ABSTRACT

ALTERING THE GAG: VALIDATING A SECONDARY PALM PRESSURE POINT

by Kerry Hankins

The gag reflex is a protective motor response that regularly interferes with dental procedures. Findings from a recent study suggest that applying pressure to the palm may be an effective and practical technique for clinical management of the gag reflex. The current study investigated the effect of multiple palm pressure points on the afferent limb of the gag reflex in addition to changes in concomitant autonomic responses. Results were analyzed utilizing multivariate modeling. The findings revealed a significant posterior movement of the gag reflex in 32/40 participants. Changes in autonomic responses (e.g. heart rate) were observed with the application of palm pressure. A follow-up study (N=10) was conducted to further explore the participants who did not respond to the initial treatment. All participants in the follow-up study demonstrated a significant reduction in gag reflex response.
ALTERING THE GAG: VALIDATING A SECONDARY PALM PRESSURE POSITION

A Thesis

Submitted to the
Faculty of Miami University
in partial fulfillment of
Master of the Arts
Department of Speech Pathology and Audiology

by
Kerry Ann Hankins

Miami University
Oxford, OH
2012

Advisor____________________________________
(Donna Scarborough, Ph.D.)

Reader____________________________________
(Michael Bailey-Van Kuren, Ph.D.)

Reader____________________________________
(Laura Kelly, Ph.D.)
Table of Contents

The Gag Reflex: Etiology, Prevalence, and Remedies ........................................1
Method ..................................................................................................................2
   Participants .......................................................................................................2
   Materials and Measures ..................................................................................3
   Procedures .......................................................................................................5
   Analyses ...........................................................................................................7
Results ...............................................................................................................8
   Descriptive Statistics .....................................................................................8
   Statistical Analysis .........................................................................................11
Discussion ..........................................................................................................14
Conclusion ..........................................................................................................19
Reference ..........................................................................................................20
Figures ..............................................................................................................22
Appendices ..........................................................................................................37
   Appendix A ....................................................................................................37
   Appendix B ....................................................................................................38
List of Tables

Table 1: Participant Criteria .................................................................2
Table 2 Gag Trigger Point Index ..........................................................4
Table 3: Method of Measurement for Autonomic Responses ......................5
Table 4: Summary of Participant Questionnaire Results ..........................9
Table 5: Scaled Perceptions ................................................................10
Table 6: A Comparison of Baseline and Treatment Trials Using a Least Square Means ANOVA .................................................................11
Table 7: Summary of Pressure Point Location Analysis .............................12
Table 8: Analysis of the Effect of Time Using a Type 3 Test of Fixed Effects ..........12
Table 9: Analysis of Order Effect Using a Solution for Fixed Effects .............12
Table 10: Test of Fixed Effects for Behavioral Autonomic Responses ...........13
List of Figures

Figure 1. Control Pressure Point ................................................................. 22
Figure 2. Hand Diagram from Pressure Point Location Pilot Study .................. 23
Figure 3. Hand Diagram from Pressure Variation Pilot Study .......................... 24
Figure 4. Hand Diagram for the Current Study ............................................ 25
Figure 5. Second Generation Hand Pressure Device .................................... 26
Figure 6. Gag Sensor Probe ...................................................................... 26
Figure 7. Anatomical View of Gag Trigger Point Index ................................. 27
Figure 8. Finger Pulse Oximeter ................................................................ 28
Figure 9. Pneumotrace II Respiration Transducers .................................... 29
Figure 10. Hand Measurement Protocol for the Current Study ...................... 30
Figure 11. Follow Up Methods ................................................................... 31
Figure 12. Positioning for First Generation Device Hand Scanning ................ 32
Figure 13. Positioning for Second Generation Device Hand Scanning .......... 32
Figure 14. Overall Perception of Gag Sensitivity ....................................... 33
Figure 15. Male Perceptions ..................................................................... 34
Figure 16. Female Perceptions .................................................................. 34
Figure 17. Heart Rate Variation ................................................................. 35
Figure 18. Example of Atypical Hand Dimensions ...................................... 36
Figure 19. Example of Typical Hand Dimensions ....................................... 36
The Gag Reflex: Etiology, Prevalence, and Remedies

The gag reflex is a protective motor response that prevents unwanted materials from entering the airway (Miller, 2002). Both sensory and motor components are involved in order to produce a gag reflex. The gag reflex is typically initiated by tactile stimulation of structures in the posterior one-third of the oropharynx (Kramer & Braham, 1977). However an individual may also initiate a gag reflex in response to various olfactory, acoustic, visual, and psychological stimuli (Murphy, 1979). Although the gag reflex is typically initiated in the posterior one-third of the oropharynx, some individuals who are more sensitive, elicit a gag reflex in unexpected regions in front of the anterior faucial pillars (Scarborough, Bailey Van-Kuren, & Hughes, 2008). The motor component of the gag reflex consists of a downward movement of the mandible, constriction of the pharynx, and elevation of the velum (Leder, 1996). Additional physiologic responses such as abdominal, thoracic, and diaphragmatic movements as well as, various autonomic responses have also been documented (Conny & Tedesco, 1983).

A recent study found that approximately 45% of individuals experience some degree of dental anxiety; a quarter of these individuals indicated gagging as a cause of dental anxiety. In addition, individuals who self-reported high levels of dental anxiety were more likely to attribute gagging as a cause (Armfield, 2010). Attempts have been made by dental professionals to manage the gag reflex with a variety of remedies, such as changes in respiratory patterns, behavior modification, and relaxation techniques with largely insignificant results (Bassi, Humphris, & Longman, 2004). To date pharmacological therapies and acupuncture via needle and laser stimulation to the mentolabial groove are believed to be the most effective means for successful management of the gag reflex during dental procedures (Fiske & Dickinson, 2001; Bassi et al, 2004; Sari & Sari, 2010). While the aforementioned methods have empirical support for use in the clinical setting, the techniques require advanced training and are invasive to patients. However, a recent research study revealed that the application of pressure to the center of the palm (see Figure 1) altered the afferent limb of the gag reflex in participants (N=40) with typical and hypersensitive gag reflexes. In other words, when pressure was applied to the palm of the hand, the trigger point of the gag moved more posteriorly in the oropharyngeal region. These preliminary findings suggest an alternative, effective and practical technique for management of the gag reflex in the clinical setting (Scarborough et al., 2008).
Due to the significant preliminary findings from Scarborough et al., (2008), the relationship between palm pressure and the gag reflex continued to be explored. Six additional pressure points were studied to test the variability surrounding the control pressure point, determined to be effective in Scarborough et al., (2008). Findings revealed two additional pressure points (points A and D) demonstrated the greatest effect on the afferent limb of the gag reflex (see Figure 2A). The focus of the continued research investigated the effect of varying degrees of force applied to the two aforementioned pressure points on the palm (see Figure 3). The results revealed that point A tended to be effective when 2lbs of force were delivered through a 1cm disk and Point D tended to be effective when at least 2lbs of force were delivered through a 2 cm disk (Figure 2A). Further, changes in concomitant autonomic responses such as heart rate, diaphoresis, and facial flushing were noted to occur with pressure applied to the palm. Specifically, an average heart rate variation (increases and decreases) of 30 bpm was observed (Scarborough, Bailey Van-Kuren, Hankins, Lanham, Mallon, Steiner, & Hughes, unpublished data, 2011).

To further investigate the aforementioned findings, the current study was initiated to document the degree of position variability of point D (see Figure 4) and to systematically observe changes in concomitant autonomic behavioral responses with the application of pressure to the palm. Based on the results of previous data, the following hypotheses were developed: 1) Point D is expected to be the most effective pressure point. 2) The use of the hand pressure device is expected to alter autonomic responses of lacrimation, diaphoresis, facial flushing, and heart rate.

**Method**

**Participants**

The Institutional Review Board of Miami University approved this study. Universal precautions for infection control were used in all participants. A total of 44 participants were recruited to participate in the study via flyers distributed throughout the university campus. The participants, who met inclusionary criteria (see Table 1), were reimbursed for their time and travel.

Table 1

Participant Criteria
<table>
<thead>
<tr>
<th>Inclusionary Criteria</th>
<th>Exclusionary Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Presented with self-reported normal to hypersensitive gag reflex</td>
<td>1) Significant bilateral damage to hands (broken bones in hands and/or wrists, nerve damage, surgeries, burns, etc.)</td>
</tr>
<tr>
<td>2) Neurologically intact adults between 18-40 years</td>
<td>2) Absent gag response with tactile stimulation to posterior pharyngeal wall. GTPI (see Table 2 and Figure 7).</td>
</tr>
<tr>
<td></td>
<td>3) Overt neurological difficulties (e.g. gait disturbances, tremors, physical asymmetries, abnormal vocal qualities, and speech/language difficulties.</td>
</tr>
</tbody>
</table>

**Materials and Measures**

**Hand Pressure Device.** A 2nd generation (U.S. Patent No. 20090292228, 2009), hand pressure device was developed specifically to apply discrete amounts of force to designated points on the palm. The new generation device is a convex hemisphere shape and was developed to accommodate all hand sizes without restriction (see Figure 5). Further, the hand pressure device adapts to both left and right hands with minimal. A hole was placed in the center of the hemisphere with an actuating cylinder fastened directly beneath the device. Force was applied by means of a voice coil actuator with a two inch-diameter circular disk that contacted a specific point on the participant’s palm. The device was powered by a bipolar operational power supply/amplifier, which allowed for manual control of the force applied to the participant’s hand.

**Gag Sensor Probe.** A prototype gag probe with a bend sensor potentiometer was utilized to record the amount of force applied to the anatomical structures stimulated to elicit a gag response (see Figure 6). As the probe contacted the inner surface of the oral cavity, the probe bent the flexible sensor and generated a change in the output voltage. Changes in output voltage were then recorded by a Dell Latitude laptop computer using Tracer Daq™ Software. A light was fastened to the end of the probe to allow for more accurate identification of the structures that were stimulated (Scarborough et al., 2008). Prior to use with each individual subject, the gag sensor probe was thoroughly sealed with a protective wrapping to comply with universal precautions.
**Gag Trigger Point Index.** Each gag reflex was rated using the Gag Trigger Point Index (GTPI). The GTPI scale quantifies the severity of the gag reflex on a scale of 0-8 in terms of anatomical structures within the oral cavity. GTPI ratings in more anterior oropharyngeal regions yield higher GTPI scores, while ratings in the posterior oropharyngeal regions yield low GTPI scores (see Table 2 and Figure 7). Each subject was provided with an initial baseline GTPI rating and 5 additional GTPI ratings following treatment trials.

Table 2
Summary of Gag Trigger Point Index

<table>
<thead>
<tr>
<th>Location of Gag Trigger Point</th>
<th>GTPI Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior Pharyngeal Wall, No Motor Response</td>
<td>0</td>
</tr>
<tr>
<td>Posterior Pharyngeal Wall, Motor Response</td>
<td>1</td>
</tr>
<tr>
<td>Between Posterior Faucial Pillars and Posterior Pharyngeal Wall</td>
<td>2</td>
</tr>
<tr>
<td>Posterior Faucial Pillars</td>
<td>3</td>
</tr>
<tr>
<td>Between Anterior Faucial Pillars and Posterior Faucial Pillars</td>
<td>4</td>
</tr>
<tr>
<td>Anterior Faucial Pillars</td>
<td>5</td>
</tr>
<tr>
<td>Between Second Molars and Anterior Faucial Pillars</td>
<td>6</td>
</tr>
<tr>
<td>Second Molars</td>
<td>7</td>
</tr>
<tr>
<td>Internal Cheek, Center</td>
<td>8</td>
</tr>
</tbody>
</table>

**Pulse Oximeter.** Heart rate and SpO2 were measured via a Contec CMS 50E finger pulse oximeter and recorded on a Dell Latitude laptop computer with SP02 Review software. The finger pulse oximeter was placed on the index finger of the non-treatment hand prior to initiating trials (see Figure 8).

**Video recording.** Autonomic responses were recorded via a video camera. Tape markings were placed on the floor to ensure the distance between the participants and video camera remained consistent between sessions. The video camera was then placed on a tripod and angled diagonally for an optimal view of the participant.

**Respiration Bands.** Two Pneumotrace II respiration transducers were securely placed below the underarms and over the navel to detect changes in thoracic and abdominal movements (see Figure 9). The PneumotraceII respiration transducers were connected to a DAQ board,
which in turn was connected to a Dell Latitude laptop computer. Thoracic and abdominal movements were monitored and recorded with TracerDaq™ Software.

**Electronic Timer.** An electronic split timer was used to record the times of each gag. The electronic timer was manually activated to synchronize with TracerDaq™ Software ([http://www.online-stopwatch.com/split-timer/](http://www.online-stopwatch.com/split-timer/)).

**Procedures**

Once participants signed an informed consent form, an oral questionnaire was administered in which participants were asked to report their medical history and provide a rating regarding their perceived gag reflex sensitivity (Appendix A). Participants were asked to remove all rings, watches, and jewelry from both hands. The treatment hand was randomly selected a priori; however, if the participant indicated previous injury to the randomly selected treatment hand, investigators utilized the uninjured hand. Following hand selection, calipers were used to obtain multiple hand dimensions (see Figure 10A). X and Y axis were calculated based on the participants’ hand measurements. Six pressure points were then plotted using coordinates calculated by computing 10% of the measurements of X and Y (see Figure 10B).

Once hands were appropriately marked, Pneumotrace II Respiration Transducers were secured across the chest and abdomen. The participant was then seated in a chair with his/her back towards the equipment to blind the participant to the specific amount of force applied to the palm. The Contec 50 E finger pulse oximeter was placed on the participant’s finger; a minimum sixty seconds was allotted for the device to calibrate. The online split timer, video camera, and TracerDaq™ Software were then initiated synchronously.

**Table 3**  
**Method of Measurement for Autonomic Responses**

<table>
<thead>
<tr>
<th>Autonomic Responses</th>
<th>Method of Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart Rate and Sp02</td>
<td>Monitored via Contec 50 E finger pulse oximeter. Recorded into SP02 Review software</td>
</tr>
<tr>
<td>Respiratory movements:</td>
<td><em>Pneumotrace II Chest Respiration Transducer:</em> measured thoracic respiratory patterns via band securely placed under participant’s underarms and fastened across the chest.</td>
</tr>
</tbody>
</table>
Behavioral Autonomic Responses

*Pneumotracer II Stomach Respiration*

**Transducer:** measure abdominal respiratory patterns via band securely fastened over participant’s navel.

**TracerDAQ™ Software:** recorded respiratory movements on Dell Latitude laptop computer

**Self-Report:** Lacrimation

**Video camera:** diaphoresis, facial flushing, withdrawal responses, grimacing

Following the aforementioned preparations, participants underwent a total of 7 gag trials. During all trials, a minimum of three investigators were present. A baseline gag reflex was elicited by the primary investigator (PI) using the gag sensor probe. When the baseline gag occurred, two pieces of data were recorded: 1) the time using the online split timer 2) the GTPI. Participants were then provided with a break of at least 60 seconds prior to initiating subsequent trials. Following the baseline trial, a 2cm disk was taped to a randomly selected point on the palm. The PI was blinded to the specific pressure point receiving treatment. The treatment hand was then placed on the second generation hand pressure device at a 90 degree angle with the actuator and disk in alignment. The device actuator was initiated via the bipolar power amplifier and 2 pounds of force were applied to the selected point on the palm prior to stimulation of the treatment gag. When the treatment was elicited, the time was recorded using the online split timer. The initial treatment gag reflex was then rated using the GTPI scale. Participants were then provided with a minimum of 60 second prior to initiating subsequent treatment trials. The participants then underwent 5 additional treatment trials with force applied randomly to the remaining five pressure points, repeating the process.

**Follow-Up Methods.** Ten participants from both current and previous studies, who did not respond to treatment trials, were called to participate in a follow-up session. This included 2 participants from previous studies and 8 from the current study. Participants were considered as having not responded to the treatment if the gag reflex showed absent or minimal (≤ 1 GTPI score) posterior movement with force applied to the palm. Participants were blinded to the objectives of the follow-up measure and were told that they were recruited “based on previous
The 10 participants were randomly assigned to two treatment groups. Each group consisted of 5 participants. The participants underwent a specific hand measurement protocol and received treatment from either the first or second generation hand pressure device depending on their group assignment. For example, the 5 participants assigned to Group 1, underwent the hand measurement protocol used in previous studies and received treatment from the second generation palm pressure device. The 5 participants assigned to group 2, underwent the hand measurement protocol used in the current study and received treatment from the first generation palm pressure device (See Figure 11).

**Hand Scans.** The 10 follow up participants underwent digital 3-D hand scanning to explore the possible effects of varying palm contours via a ZScan®700. The follow-up participants were matched with 10 participants who positively responded to treatment trials based on hand dimensions and gender. Prior to initiating hand scanning, participants were seated and asked to place the treatment hand on a table at approximately a 90 degree angle. Two pieces of foam were positioned under the participants’ treatment hand to provide comfort and stable positioning. The participant’s treatment hand was then stabilized with a modified first generation palm pressure device. The purpose of the modified first generation palm pressure device was to stabilize the digits for optimal 3-D imaging, and to mimic the curvature of the palm within the device (see Figure 12). Following completion of the initial hand scan, participants were provided with a short break. The participant’s hand was then positioned in a modified second generation palm pressure device for the second 3-D hand scan. The modified device was used to stabilize the fingers and mimic the curvature of the palm within the second generation device (see Figure 13).

**Analysis. Descriptive Statistics.** Microsoft Excel 2007 was used for the analysis of all descriptive statistics. Data on participants’ gag perceptions were entered into an excel spreadsheet and categorized into 6 separate columns entitled: low perception, low baseline GTPI, average perception, average GTPI, high perception, high GTPI. The data was then graphically displayed for comparison. Following the overall analysis of perception, data was divided for a comparison of gender.

Participant heart rate data was taken from the SP02 Review program and inputted into an excel spreadsheet. Excel formulas were used to identify the minimum and maximum heart rate for each participant. Participants’ minimum and maximum heart rates were then inputted into two separate columns and graphically displayed for comparison.
**Statistical Analysis.** Investigators collaborated with the Statistical Center for Consulting at Miami University in Oxford, OH, due to the complexity of primary statistical analyses. A priori was set to \( \alpha = 0.05 \) prior to analysis.

**GTPI Analysis.** Statistical Analysis Software 5.1 (SAS) for Microsoft was used for all statistics analyses. Mixed model analyses were used on GTPI measures adjusted for baseline (GTPI-Baseline), with an unstructured covariance structure for the subjects. Initially, the interaction effects between the factors were tested. If results indicated no significant interaction effects, the model was reduced to only include the main factors. Subsequently, tests for significant main effects were administered. For the treatment factors only, this model was used to check that the glove treatments were reducing the GTPI. This was done by testing the least squares means leveled factors. Each t-test evaluates if the adjusted GTPI score was significantly different from 0 (or equivalent, if the GTPI for a given level of the factor is significantly different from the baseline GTPI.) If the test revealed significance, a negative value for the least squares mean indicated a decrease in GTPI when that level of the factor was applied.

**Time/order effects.** Hierarchical models were used on the GTPI adjusted for baseline. For each subject, gags that were closer together appeared to be strongly related; conversely, gags that were further apart were not likely related. For this reason, an Autoregressive1 covariance structure was applied to the subjects. The effect of time was tested using a t-test. An estimate of the mean change in adjusted GTPI was also given. A negative value was indicative of a significant effect of time on the GTPI score.

**ANS Rater Agreement.** An Intraclass Correlation (specifically, an ICC (3, 1)) was calculated, (the “Shrout-Fleiss reliability: fixed set”). The ICC (3, 1) was chosen because all subjects were rated by four independent raters and tests were administered solely to determine inter-rater reliability.

**Results**

**Descriptive Statistics**

**Participants.** A total of 40 participants, 20 males and 20 females, met the inclusionary criteria to participate. All were between 18-27 years of age and presented with a self-reported normal to hypersensitive gag reflex. Ethnicities included: Caucasian 82.5%, African American 5%, Asian 5%, Middle Eastern 5%, and Hispanic 2.5%.
**Questionnaire.** All participants completed the oral survey regarding gag severity, significant implications of their gag reflex, and relevant medical history (see Table 4).

Table 4  
Summary of Participant Questionnaire Results

<table>
<thead>
<tr>
<th>Questionnaire</th>
<th>Results (n=40)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Were you born prematurely?</td>
<td>3</td>
</tr>
<tr>
<td>Do you avoid certain foods to avoid gagging?</td>
<td>6</td>
</tr>
<tr>
<td>Do you gag with certain Tastes</td>
<td>4</td>
</tr>
<tr>
<td>Textures</td>
<td>3</td>
</tr>
<tr>
<td>Smells</td>
<td>1</td>
</tr>
<tr>
<td>Sizes</td>
<td>1</td>
</tr>
<tr>
<td>Do you get regular 6-month dental check-ups?</td>
<td>30</td>
</tr>
<tr>
<td>Do you avoid going to the dentist because of your gag reflex?</td>
<td>0</td>
</tr>
<tr>
<td>Do you require any accommodations at the dentist because of your gag?</td>
<td>1</td>
</tr>
<tr>
<td>Are you on any medications for acid reflux?</td>
<td>1</td>
</tr>
<tr>
<td>Do you experience difficulty swallowing pills?</td>
<td>7</td>
</tr>
<tr>
<td>Large Pills Only</td>
<td>4</td>
</tr>
<tr>
<td>All Pills</td>
<td>3</td>
</tr>
<tr>
<td>Do you frequently gag or vomit?</td>
<td>3</td>
</tr>
<tr>
<td>Do you consider yourself a picky eater?</td>
<td>2</td>
</tr>
<tr>
<td>Taste:</td>
<td>1</td>
</tr>
<tr>
<td>Texture:</td>
<td>1</td>
</tr>
<tr>
<td>Size</td>
<td>1</td>
</tr>
<tr>
<td>Do you have a history of hand/wrist surgery?</td>
<td>3</td>
</tr>
<tr>
<td>Do you have Carpal Tunnel Syndrome?</td>
<td>2</td>
</tr>
<tr>
<td>Do you have a history of hand trauma</td>
<td>11</td>
</tr>
<tr>
<td>Right:</td>
<td>6</td>
</tr>
</tbody>
</table>
Left: 6
Small b/l injuries: 1
Do you have an unusual hand condition(s)? 2
Reynaud 1
Excessive Calluses 1
Are you an insulin dependent diabetic? 0
Are you on any heart medications? 0
Do you have any known heart issue? 1
Do you still have your tonsils? 36

**Perception.** All 40 participants provided a perceptual rating, on a scale from 1-10, of their perceived gag sensitivity prior to participating in baseline and treatment trials (See Appendix A). The perceptual rating scale and the GTPI scale were compared and divided into three categories (see Table 5).

Table 5
Scaled Perceptions

<table>
<thead>
<tr>
<th>Perception (1-10)</th>
<th>Baseline GTPI (0-8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low 1-3</td>
<td>Low 0-2</td>
</tr>
<tr>
<td>Average 4-6</td>
<td>Average 3-4</td>
</tr>
<tr>
<td>High 7-10</td>
<td>High 5-8</td>
</tr>
</tbody>
</table>

A comparison between participants’ perceived gag severity rating and their actual baseline GTPI scores revealed notable discrepancies. Overall participants with low or average GPTI ratings, overestimated the sensitivity of their gag reflex (see Figure 11). For example, only 2 participants provided a low sensitivity rating, yet 30 present with low GTPI baseline scores. Conversely, individuals with high GTPI baseline scores were relatively accurate in their gag perceptions. For example 6 participants rated their gag sensitivities as highly sensitive and 5 presented with high GTPI baseline scores.
Further, a comparison between female and male sensitivity ratings revealed that females overestimated the sensitivity of their gag reflex to a greater degree than male participants (see Figure 12 and Figure 13).

**Heart Rate.** The average heart rate across all subjects throughout the entire session was 80 beats per minute (bpm). Heart rate variation ranged between 15-52 bpm, with an average heart rate variation of 29 bpm (see Figure 17). Participants demonstrated both increases and decreases in heart rate. Sixteen participants recorded heart rates at 65 bpm or less, with the lowest recorded heart rate as 48 bpm. Sixteen participants demonstrated heart rates of 100 bpm with the highest heart rate recorded as 127 bpm.

**Statistical Analysis**

**Changes from baseline.** A total of 32/40 participants demonstrated a significant (≥2 positions on GTPI scale) posterior movement of the gag reflex. A Least Square Means ANOVA was used to determine the effect of palm pressure on the gag reflex. ANOVA results revealed a significant change in the gag reflex from baseline to treatment trials (see Table 6).

Table 6
Summary of Least Square Means ANOVA for baseline vs. treatment trial

<table>
<thead>
<tr>
<th>EFFECT: Treatment</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>Degrees of Freedom</th>
<th>T Value</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>-0.9000</td>
<td>0.1922</td>
<td>39</td>
<td>-4.69</td>
<td>&lt;.0001*</td>
</tr>
<tr>
<td>D</td>
<td>-1.0000</td>
<td>0.1861</td>
<td>39</td>
<td>-5.37</td>
<td>&lt;.0001*</td>
</tr>
<tr>
<td>D1</td>
<td>-0.9000</td>
<td>0.2051</td>
<td>39</td>
<td>-4.39</td>
<td>&lt;.0001*</td>
</tr>
<tr>
<td>D2</td>
<td>-0.7693</td>
<td>0.2026</td>
<td>39</td>
<td>-3.80</td>
<td>0.0005*</td>
</tr>
<tr>
<td>D3</td>
<td>-1.0745</td>
<td>0.2147</td>
<td>39</td>
<td>-5.00</td>
<td>&lt;.0001*</td>
</tr>
<tr>
<td>D4</td>
<td>-0.9000</td>
<td>0.1987</td>
<td>39</td>
<td>-4.53</td>
<td>&lt;.0001*</td>
</tr>
</tbody>
</table>

*indicates high statistical significance

**Single Pressure Point Location.** Although all treatments showed a significant difference from baseline, a Test of Fixed Effect revealed that one pressure point was not significantly more effective than others (see Table 7). Therefore, an “optimal”, or most effective pressure point, was not determined.
Table 7
Summary of Pressure Point Location Analysis

<table>
<thead>
<tr>
<th>EFFECT:</th>
<th>Numerator Degrees of Freedom</th>
<th>Denominator Degrees of Freedom</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure point location</td>
<td>5</td>
<td>39</td>
<td>1.64</td>
<td>0.1724</td>
</tr>
</tbody>
</table>

**Time Effects.** A Test of Fixed Effect was used to determine the degree of GTPI reduction per minute. Results revealed a significant posterior movement of 0.07 GPTI ratings per minute indicating palm pressure has a significant effect on the gag reflex over time (see Table 8).

Table 8
Summary of Time Effects

<table>
<thead>
<tr>
<th>EFFECT:</th>
<th>Numerator Degrees of Freedom</th>
<th>Denominator Degrees of Freedom</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Time</td>
<td>1</td>
<td>39</td>
<td>29.69</td>
<td>&lt;.0001 *</td>
</tr>
</tbody>
</table>

*indicates high statistical significance

**Order Effect.** A Solution for Fixed Effects was used to determine the effect of treatment order on the gag reflex. Results revealed that the order of treatments did not significantly affect the gag reflex (see Table 9).

Table 9
Summary of Order Effects

| EFFECT | Estimate | Standard Error | Degrees of freedom | T Value | Pr > |t| |
|--------|----------|----------------|--------------------|---------|------|---|
| Order  | -0.03690 | 0.04418        | 39                 | -0.84   | 0.4086 | |

**Gender.** A Type 3 Tests for Fixed Effects was used to determine the effect of gender on the gag reflex. Results revealed that the effect of gender was not significant.
**Follow up trials.** All 10 participants returned to participate in the follow-up session. All participants demonstrated a significant posterior movement of the gag reflex with pressure applied to the palm in follow-up trials.

**Behavioral Autonomic Responses.** Test of Fixed Effects was used to determine the relationship between participants GTPI scores and observed behavioral autonomic responses obtained via videotape. Results revealed significant changes in behavioral autonomic responses as GTPI scores increased (see Table 10).

A Test of Fixed Effects was then used to determine the relationship between the participants’ GTPI scores from each treatment and the presence of behavioral autonomic responses. Results revealed significant changes in behavioral autonomic responses when force was applied to the control point and D1. Further, results revealed that there were marginally significant changes in behavioral autonomic responses when force was applied to points D2 and D3.

| Effect   | Estimate | Standard Error | Degrees of Freedom | t Value | Pr>|t| |
|----------|----------|----------------|--------------------|---------|------|
| GTPI     | 0.3288   | 0.09792        | 3                  | 3.36    | 0.0020** |
| Baseline | 0.06881  | 0.05899        | 3                  | 1.17    | 0.3277 |
| Control  | 0.2827   | 0.07198        | 3                  | 3.93    | 0.0294** |
| D        | 0.1208   | 0.07458        | 3                  | 1.62    | 0.2038 |
| D1       | 0.5544   | 0.06845        | 3                  | 8.10    | 0.0039** |
| D2       | 0.1975   | 0.07102        | 3                  | 2.78    | 0.0689* |
| D3       | 0.2222   | 0.06745        | 3                  | 3.29    | 0.0460* |
| D4       | 0.1399   | 0.08160        | 3                  | 1.71    | 0.1850 |

*indicates marginal statistical significance  **indicates high statistical significance

Interclass correlations were used to determine inter-rater reliability between four independent viewers using the Shrout-Fleiss Reliability Fixed Set. Results revealed a strong correlation of 0.82 between raters (see Table 12).
Discussion

The findings from the current study revealed that palm pressure is an effective method for altering the afferent limb of the gag reflex. These findings are in accordance with previous studies that found that the application of pressure to the palm results in a functional posterior movement of the gag reflex (Scarborough et al., 2008). Although the application of pressure to all tested points resulted in a significant posterior movement of the gag reflex, a single “optimal” pressure point was not determined. In addition, changes in autonomic and behavioral responses were observed with palm pressure. This information presents a potential clinical benefit for patients who experience frequent gagging and physiologic responses that interfere with appropriate dental treatments (e.g. tongue guarding, retching, withdrawal responses, etc.).

The palm pressure device was designed to apply firm pressure to discrete points on the palm stimulating the palmar branch of the median nerve. The variability of palm pressure points was studied for commercialization and manufacturing of the device. A significant posterior movement of the gag reflex was observed with pressure applied to all tested points in both the original and follow-up studies. The connection between palm pressure and the gag reflex can be explained with a hypothetical model. The palmar cutaneous branch of the median nerves carries information on firm pressure to the dorsal root ganglion of the 7th cervical nerve (Martin, 1996), and is then transported to the subnucleus of the nucleus tractus solitarius (NTS) in the medulla oblongata (Gamoia-Esteves, Taveres, Almeida, Batten, McWilliam & Lima, 2001). In turn, the gag reflex is elicited by mechanical stimulation of the glossopharyngeal nerve and pharyngeal plexus. Sensory information then courses to the rostral nucleus tractus solitarius (NTS) within the medulla oblongata, where efferent components of the gag reflex are initiated. Therefore, it is theorized neurons activated with palm pressure send information to the cervical spinal cord laminae IV/ V, which then modulate the gag reflex in the ventrolateral subnucleus of the NTS via a collateral neuron. Although all tested pressure points were determined to be effective compared to baseline trials, a single “most effective” pressure point was not determined. The absence of a trend in pressure point location among the 40 participants may be attributed to the varying distribution of the palmar nerve and pacician corpuscles within the palm (Matloub, Yan, Mink Van Der Molen, Zhang, Sanger, 1998; Stark, Carlstedt, Hallin&Risling, 1998).

Although statistical significance between baseline and treatment trials was achieved for the current study, 8/40 participants did not respond or presented with minimal posterior
movement of the gag reflex ($\leq 1$ GTPI score). In previous pilot studies, only 2/80 participants did not respond to treatment trials. The decrease in participant response to treatment was believed to be attributed to two notable methodological changes in the current study: 1) the hand measurement protocol (see Figure 4), 2) hand pressure device (see Figure 5). To further explore the subset of participants who did not present with notable changes in the gag reflex, investigators initiated follow-up trials. Follow-up trials consisted of 10 participants who did not previously respond to treatment. Participants were randomly assigned to two treatment groups. The treatment groups were designed to test the aforementioned methodological changes believed to be causal to the decreased participant response to treatment (see Figure 11). For example, if the new hand device was causal to the decrease in response to treatment, the participants assigned to the Group 1 would show no response to treatment trials. Conversely, if the new hand measurement protocol was causal to decreased response to treatment, the participants assigned to Group 2 would demonstrate no response to treatment. However, results were unexpected, as all 10 participants demonstrated a significant posterior movement of the gag reflex. Results indicated that the decrease in participant response to treatment observed in the current study may be attributed to multiple factors, rather than a single cause.

Possible factors attributed to the initial decreased participant response to treatment include: technical difficulties related to the hand pressure device and variations in hand sizes and palm contours. On rare occasions, despite initiating the power source, the actuator did not engage and apply pressure to palm. After a careful review of the videotaped sessions, it is possible that the device malfunctioned in 3/10 participants’ initial sessions. Indicators of device malfunction included participant comments such as “I’m not feeling the pressure anymore”. In addition, when the actuator on the palm pressure device engaged fully, the device made a distinct sound. The videotape did not allow us to view the actuating device in that amount of detail, but auditory cues led us to the conclusion of possible device malfunction for 3/10 participants.

Despite careful measurements of each participant’s palm were taken, a number of participants demonstrated atypical hand shapes and palm contours, which effected the location of points plotted on the palm. For example, one follow up subject presented with a thumb positioned lower on the hand (see Figure 14). This participant’s pressure points were subsequently plotted lower on the palm than the majority of participants (see Figure 15). Therefore, force was not being applied to the appropriate positions on the palm.
Although all pressure points were effective, the findings revealed that the order in which pressure point treatments were presented, had no significant effect on the gag reflex; however, results revealed a time order effect. The time order effect indicated that following the application of pressure to the palm, the gag reflex moved posteriorly at a rate of 0.07 GTPI scores per minute. These results purport that participants tended to present with greater posterior movement of the gag reflex in the later treatment trials. This phenomenon cannot be explained as habituation, because each participant was provided with a minimum of 60 seconds to allow for the reflex to return to its’ baseline state to avoid effects of habituation (Jacobs & Grossman, 1980). However, further research is warranted to determine if this phenomenon is a result of a cumulative effect relating to potential neurotransmitters that may be affecting the rate at which posterior movement of the gag reflex occurs.

Although, results regarding posterior movement of the gag reflex were consistent with previous studies, the analysis of gender differences in the gag reflex yielded surprising results. A total of 5 participants presented with hypersensitive baseline GTPI scores (3 males; 2 females). Results indicated there were no significant differences in the gag reflex between genders. These findings are inconsistent with observations from a previous study in which a trend of gender was noted. Results of the previous study revealed that males with hypersensitive gag reflexes tended to elicit a response more anteriorly than women with hypersensitive gag reflexes, although results were not statistically significant (Scarborough et al., 2008). The rationale behind the discrepancies in gender effects are unknown at present and yield further investigation with a larger sample size of “hypersensitive” gaggers.

In addition to posterior movement of the gag reflex, changes in behavioral autonomic responses were observed with pressure applied to the palm. Throughout the literature, observations of autonomic responses have been reported to occur following elicitation of the gag reflex (e.g. lacrimation, excessive sweating, facial grimaces, tongue guarding, etc.) (Bassi et al., 2004). Further, these autonomic behavioral responses have been reported to be exaggerated in individuals with sensitive gag reflexes (Eitner, Wichmann & Holst, 2004). However, to our knowledge, this is the first study of its’ kind to report a statistically significant increase in the number of observed behavioral autonomic responses in individuals with more sensitive gag reflexes. In addition, results revealed decreases in the aforementioned autonomic behavioral responses with the application of pressure to discrete points on the palm (Control, Point D1, D3,
and D4). Continued analysis is needed to determine the functional applications of this information. Identification of the degree and direction (increase or decrease) of changes in autonomic responses are needed, in addition to, the specific responses that underwent the most change with the application of pressure.

Similar to changes in behavioral responses, interesting trends in heart rate variability were also observed in participants as well as changes in the gag reflex. Studies have found that the majority of individuals present with heart rate variation between 0-10 bpm at rest and 20-50 bpm during non-strenuous activities (e.g. valsalva maneuvers)(O’Brien, O’Hare & Corral, 1986). In addition to physical activity, increases in heart rate and heart rate variability are observed during stressful situations (Boomsma, van Ball, Orlebeke, 1990). Heart rate variability may be attributed to genetics, personality and environmental factors, (Wang et al., 2009; Burns & Katkin, 1992

A number of participants demonstrated an increase in heart rate during trials; however, this was expected due to the invasive nature of the tasks being asked of participants. To our surprise, many individuals also presented with unexpected decreases in heart rate to as low as 48 bpm (see Figure 15). To our knowledge, there are no studies specifically investigating the effect of palm pressure on heart rate. To explain this unusual phenomenon we hypothesize that a potential underlying neurologic mechanism is responsible. A previous hypothesis was developed to describe the potential mechanisms involved in altering autonomic responses such as heart rate through median nerve stimulation. It is theorized neurons activated with palm pressure are mediated in the ventrolateral subnucleus of the NTS. Similarly, cardiovascular afferents course upward to the caudal NTS via glossopharyngeal and vagal nerves. Within the caudal NTS, inputs from higher cortical areas coordinate with the afferent cardiovascular inputs to determine cardiovascular responses (Gamboa-Esteves, Tavares, Almeida, Batten, McWilliam & Lima, 2001). Due to the proximity and complexity of the NTS structures, it is not unreasonable to purport that firm pressure to the palm of the hand may influence the parasympathetic heart rate responses; thus, the observations of decreases in heart rate during gag trials with the application of palm pressure.

Furthermore, descriptive analysis of the participants’ responses to the oral questionnaire yielded surprising results as well. Participants were asked to report on a variety health conditions such as gagging while eating and/or going to the dentist, presence and severity of reflux, heart
conditions, etc. A variety of inaccuracies were discovered upon analysis. Participants both under- and over-reported symptoms they were experiencing. For example, only one participant indicated experiencing heartburn. The literature suggests that gastroesophageal reflux is the most common gastrointestinal disorder with 50% of Americans reporting symptoms (Johanson, 2000). It is likely participants under-reported or did not understand the symptoms of gastroesophageal reflux and therefore, provided inaccurate responses. In addition, 6 participants reported avoiding certain foods due to their gag reflex and 2 participants classified themselves as picky eaters; however, only 2 participants actually presented with a sensitive gag reflex. According to Pennebaker (2000), self-reported medical symptoms may be influenced by a variety of factors. An individual may be biologically experiencing a symptom, but their report of the symptom is subjective to how the individual attends to and interprets the severity of the symptoms.

Analysis of perceptual gag severity ratings revealed similar trends of discrepancies in self-report. A comparison between participants’ perceived gag sensitivities and their baseline GTPI scores revealed notable discrepancies. Participants with low baseline GTPI scores, tended to overestimate the sensitivity of their gag reflex. For example, 55% (22/40) of participants presented with low GTPI baseline scores. However, only 7% (3/40) accurately perceived their gag reflex as low. Conversely, participants who rated their gag reflex as highly sensitive, were more accurate in their perceptions. For example, 12.5% (5/40) of participants presented with highly sensitive baseline GTPI scores and 15% (6/40) of participants accurately perceived their gag reflex as highly sensitive. Further, a gender analysis revealed that females more females than males overestimated the sensitivity of their gag reflex. For example, 33.3% (3/9) male participants accurately perceived their gag reflex as “low sensitivity”, yet 0% (0/13) of females accurately perceived their gag reflex as “low sensitivity. Results are in accordance with the literature (Van Linden Van Den Heuvell, Pelkwijk & Stegenga, 2008; Pennebaker, 2000).

Multiple possibilities may be attributed to participants overestimating the sensitivity of their gag reflex. In the current study, a gag reflex was elicited by applying tactile stimulation to the posterior oral pharynx via a small gag probe (see Figure 6). Changes in the gag reflex were then measured by posterior movement of the gag trigger point via the GTPI scale (see Figure 6), rather than strength of the motor response. Therefore, an individual may trigger a gag reflex at
the posterior pharyngeal wall and fall within the “low sensitivity” category, yet present a strong motor response.

**Conclusions**

The current study found that the application of palm pressure is an effective method for altering the afferent limb of the gag reflex. However, a single “optimal” pressure point remains elusive at the present time and warrants further investigation. The current study also revealed both expected and unexpected changes in autonomic responses among the participants. Findings that signified increases in autonomic behavioral responses as gag severity increased were in accordance with previous autonomic observations noted throughout the literature. Further, increases in heart rate during gag trials were expected given the strenuous nature of eliciting a gag response; however, unexpected decreases in heart rate with palm pressure during gag trials, suggests a potential neurological mechanism relating firm pressure and parasympathetic responses.

**Limitations.** Preliminary findings revealed that the hand pressure device was effective in reducing the gag reflex in the laboratory setting; however, the effectiveness of the palm pressure device in the clinical setting is unknown at the present time. Future research is needed to determine the effectiveness of the palm pressure device during dental examinations and routine procedures. Further, the age range of participants in the current study was 18-27 years, with the average age being 20.4 years. Information on the effectiveness of the palm pressure device for populations beyond young healthy adults is needed to further the clinical benefit of the device in for individuals of all ages. In addition, the current study determined reduction of the gag reflex by measuring posterior movement in the oral cavity via GTPI scale. However, a number of participants elicited gag reflexes in the posterior oral pharynx, yet presented with strong motor responses. Therefore, the effect of palm pressure on the strength of the motor response in the gag reflex is unknown at present. Future studies should include a gag rating scale that encompasses both anatomical “trigger zones”, such as the GTPI, in addition to the strength of motor response.
Reference


Figure 1. The above diagram depicts Point Co. Point Co was determined to be effective in previous studies (Scarborough et al., 2008) and was used as the control point for the current study.
Figure 2.A. The above diagram depicts the hand pressure points tested in previous unpublished pilot studies. The purpose of the study was to determine the variability of pressure points surrounding the control pressure point. Point Co was used as the control pressure point, as it was determined to be effective from Scarborough et al. (2008). All pressure points resulted in significant posterior movement of the gag reflex compared to baseline trials. However, Point A was the most effective pressure point with the application of 2lbs of force onto a 1cm disk and, Point D was the most effective pressure point with the application of 2lbs of force onto a 2cm disk (Scarborough, Bailey Van-Kuren, Hankins, Lanham, Mallon, Steiner, & Hughes, unpublished data, 2011).

Figure 2.B. The above diagram depicts the measurements taken from each subject from the Pressure Point Location Pilot Study. The following measurements were taken from each participant: 1) Width of the wrist, 2) Width of the middle finger base, 3) Width of the palm. The following axes were created based on the aforementioned methods: X axis: created from the angle of the thumb across the palm, Y axis: created from the midpoint of the wrist coursing upward to the midpoint of the base of the middle finger.
Figure 3. The above diagram depicts the pressure points tested in an unpublished pilot study. The study aimed to determine the degree of pressure variability on previously tested palm pressure points. Four different degrees of force were applied to above points on the palm: 0.5lbs, 1lbs, 2lbs, and 3lbs. Results indicated that 2lbs of force had more effect than 0.5lbs and 1lb; however, there were no differences between 2lbs and 3lbs of force. Point D was determined to be the most effective point (Scarborough, Bailey Van-Kuren, Hankins, Lanham, Mallon, Steiner, & Hughes, unpublished data, 2011).
Figure 4. The above diagram depicts the pressure points tested in the current study. Point Co and Point D were control points, as both were determined to be effective from previous studies.
**Figure 5.** Second Generation Hand Pressure Device

The above photograph depicts the second generation hand pressure device.

**Figure 6.** Gag Sensor Probe

The above photograph depicts the gag sensor probe used to elicit gags from participants.
Figure 7. The above diagram represents a lateral view of the Gag Trigger Point Index (GTPI). The GTPI scale ranges from 0-8. A GTPI score of 8 indicates the participant elicited a gag reflex, including both velar and pharyngeal contraction, at the internal cheek. The GTPI scale gradually decreases towards the posterior oral cavity. A score of 0 indicates an absent motor response with tactile stimulation to the posterior pharyngeal wall, while a score of 1 indicates the participant elicited a gag reflex at the posterior pharyngeal wall.
Figure 8. Finger Pulse Oximeter

Figure 8. The Contec 50E Finger Pulse Oximeter was placed on the index finger. A minimum of 60 seconds was allotted for the device to calibrate appropriately. The pulse oximeter was connected to a Dell Latitude laptop computer and results were record via SP02 Review software.
Figure 9. Two Pneumotrace II respiration transducers were placed onto the participant. The chest respiration transducer was placed under the underarms and securely fasted over the participant’s shirt. The participant was then asked to place the abdominal respiration transducer on the navel over the shirt. The abdominal respiration transducer was then securely fasted.
Figure 10. Hand Measurement Protocol for the Current Study:

Figure 10.A. Calipers were used to obtain the following measurements from each participant: 1) Distance between the distal metacarpophalangeal joint to the distal wrist; 2) Thickness of the palm; 3) Width of the Wrist; 4) Y axis: Length of the palm measured from the midpoint of the wrist; 5) X axis: Width of the palm measured from the angle of the thumb to the midpoint of measurement 1.

Figure 10.B. The pressure points displayed above were plotted based on the aforementioned measurement.
The 10 subjects were randomly assigned to two groups. Group 1 participants underwent the hand measurement protocol used in previous studies (see Figure 2). Group 1 participants then received treatment to all seven points via the second generation palm pressure device. Group 2 participants received underwent the hand measurement protocol used in the current study (see Figure 4). Group 2 participants then received treatment to the 6 pressure points tested in current study via the first generation palm pressure device.
Figure 12. Positioning for First Generation Device Hand Scanning

Figure 13. Positioning for Second Generation Device Hand Scanning
Figure 14. Overall Perception of Gag Sensitivity

The above graph displays the perceptions and baseline GTPI scores of all 40 participants. The results were as follows: Low Perceived Sensitivity: 3, Low GTPI Baseline: 22, Average Perceived Sensitivity 31, Average GTPI Baseline: 13, High Perceived Sensitivity: 6, High GTPI baseline: 5.
Figure 15. Male Perceptions

Figure 16. Female Perceptions

Figure 12. The above graph displays the perceptions and baseline GTPI scores of all 20 male participants. The results were as follows: Low Perceived Sensitivity: 3, Low GTPI Baseline: 9, Average Perceived Sensitivity 15, Average GTPI Baseline: 8, High Perceived Sensitivity: 2, High GTPI baseline: 3.

Figure 13. The above graph displays the perceptions and baseline GTPI scores of all 20 female participants. The results were as follows: Low Perceived Sensitivity: 0, Low GTPI Baseline: 13, Average Perceived Sensitivity 16, Average GTPI Baseline: 5, High Perceived Sensitivity: 4, High GTPI baseline: 2
Figure 17. All 40 participants’ heart rates were monitored and recorded via the finger pulse oximeter and the Sp02 Review software program. The above graph displays both the minimum heart rate and maximum heart rates during all trials. The average variation in heart rate was 29 bpm and the maximum heart rate variation was 52 bpm.
Figure 18. Example of Atypical Hand Dimensions

The subject above presents with a thumb positioned at a lower on the hand. As a result, the X axis was plotted lower on the palm, which in turn, resulted in inaccurate positioning of all pressure points.

Figure 19. Example of Typical Hand Dimensions

The subject above presents with more standard hand dimensions with the control point positioned appropriately at the center of the palm.
# Appendix A

## Table 1. Participant Questionnaire

<table>
<thead>
<tr>
<th>Participant Questionnaire</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) On a scale of 1-10, how would you rate the severity of your gag reflex?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1 = absent) (5=normal) (10= severe)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) Were you born prematurely?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) Do you avoid certain foods to avoid gagging?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) Do you get regular 6-month dental check-ups?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5) Do you avoid going to the dentist because of your gag reflex?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6) Do you require any accommodations at the dentist because of your gag?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7) Are you on any medications for acid reflux?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8) Do you experience difficulty swallowing pills?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9) Do you frequently gag or vomit?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10) Do you consider yourself a picky eater?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11) Do you have a history of hand/wrist surgery?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12) Do you have Carpal Tunnel Syndrome?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13) Do you have a history of hand trauma (i.e. burns or broken bones)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14) Do you have an unusual hand condition(s)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15) Are you an insulin dependent diabetic?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16) Are you on any heart medications?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17) Do you have any known heart issue?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18) Do you still have your tonsils?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix B

Figure 1. Autonomic Nervous System Coding Methods

- A (1) indicates, behavior occurred
- A (0) indicates, behavior did not occur
  - Both EW: Both eyes (bilateral) eye watering
  - Right EW: Right eye watered only
  - Left EW: Left eye watered only
  - SW: Sweating
  - Facial Flush: Change in coloring of the face or neck
  - Cough: Only those that were within the gag time and/or if it was written down (up to 5 seconds)
  - Tongue Guard: Investigator indicated tongue guarding or you could see the tongue guarding as the probe was entering the oral cavity
  - Withdrawal Response: Posterior retraction of the head; as the gag was occurring or immediately following the gag
  - Facial Grimace: Squinting of eyes and or a change in facial expression (negative facial expression); as the gag was occurring or immediately following the gag
  - Retch: pre-emesis vocalization immediately following gag reflex
  - Forward Rocking Movement: Participant demonstrated forward rocking motion

**Note: Some subjects were noted to have both a withdrawal and a simultaneous change in facial expression. In these instances add a 1 to both categories.**