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# Gastric myoelectrical activity as an index of emotional arousal

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**Abstract**

Autonomic nervous system parameters such as electrodermal activity, heart rate, and facial EMG have been utilized extensively as measures of emotional arousal. One measure that has rarely been employed in this setting is gastric myoelectrical activity, despite the fact that "gut feelings" have an obvious and even profound role in everyday emotional life. It has been shown that the gastrointestinal system changes wall tonus and contraction rate during stressful tasks. However, the effects of emotionally salient stimuli on gastrointestinal motility have scarcely been studied. In the current study, emotional film clips designed to elicit happiness, disgust, fear, sadness, or no emotion (neutral) were presented to 16 normal participants. Electrogastrogram (EGG), skin conductance, and heart rate were measured while the participants viewed the film clips, and participants rated subjective arousal intensity and pleasantness of the film clips. We found that emotional film clips reliably induced the intended subjective feeling states. Also, EGG peak amplitudes in fear, disgust, sadness and happiness were higher than in the no emotion condition. There was a strong positive correlation ($r = 0.64$) between EGG peak amplitude and subjective ratings of arousal. This is the first evidence that gastric myoelectrical activity is strongly correlated with arousal ratings to emotionally salient stimuli, and it suggests that EGG may add useful information about how the body contributes to the phenomenology of emotion and feeling.


*Keywords:* Emotion; Arousal; Valence; Electrogastrogram; Film; Heart rate variability; Skin conductance; Autonomic nervous system; Stomach

## 1. Introduction

The body plays a key role in emotional states. In fact, everyday language is liberally sprinkled with references to this connection, especially in regard to the heart ("my heart raced," "my heart sank," "my heart skipped a beat") and the gastrointestinal system ("my stomach turned," "I had butterflies in the stomach"), and even for the skin ("my skin crawled," "It gave me goosebumps") and lungs ("he sighed in despair"). In psychophysiology, measures of electrodermal activity, cardiac function, facial EMG, and respiration have been used frequently to assess the emotional states of experimental participants (Bechara et al., 2000; Boiten, 1998; Bradley, 2000; Tranel, 2000). Remarkably, the gastrointestinal system has been almost completely neglected by emotion research.

Early descriptions of gastrointestinal physiology included references to changes in gastrointestinal activity associated with emotion and stress. One of the earliest reports of changes of stomach activity during "emotional states" is the famous case of Alexis Saint Martin, a man with a permanent gastric fistula due to a gunshot (Beaumont, 1833). This fistula allowed Beaumont to access the interior of the stomach and describe several physiological processes. Beaumont also noted changes in the color of the stomach mucous membrane due to stress and anger. After these quasi-anedoctal reports of changes in stomach activity during emotional states, Pavlov (1910) described the conditioning responses of sham feeding in dogs. He also showed that an established pattern of response could be disrupted by emotionally arousing events as described by the dog that did not produce salivary responses due to a stressful situation (Wolf, 1981). Later, Cannon (1929) reported diminished gastric acidity and motor activity in association with the fear response in cats, which he related to the fight or flight response. Wolf and Wolff (1947) also observed decreased acid

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secretion and motility of the stomach during fright and depression in a subject with a permanent gastric fistula. Additionally Cannon proposed that gastric contractions was a good measure for feelings of hunger (Cannon and Washburn, 1912). This relationship between a feeling state of hunger and gastric contractions was further demonstrated by Carlson (1916).

Changes in the gastrointestinal system during stress are well documented. For instance, Stern and coworkers reported changes in gastric myoelectrical activity in various stress-inducing tasks such as forehead cooling (Muth et al., 1999) and shock avoidance (Muth et al., 1998). There have been a few attempts to study changes of the gastrointestinal system associated with emotion. These studies are scarce, and there are conflicting findings. For instance, Baldaro et al. (1996) initially showed a decrease in electrogastrogram amplitude while participants were watching an unpleasant film. However, another study with similar methodology did not show differences in electrogastrogram when participants were presented with unpleasant films (Baldaro et al., 2001). Blomhoff et al. (2000) presented emotionally charged words to patients with irritable bowel syndrome and to normal subjects. The investigators measured rectal tone and brain event-related potentials. Overall changes in rectal tone occurred during exposure to emotionally charged words. However, the changes in rectal tone went in different directions (either positive or negative), and neither word type (positive v. negative) nor group predicted the direction of change. Overall, there is a striking paucity of data about the effects of emotionally salient stimuli on gastrointestinal motility.

The electrogastrogram (EGG) is a reliable and noninvasive method of recording gastric myoelectrical activity (Nelsen and Kohatsu, 1968; Smout et al., 1980). The gastric myoelectrical activity paces the contraction of the stomach and originates in a pacemaker region lateral to the gastroesophageal junction and is characterized by regularly recurring potentials. The gastric slow wave is present all the time, and controls the frequency and propagation of the contractions of the stomach. The normal frequency of the electrogastric wave is 3 cycles per minute (cpm), and is termed normogastria (Stern et al., 2000).

In the present study, emotionally salient films were presented to normal participants. While participants were viewing the films, electrogastrogram, skin conductance, and electrocardiogram were measured. Afterwards, participants were also asked to rate the arousal and valence of the emotion felt while watching films. The decision to use films to elicit emotional states was motivated by our desire to use strong, robust stimuli to induce emotion. Films involve more than one perceptual modality (Oatley, 2004), and they typically have a storyline. The principal psychophysiological measure of interest was the EGG. We also measured skin conductance response (SCR) and heart rate (HR), mainly as a means to have a point of comparison for these "tried and true" psychophysiological indices of emotional states. SCR and HR are reliable and well established measures of sympathetic and parasympathetic activation during emotional states (Akselrod et al., 1981; Burch and Greiner, 1960; Edelberg, 1972; Gunn et al., 1972).

## 2. Methods

### 2.1. Participants

All procedures were approved by The University of Iowa Institutional Review Board for Human Subjects Research. Sixteen participants (9 female; 7 male), mean age $M=26.7\pm2.99$, mean education $M=15.88\pm0.33$ years, were recruited for this study. Participants reported to the laboratory between 9 and 11 am after a 2-h fast. No participant had a history of gastrointestinal, neurological or psychiatric problems. Both length of fasting and medical history was based on self-report.

### 2.2. Psychophysiology

#### 2.2.1. Apparatus

The transducers, amplifiers, analog to digital converter (MP100WSW) and data acquisition (AcqKnowledge) were from Biopak, Inc. (Santa Barbara, CA). All psychophysiology measures were sampled at 200 Hz.

#### 2.2.2. Electrogastrography

EGGs were recorded using two disposable cutaneous Ag–AgCl electrodes. One electrode was placed above the umbilicus, and the second electrode was placed just below the lower left rib.

#### 2.2.3. Skin conductance

Skin conductance was recorded using disposable Ag–AgCl skin electrodes. Electrodes were placed on the thenar and hypothenar eminences of the right hand. Skin conductance output voltage was amplified by a factor of 5 μS/V and low-pass filtered at 10 Hz.

#### 2.2.4. Electrocardiogram

ECG signals were recorded using disposable cutaneous Ag–AgCl cutaneous electrodes. One electrode was attached just above the right clavicule, and the second was placed in the upper quadrant on the left side, just above the costal margin.

### 2.3. Emotional stimuli

Ten standardized films were used to elicit the discrete emotions of happiness, disgust, fear, and sadness, as well as no emotion (neutral). The films were selected on the basis of being powerful inducers of target emotion, and fairly selective in terms of inducing the target emotion but no other emotions. Several films clips were piloted, and only the ones that had the desired qualities were included in the final list (Boiten, 1998; Gross and Levenson, 1995; Waldstein et al., 2000). The film clips used were:

1. *Neutral*:
   A. *Germany: The Rhine and Mosel: The romantic road* (Steves, 1991). A scene showing the Mosel river. Length of film clip: 2.04 min.