIN UP (GAIN x 1000).
TOO MANY GAPS or TIMES TOO SHORT... Turn GAIN DOWN.

7.3) **EMG CHECK-UP** Check numbers on channels FOUR, FIVE, SIX and SEVEN.

<u>Note</u>: Each number divided by TEN gives the amount of

microvolts. At this point, the smaller the readings, the better. Ask subject to TENSE forearm and check change on channel SEVEN. Ask subject to TENSE forehead and check change on channel SIX.
Ask subject to CLENCH and check change on channels FOUR and FIVE.
Ask subject to TURN his head slightly and check changes on FIVE.

7.4) **SCL CHECK-UP:** PLUG IN SCL short wires into outer jacks on extension cable.
Be sure they don't fall down from jacks easily.
Check for variability on channel ZERO (light blue). If none is present have the subject take a deep breath, which will usually produce a moderate and slow but noticeable response.

APPENDIX G

Protocol for Neutral Baseline

BEFORE HOOK-UP:

1. INTRODUCE YOURSELF in a mildly friendly, professional manner. Maintain a MILDLY FRIENDLY but IMPERSONAL ATTITUDE toward the subject.

2. GIVE subject a CONSENT FORM; be sure it is read thoroughly. Ask subject if he has any questions; obtain his signature and GIVE him a COPY of the form.

3. FILL OUT the DATA SHEET.

AFTER CHECKING SIGNALS:

1. EXPLAIN this part of the experiment to subject in a brief manner, you can paraphrase the following description:

" The purpose of this first part of the experiment is to study PHYSIOLOGICAL RESPONSES that accompany a NON-DEMANDING SITUATION. That is, we are interested in finding out about people when they are in a emotionally NEUTRAL SITUATION. We will be recording muscle tension, heart rate and skin resistance. You will be instructed about what to do but THERE IS NO PARTICULAR PERFORMANCE EXPECTED".

2. Continue instructions by saying: " We need you just to BE THERE, but is extremely important that you AVOID FALLING SLEEP. If I see you going to sleep, I will speak to you over the intercom. Also, your mind may wander after a while; if you notice that, try to refocus your attention on the slides that you will be seeing or the music you will be listening to".

A) **SLIDES:**

A.1) INSTRUCT subject to WATCH the slides; tell him that they were selected because they are non-arousing.

A.2) EMPHASIZE that the slides are arranged in a ARBITRARY ORDER and that there is no specific sequence or overall message that they convey.

A.3) REMIND him that he is only EXPECTED TO BE THERE and instruct him to AVOID SILENTLY TALKING TO HIMSELF.

A.4) INSTRUCT subject TO PRESS any of the joystick buttons EVERY TIME the STIMULI CHANGE either to a "BLUE SCREEN" or to a NEW SLIDE. This will help him or her to stay awake. REMIND HIM that you will know if he is not keeping up with the task.

B) **MUSICAL PIECES:**

B.1) REMIND subject that he is only expected TO BE THERE; instruct him to AVOID either TALKING to himself or "HUMMING" ANY particular MELODY. Tell him that it is o.k. if he likes a particular piece, but that he needs to ENJOY it in a quiet manner without reacting.

B.2) INSTRUCT subject TO PRESS any of the joystick buttons EVERY TIME the STIMULI CHANGE either to SILENCE or to a NEW MELODY. This will help him or her to stay awake. REMIND HIM that you will know if he is not keeping up with the task.

AFTER FIRST HALF IS COMPLETED:

1) ASK subject to "RATE" his REACTION experience to both stimuli on a rating form (i.e., semantic differential). ASK that he READ the INSTRUCTIONS carefully before proceeding to do the rating. GIVE him a BRIEF EXAMPLE.

After SESSION is COMPLETED:

1) ASK subject to "RATE" his REACTION experience to both stimuli on a rating form (i.e., semantic differential). ASK that he READ the INSTRUCTIONS carefully before proceeding to do the rating. GIVE him a BRIEF EXAMPLE.

2) UNHOOK subject, CLEAN electrode SITES.

3) ASK subject to ANSWER the RELAXATION EVALUATION.

IF FIRST SESSION:

4) EMPHASIZE that INFORMATION about the experiment should be KEPT STRICTLY CONFIDENTIAL, since some of his classmates or friends could be selected to participate in the experiment in the immediate future.

5) Be sure to ADDRESS any OBVIOUS DISCOMFORT or CONCERN about PERFORMANCE expressed by the subject. INVITE SUBJECT to GIVE YOU A CALL in the unlikely event that there is any LATER PHYSICAL or EMOTIONAL REACTION that seems to be RELATED to this experiment.

6) TURN OFF equipment in CHAMBER and CLEAN ELECTRODES.

IF LAST SESSION:

7) While doing step TWO, DEBRIEF subject on PURPOSE of the experiment. Be sure to mention the POTENTIAL BENEFITS that could be derived FROM the STUDY and FROM the LOW AROUSAL inducing TECHNIQUES he has LEARNED. EMPHASIZE that INFORMATION about the experiment should be KEPT STRICTLY CONFIDENTIAL, since some of his classmates or friends could be selected to participate in the experiment in the immediate future.

8) IF it is the FOURTH session, GIVE subject CREDIT SLIPS and/or MONEY earned, be sure to have a RECEIPT signed.

9) Be sure to ADDRESS any DISCOMFORT or CONCERN about PERFORMANCE that either the experimental material or the nature of the task may have produced in the subject. INVITE SUBJECT to GIVE YOU A CALL in the unlikely event that there is any LATER PHYSICAL or EMOTIONAL REACTION that seems to be RELATED to this experiment.

10) UNHOOK subject, CLEAN electrodes SITES.

11) OFFER subject an "EDUCATIONAL TOUR "to show him the recording equipment" and the computer that controls the experiment and store the data. Give him a brief EXPLANATION about HOW the "HARDWARE" and "SOFTWARE" work together.

APPENDIX H

Protocol for Pleasant Low Arousal

1. BE SURE to INCREASE established RAPPORT with subject asking a few semipersonal questions. Take some time to PUT SUBJECT AT EASE.

2. EXPLAIN this part of the session in a brief manner, you can paraphrase the following description:

" The purpose of this part of the experiment is to study physiological responses that accompany low arousal levels. That is, we are interested in people when they are relaxed. You will be instructed to try to relax deeply". Explain to him that he will be instructed in different relaxation techniques involving deep abdominal breathing, tensing and relaxing a few muscle groups and letting go all tension from major muscle groups of the body.

3. EXPLORE subject's PREVIOUS EXPERIENCE with SELF-REGULATION techniques such as relaxation, meditation or biofeedback. (FILL IN subject's data sheet).

3.1) In the affirmative case, find out WHAT KIND of technique, HOW LONG he has been practicing it and ask for an ESTIMATE of the LEVEL of RELAXATION attained. Tell the subject that his previous experience might facilitate the learning process and that he may practice his usual techniques after following the "standard instructions" that will be given to all participants for consistency purposes.

3.2) If the subject has had NO PREVIOUS EXPERIENCE with relaxation techniques, tell him that he is likely to have experienced deep relaxation before without being fully aware of it, such as when lying on the beach, watching a sunset, contemplating a beautiful landscape or when having pleasant daydreams. EXPLAIN to the subject that a RELAXED STATE is usually characterized by lack of muscle tension, slow and deep breathing, warm extremities and a nice sensation of inner quietness and calm. Explain to him that he will be INSTRUCTED in DIFFERENT relaxation TECHNIQUES involving TENSING and RELAXING different muscle groups and letting go all tension from major muscle groups of the body. Explain to the subject that he will also be asked to relax his muscles assisted by EMG BIOFEEDBACK. This procedure will consist of his decreasing the level of muscle tension by changing the pitch of a tone proportional to his tension. Tell the subject that as he attains deeper levels of relaxation, the sound will become deeper in tone.

4. <u>RELAXATION PROCEDURES</u>

4.1) PROGRESSIVE MUSCLE RELAXATION

4.1.1) Give subject a brief explanation of the overall procedure. You may paraphrase the following description:

"The FIRST phase of PMR involves the progressive TENSING and RELAXING of a few muscle groups. The second phase, "LETTING-GO", involves letting go of all tension, muscle group by muscle group, to help you relax completely. Although the exercise is a relaxation technique, we will start with tension because most individuals find it EASIER to go FROM a TENSED STATE to a RELAXED STATE than simply to relax. Progressing from a tensed state to a relaxed one also HELPS to DEVELOP the ABILITY to RECOGNIZE and differentiate FEELINGS of TENSION and RELAXATION. As you proceed through this exercise, a few muscle groups will be tensed for a short time and then relaxed. Each cycle will be done TWICE. You will follow these cues: "NOW" for tensing (10-15 s.), "RELAX" for relaxing (20 s.). After hearing "NOW", you should tense the muscles that I draw your attention to and hold the tension until you hear the word "RELAX". When you hear the word "RELAX" you should let all the tension go suddenly. As you go through cycles of tension-relaxation, you will be asked to pay attention to the sensations from your muscles. This exercise requires your active participation. As you become more and more relaxed, you may start feeling drowsy. DO NOT GO TO SLEEP; try to wake yourself up since it is important that you stay awake".

4.1.2) MODEL the first tense-relax cycle using your HAND. First make a tense fist then relax the tension; then dorsiflex (extend) hand (i.e., bend it backwards toward your shoulder) while tensing forearm muscles; then relax.

4.1.3) INSTRUCT subject to carry out the movement you have modeled; correct his form if necessary and then ask him to repeat the process.

4.1.4) MODEL the second tense-relax cycle. First flex your ARM at the elbow moving your hand toward your shoulder while tensing the biceps; then relax tensed muscles. Next straighten your arm with palm down and elbow locked while tensing the triceps; then relax.

4.1.5) INSTRUCT subject to carry out the movement you have modeled; correct his form if necessary and then ask him to repeat the process.

4.1.6) INFORM subject that he may close his eyes (but only if he wants to). Ask him to adjust himself comfortably in the reclining chair and LISTEN to your INSTRUCTIONS.

4.1.7) INSTRUCT subject to carry out the tense-relax process twice in succession for each of the following BODY AREAS (a brief period of relaxation follows each maneuver):

a) HANDS: make a FIST, then DORSIFLEX it (bend it backwards toward the shoulder).

b) ARMS: FLEX arm at elbow, moving fist close to shoulder and TENSE BICEPS; then EXTEND arm at shoulder and elbow as far as possible and TENSE TRICEPS.

c) FACE: FROWN, tensing all face muscles including jaws, forehead and eyelids.

4.1.8) During each tense-relax cycle ASK subject to CONCENTRATE on the FEELINGS of TENSION FIRST, and then on the CONTRAST with the relaxed state. Be sure to emphasize the relaxation phase by prolonging the pronunciation of this word using a soft, calming tone of voice:
(e.g., RELAXXXSSS...)

You may PARAPHRASE the following description and adapt it to each muscle group:

" FOCUS YOUR ATTENTION ON your right hand ...Clench your right fist... NOW...squeeze very hard...hold the tension there...be very AWARE OF THE TENSION and what it feels like right now...what does the hand feel like at this moment...HOLD THE TENSION.. be very aware of it...; RELAX... RELEASE the TENSION from your right arm and hand...let it FLOW OUT...let it DISSOLVE... FEEL your hand suddenly BECOME HEAVY, LOOSE, LIMP, RELAXED and SOFT...be very aware of the feelings in your hand right now and the way it felt a moment ago when they were very tense.

ONCE AGAIN...clench your right fist...NOW...once again make the hand very tense...make a lot of tension...SQUEEZE very hard...NOTICE HOW it FEELS to have a very tight hand... become very aware of this feeling...and NOW again... RELEASE all the tension...LET the TENSION DROP OFF...let the tension DISSOLVE...let your arm become very SOFT...the hand is becoming LOOSE...LIMP...HEAVY...RELAXED and SOFT. NOTICE how it's SUCH a CONTRAST with that tight,tense feeling of before...examine the contrast between the way it FEELS RIGHT NOW and the way it FELT JUST a MOMENT AGO when it was very tense".

4.2) LETTING-GO

4.2.1) INSTRUCT the subject to sit comfortably , close his eyes and take a deep breath. After that tell the subject TO CONCENTRATE on your VOICE. You may paraphrase the following instructions:

" You are sitting comfortably with your EYES CLOSED, all parts of your body are supported so there is no need to tense any muscle, just let go as best as you can. O.K, now FOCUS on the feelings in both your LEGS and LET GO any tension that might be there, LET ANY TENSION DISSOLVE, GO AWAY. RELAX your

FEET, your CALVES, the BACK of your THIGHS, the FRONT of your THIGHS, all those muscles become SOFT, LIMP, RELAXED. O.K, while you continue to let go the tension from your legs, FOCUS your attention in your ABDOMINAL area, DISSOLVE any TENSION there, let it go away, RELAX your PELVIC area, feel the relaxation, all those muscles relaxing deeply.

O.K,take a DEEP BREATH, another one, now your LEGS and your ABDOMINAL area are RELAXING DEEPER and DEEPER as you go on. Now TURN your ATTENTION to your LOWER BACK,let ANY TENSION remaining there GO AWAY,relax those muscles and FEEL the TENSION DRAINING OUT from your back INTO the CHAIR, let those MUSCLES become SOFT, LOOSE, LIMP. O.K. now SHIFT your attention to your CHEST and SHOULDERS, let ANY TENSION there just GO AWAY,let it DISSOLVE, RELAX your chest, both your shoulders, let THOSE MUSCLES become SOFT and LIMP.

O.K, while you continue relaxing your legs, abdominal area, chest and shoulders SHIFT your attention to your HANDS, RELAX them, LET any TENSION GO AWAY, now RELAX your LOWER ARMS, let them go, now RELAX your UPPER ARMS, let them BECOME SOFT, LOOSE, LIMP. O.K, take a DEEP BREATH and while you EXHALE FEEL your LEGS, PELVIC AREA, CHEST, SHOULDERS and both your hands and ARMS very RELAXED..very SOFT, LOOSE, LIMP. O.K. now release any tension on your UPPER BACK, on the BACK of your NECK, RELAX your NECK, your THROAT, LET all the TENSION FLOW AWAY from your neck INTO your CHAIR, just let it go.

O.K., SHIFT your ATTENTION to your FACE, RELAX the MUSCLES AROUND your MOUTH, let any TENSION there GO AWAY, let your LIPS come SLIGHTLY APART, RELAX your JAW, relax your TONGUE, LET it be LOOSE inside your mouth. Now, FEEL the RELAXATION SPREADING to your CHEEKS, SMOOTH the MUSCLES AROUND your EYES, let all the tension and FATIGUE around your eyes GO AWAY, now RELAX your FOREHEAD, let all the LINES SMOOTH out.

O.K., take a DEEP BREATH, ANOTHER one, FEEL how your LEGS, your ABDOMINAL AREA,your CHEST and SHOULDERS, your BACK, your NECK and your WHOLE FACE are BECOMING DEEPLY RELAXED.

O.K, now CONCENTRATE on the TOP of your HEAD, let any TENSION remaining there GO AWAY, let it dissolve, RELAX the SCALP from your HAIRLINE ALL the WAY DOWN to your NECK, let it become SOFT, LOOSE, LIMP, let it go.

NOW, your WHOLE BODY is BECOMING DEEPLY RELAXED, there is NO TENSION LEFT,you are letting go now and BECOME even MORE RELAXED, there is a NICE, WARM, PLEASANT SENSATION that you can FEEL ALL OVER your BODY and you are PROFOUNDLY RELAXED. TAKE a DEEP BREATH, ANOTHER one, and AS you EXHALE REALIZE how your LEGS, PELVIS, BACK, CHEST, SHOULDERS, NECK, FACE and SCALP are completely RELAXED, they are SOFT, LOOSE, LIMP. Now just STAY there and ENJOY IT".

LETTING GO SEQUENCE :

a) FEET, lower and upper LEGS.
b) ABDOMINAL area.

c) LOW BACK.
d) CHEST and SHOULDERS.
e) Both HANDS, lower ARMS and upper arms.
f) UPPER BACK, NECK and THROAT.
g) FACIAL muscles (Mouth, jaws, tongue, cheeks, eyes, forehead).
h) TOP of head (scalp and back of head).
i) Overview of the WHOLE BODY.

4.3) EMG BIOFEEDBACK

4.3.1) EXPLAIN briefly this relaxation technique. You may paraphrase the following explanation:

"Biofeedback is a SPECIAL form of feedback in which INFORMATION about your body's functioning, such as MUSCLE TENSION, is recorded and amplified by sensitive electronic instruments; the recorded information is then transformed so that it can be EASILY PERCEIVED and UNDERSTOOD.

In this experiment we will be using an audible signals. The PITCH of a TONE will be PROPORTIONAL to YOUR MUSCLE TENSION: the MORE TENSE you are, the HIGHER the TONE; the MORE RELAXED you are, the LOWER the TONE. This is what is referred to as biofeedback. When this type of information becomes available to a person, it becomes POSSIBLE for that person to LEARN to detect and CONTROL muscle TENSION more easily than he would otherwise be able to under normal circumstances.

Again, in this experiment you will notice that as you relax deeper and deeper, the pitch of the tone you will hear will decrease; it will get lower or deeper. Your TASK will be to DECREASE the PITCH of the TONE as MUCH AS POSSIBLE throughout the session. HOWEVER, DO NOT WORK at IT with effort; that could make you tense. Just LET it HAPPEN ".

4.3.2) INSTRUCT subject to "PLAY AROUND" with the tone for a few moments; e.g., TENSING and RELAXING different muscles of the FACE or ARM and NOTICING the CHANGES in the tone. ENCOURAGE subject to BE AWARE of how an INCREASE in muscle TENSION INCREASES the PITCH of the tone and how a DECREASE after TENSING, DIMINISHES the PITCH of the TONE.

4.3.3) INSTRUCT subject to TRY to DECREASE the TONE by RELAXING his MUSCLES.

4.3.4) TELL the subject that he is NOT supposed to FORCE the PROCESS, that his OWN BODY will FIND the WAY to decrease the tone and that he is supposed to just "LET IT HAPPEN....the EMG SIGNAL; will be JUST an INDICATOR of HOW RELAXED you are".

4.3.4) INFORM the subject that FOLLOWING the TONE can HELP him attain very DEEP level of RELAXATION and, once attained, help him to MAINTAIN IT. TELL subject that this a LEARNING PROCESS that takes PATIENCE and PRACTICE and may not happen in a short period.

4.3.5) ENCOURAGE the subject to INCORPORATE the SKILLS LEARNED in the "ABDOMINAL BREATHING" and "LETTING-GO" phases of his relaxation training IF THEY HELP him to DECREASE the PITCH of the tone but REMIND them to AVOID TALKING TO THEMSELVES.

4.3.6) TELL subject "PLEASE STAY AWAKE. This is important. If I see you GOING TO SLEEP, I WILL SPEAK TO YOU over the intercom ".

4.3.7) As part of the concern with going to sleep, EXPLAIN to the subject that EVERY FIVE MINUTES a "CHECK-UP" procedure will be carried out. The FEEDBACK TONE will STOP for a short period and he will have to RAISE the INDEX FINGER of his DOMINANT HAND until you ACKNOWLEDGE his movement THROUGH the INTERCOM. Instruct him to LISTEN to and FOLLOW your instructions WITHOUT TALKING to you.

4.3.8) INFORM him that the PITCH of the TONE may be HIGHER AFTER the FEEDBACK is RESUMED than before it was interrupted; EXPLAIN to him that this will be related to AN INCREASE in the SENSITIVITY of the EMG signal and that this will happen when he has been MAKING PROGRESS toward deeper relaxation. Reassure him that this means "JUST DOING FINE".

4.3.9) REMIND him that he is expected to PERFORM SILENTLY and instruct him to AVOID TALKING TO HIMSELF in excess, like making OVERT COMMENTS about his performance and MOVE AROUND UNNECESSARILY.

4.3.11) START EMG biofeedback typing "A" (Audio ON) and ask subject to TENSE FOREHEAD and pay ATTENTION to the CHANGE in PITCH. Remind him that the LOWER the PITCH the MORE RELAXED he is going to be.

4.3.12) ENCOURAGE him to ATTEND to the SOUND as a PERIPHERAL INPUT that will tell him the level of relaxation achieved. Tell him to use his BODY SENSATION as the "FIGURE" of his perception and the PITCH of the sound as the "GROUND".

4.3.13) CHECK with him if the VOLUME of the AUDIO signal is OK, otherwise adjust it with U (Up) or D (Down).

APPENDIX I

Protocol for Aversive High Arousal

1. GIVE instructions adopting a professional, distant manner. MAINTAIN an IMPERSONAL ATTITUDE toward the subject.

2. EXPLAIN this SECOND PART OF THE EXPERIMENT in a BRIEF MANNER; you can paraphrase the following description:

"The purpose of THIS SECOND PART is to STUDY PHYSIOLOGICAL RESPONSES that accompany DEMANDING SITUATIONS. You will expose to VISUAL and AUDITORY stimuli. Visual stimuli will consist of IMAGES OF wounds, burns and injured persons; auditory stimuli will consist of LOUD NOISES. We are interested in HOW ACCURATE and FAST your answers can be under demanding conditions. There seems to be a DIRECT RELATIONSHIP between ACCURACY and SPEED OF RESPONSES and INTELLECTUAL CAPACITY. That is, there is a PHYSIOLOGICAL I.Q. somewhat similar to the INTELLECTUAL I.Q. Your performance will be compared to the average performance for your age group. We will be recording muscle tension, heart rate and skin sweating and you will BE INSTRUCTED on HOW TO DO these tasks."

A) **AVERSIVE SLIDES**

A.1) TELL subject that he NEEDS TO WATCH each slide for the ENTIRE PERIOD that is going to be SHOWN so he CAN ANSWER the FORECOMING question CORRECTLY.

A.2) TELL subject that he will be ASKed a QUESTION AFTER each slide and he will have approximately SIX SECONDS to answer TRUE OR FALSE. These answers will be CLEARLY TRUE OR FALSE but he must watch the slide closely to be able to tell.

A.3) INSTRUCT subject to PRESS the BLACK BUTTON on the joystick if the answer is "TRUE" and the ORANGE one if it is "FALSE". Tell him that every time he press a button, his ANSWER will be REGISTERED BY THE COMPUTER which runs the testing.

A.4) TELL subject that his SCORE will be BASED only ON his WRONG ANSWERS. WARN HIM that LATE ANSWERS, independently if they are correct, WILL COUNT AS WRONG.

A.5) TELL the subject that his SCORE will be COMPARED TO the AVERAGE PERFORMANCE for his AGE GROUP. If he does BETTER than his age group, his "physiological I.Q." will be OVER 100; if he does WORSE, his I.Q. will be LESS than 100.

B) **AVERSIVE NOISE DISCRIMINATION TASK**

B.1) TELL subject that this is a DISCRIMINATION task in which he needs to COMPARE TWO NOISES in terms of either DURATION OR LOUDNESS. Explain to him that a message on the T.V. MONITOR will REMIND him WHICH comparison TO MAKE and will instruct him on WHICH choice each BUTTON TO PRESS.

B.2) EXPLAIN to subject that there will a LONG SERIES OF NOISES and that the task will ALWAYS be to COMPARE the LAST NOISE heard WITH the IMMEDIATELY previous ONE. The LAST noise will ALWAYS be the REFERENCE NOISE. That is, a judgment of "louder" will mean that the last noise was louder than the one before, while a judgment of "softer" will mean that the last noise was softer than the one before.

B.3) TELL subject that the ONLY EXCEPTION to this procedure will be the FIRST NOISE of each series, after which there will be no comparison to make.

B.4) REMIND subject that he needs to ANSWER RAPIDLY, otherwise he will get the MESSAGE "WRONG, GO FASTER"; this will COUNT AS A "MISS".

B.5) EXPLAIN to subject that his CHOICE is NOT THE RIGHT ONE, the message on the screen will be "WRONG...TRY HARDER". In addition, I WILL TELL YOU when you make an error OVER THE INTERCOM every other mistake.

B.6) TELL subject that his SCORE will be BASED only ON his FALSE ANSWERS BUT both his WRONG and LATE answers, will COUNT AS MISSES.

B.7) REMIND him that he is EXPECTED to PERFORM SILENTLY and instruct him to AVOID TALKING TO HIMSELF or MAKE OVERT COMMENTS about his performance.

B.8) REMIND subject to keep movement to a minimum.

B.9) BEFORE leaving experimental chamber TELL subject " I want you TO DO YOUR BEST ".

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