The Effect of Interoceptive Awareness and Diagnosis of Anorexia Nervosa on Susceptibility to the Rubber Hand Illusion

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Abstract

**Introduction.** Previous studies have reported that women with anorexia nervosa (AN) are more susceptible to the rubber hand illusion—a perceptual illusion used to measure somatosensory processing deficits—compared to healthy women. Susceptibility to the rubber hand illusion is measured by a shift in perceived location of one’s index finger and skin temperature changes pre- and post-exposure to the task as well as a self-report questionnaire. This study aimed to assess whether there is a significant effect of an interoceptive-awareness-raising task on susceptibility to the illusion.

**Methods.** The rubber hand illusion was elicited twice (once during each of the two visits) in 19 healthy women (HC group) and 13 women with a current diagnosis of AN. Skin temperatures were taken before and during exposure to the rubber hand illusion. Perceived locations of the index finger were measured before and after exposure. All participants filled out a self-report questionnaire about their experience of the illusion after exposure. During the second visit, participants monitored and reported their perceived heart beats before undergoing the rubber hand illusion task.

**Results.** Women with AN had significantly lower scores on the Body Awareness Questionnaire compared to healthy control women. Contrary to previous research findings, women with AN endorsed less susceptibility to the rubber hand illusion compared to healthy women based on results from a self-report questionnaire, and there were no significant differences in perceived index finger location changes (proprioceptive drift) between AN and HC groups. There was a trend toward women with AN having a lower interoceptive sensitivity score based on a heart-rate monitoring task. When age and body awareness were controlled for, there was a trend of a difference between healthy control women and women with AN on right hand skin temperature changes pre- and post-exposure to the rubber hand illusion.

**Discussion.** Nonsignificant results on the heart rate monitoring task and proprioceptive drift could have resulted from a change in methodology used in this study. On subjective measures, women with AN are less likely to report feeling susceptible to the illusion. Low body awareness and higher age may cause women with AN to be less likely to endorse susceptibility to the rubber hand illusion. Because there were no significant differences in any measure across visits, no support was found for a possible learning effect or effect of the heart-rate monitoring (possible interoceptive awareness-raising) task. Future research should seek to find support for either explanation. The rubber hand illusion could be used a therapeutic tool to assess somatosensory processing deficits in women with AN.

**Keywords:** rubber hand illusion, interoceptive awareness, body awareness, anorexia nervosa, heart rate monitoring, skin temperature, proprioceptive drift
Effect of Interoceptive Awareness and Diagnosis of Anorexia Nervosa on Susceptibility to the Rubber Hand Illusion

The inability of women with anorexia nervosa (AN) to accurately report their body size is one of the most bewildering aspects of the disease. Many individuals with AN report distorted perceptions of body shape and size (Cash & Deagle, 1996; Guardia et al., 2010) and have difficulty in predicting the boundaries of their own bodies (Nico et al., 2010). This perceptual deficit is not a generalized deficit in object shape and size perception but rather seems to be a specific deficit in processing somatosensory information about one’s own body (Cash & Deagle, 1996). Women with anorexia also often report thinking that they are fat, large, and oversized (Meyer, Arcelus, & Wright, 2009; Pierloot & Houben, 1978; Schneider, Frieler, Pfeiffer, Lehmkuhl, & Salbach-Andrae, 2009) which, in turn, fuels eating disorder pathology (Exterkate, Vriesendorp, & de Jong, 2009).

In recent years, researchers have attempted to measure somatosensory processing deficits in AN with a task known as the rubber hand illusion. In the rubber hand illusion, a participant places his or her real hand into a section of a two-compartment box with an opaque cover. A life-like rubber hand is placed in a neighboring compartment with a transparent cover. An experimenter synchronously strokes the participant’s unseen real hand and the visible rubber hand using two paintbrushes (Botvinick & Cohen, 1998). While experiencing the visual cue of seeing the paintbrush stroking the rubber hand and the tactile cue of feeling the stroking of the paintbrush on one’s unseen hand, participants report that they feel bodily ownership of the rubber hand (Tsakiris, Tajadura-Jiménez, & Costantini, 2011). Most participants also report feeling their unseen real hand drifting toward the rubber hand during the illusion: this is called
**proprioceptive drift**, and it is often used as a measure of the strength of the illusion (Botvinick & Cohen, 1998; Eshkevari, Rieger, Longo, Haggard, & Treasure, 2011; Mussap & Salton, 2006; Thakkar, Nichols, McIntosh, & Park, 2011; Tsakiris et al., 2011).

Women with AN have been found to be more susceptible to the rubber hand illusion than healthy individuals on both subjective (self-report questionnaire) and perceptual (proprioceptive drift) measures (Eshkevari et al., 2011). Women with eating disorders may be more easily tricked by the false visual input of the illusion and likely have difficulty recognizing the proprioceptive sensory signals that would indicate where their hand is located (Eshkevari et al., 2011) because they have lower interoceptive awareness. Interoceptive awareness, the ability to recognize and respond to internal body signals and emotional states (Matsumoto et al., 2006), has been found to be lower in women with AN than healthy women (Lilenfeld, Wonderlich, Riso, Crosby, & Mitchell, 2006) and is an important factor in determining proprioceptive sensation.

Lower interoceptive awareness could cause women with AN to be more heavily influenced by external visual cues about the location of their hand and lead to increased susceptibility to the rubber hand illusion. However, no studies have tested whether there is an association between interoceptive awareness and the strength of the rubber hand illusion in women with eating disorders. Thus, the overarching goal of the current study is to determine the association between interoceptive awareness and susceptibility to the rubber hand illusion in women with and without AN.
Anorexia Nervosa: Prevalence and Symptoms

Anorexia nervosa is a mental illness characterized by an inability to maintain one’s body weight at or above 85% of the normal body mass index for a person of that particular age and height, over-evaluating one’s shape and size, having a distorted body image, amenorrhea, and intensely fearing weight gain (*Diagnostic and Statistical Manual of Mental Disorders; 4th ed., text rev.; DSM-IV-TR;* American Psychiatric Association [APA], 2000). Chronic depression, anxiety, obsessive-compulsive disorder, and other mood disorders are also frequently comorbid (Godart et al., 2007; Touchette et al., 2010).

A significant number of individuals with AN die from malnutrition and starvation, and there is a high rate of suicide in women diagnosed with AN (Keel et al., 2003). Men and women with anorexia who are diagnosed in their 20s are 18 times more likely to die compared to healthy individuals matched by age (Arcelus, Mitchell, Wales, & Nielsen, 2011). The road to recovery is long and difficult for individuals with AN. At a 21-year follow-up assessment, only 50.6% of individuals diagnosed with AN had recovered, and 10.4% continued to meet the diagnostic criteria for AN fully (Zipfel, Loewe, Reas, Deter, & Herzog, 2000). Discovering new approaches to treatment is especially critical because the treatments for adults with AN are largely ineffective. In a recent long-term follow-up study, only half of participants recovered when treated using the most common therapy, cognitive-behavioral therapy (CBT; Carter et al., 2011).
Interoceptive Awareness and Anorexia Nervosa

A lack of interoceptive awareness in patients with AN may unintentionally contribute to the onset and maintenance of disordered eating. Having trouble distinguishing between satiety and hunger and between sensation and feeling is thought to be a core characteristic of AN (Bruch, 1973; Fassino, Piero, Gramaglia, & Abbate-Daga, 2004; Garner, Olmstead, & Polivy, 1983). Low interoceptive awareness has been theorized to perpetuate disordered eating by contributing to negative body attitudes in women with AN (Exerkate et al., 2009). It causes women to ignore hunger cues and to misinterpret satiety cues as feeling “bloated” (Polivy & Herman, 2002). Interoceptive awareness appears to improve with recovery. Based on scores from the Eating Disorders Inventory (EDI), Matsumoto et al. (2006) and Garner et al. (1983) reported that recovered individuals have improved interoceptive awareness scores.

Although many previous studies have used responses from the EDI (Garner et al., 1983) to judge interoceptive awareness in women with eating disorders, some have questioned whether self-report responses of interoceptive awareness are biased by cognitive and emotional factors (Pollatos et al., 2008). Women with AN have less cognitive flexibility in comparison to healthy women (Abbate-Daga et al., 2011). For example, to an individual with AN, each self-report questionnaire item seems like it should have a “right” and “wrong” answer, and it can be challenging for low-weight individuals to think abstractly about their bodies. Both of these factors might contribute to inaccurate self-reports regarding interoceptive awareness. Thus, more recently, a heart rate monitoring task was used to assess levels of interoceptive awareness in women with AN (Pollatos et al., 2008). This task directly measures interoceptive awareness and is unbiased by cognitive and emotional factors.
In the heart rate monitoring task, participants close their eyes and count the number of heartbeats that occur during four time intervals (25 s, 35 s, 45 s, 100 s). They are unable to hold a hand to their chest or apply pressure to a pulse point while counting. Each individual’s counted heartbeats are compared to the actual number of heartbeats that occurred during each interval. Women with AN were less accurate in counting their own heart beat compared to a control group of healthy participants (Pollatos et al., 2008). In addition, even in healthy control women, those who are more accurate at judging their own heartbeat are less likely to self-objectify and treat their body like an object (Ainley & Tsakiris, 2013).

**Biological Basis for Proprioceptive Processing Deficits**

Fundamental differences in brain activation between individuals with AN and healthy individuals may contribute to the deficits women with AN demonstrate in processing proprioceptive information. The insula—a portion of the cerebral cortex between the temporal and frontal lobes—processes spatial information about the body (Bonda, Petrides, Frey, & Evans, 1995), integrates different sensory inputs, and relays information from the somatosensory cortex to the limbic system (Nunn, Frampton, Gordon, & Lask, 2008; Schneider, Friedman, & Mishkin, 1993). The insular cortex is thought to be the major region of the brain activated in self-recognition and recognizing other highly familiar individuals (Devue, et al, 2007). The activity of the insula is altered in women with AN. In contrast to healthy control women, when women with AN viewed images of themselves, the insula was not activated (Sachdev et al., 2008). However, when viewing images of other people, patients with AN had normal activation of the insula (Sachdev, Mondraty, Wen, & Gulliford, 2008).
Inactivation of the insula could explain the self-image disturbances and negative attitudes about one’s own body common in individuals with AN. Women with AN may have difficulty recognizing parts of their body. This abnormal somatosensory processing deficit is not usually targeted in cognitive-behavioral therapy, but the rubber hand illusion task could be used as a method to assess the severity of this deficit. Assessing the role of perceptual deficits in body image distortions can be difficult in individuals with AN because emotional and cognitive factors also contribute to body image disturbances (Eshkevari et al., 2011). To determine where psychotherapeutic treatment should be focused, the current study aims to provide support for using the rubber hand illusion to judge perceptual deficits in women with AN.

**Hypotheses and Importance of Current Study**

Prior research indicates that women with AN have distorted body size and shape judgments and somatosensory deficits. In the current study, I predict women with AN will be more susceptible to rubber hand illusion. I predict they will have a higher proprioceptive drift, greater decreases in skin temperature of their right hands compared to healthy controls, and have higher scores on the self-report, subjective Rubber Hand Illusion Questionnaire.

In previous studies involving the rubber hand illusion (Thakkar et al., 2011; Moseley et al., 2008), participants’ skin temperature of their right hand decreased with increasing strength of the illusion. After the rubber hand illusion task, the skin temperature was on average 0.27 °C cooler than the baseline temperature (Moseley et al., 2008). The skin temperature decrease could be the result of blood flow being directed away from the right hand. If the brain is
susceptible to the illusion and is tricked into adopting the rubber hand as its own hand, blood flow may be directed away from the actual right hand causing a decrease in skin temperature (Charkoudian, 2003).

Because they are less attuned to their own bodies and more heavily affected by environmental cues, women, both healthy controls and women with AN, who have low interoceptive awareness will be more susceptible to the rubber hand illusion. Women with low interoceptive awareness should have a higher proprioceptive drift, greater decreases in skin temperature of their right hands, and higher scores on the Rubber Hand Illusion Questionnaire compared to women with high interoceptive awareness.

Another aim of the study is examining if there is a difference between participants responses to the rubber hand illusion task across visits. Participants may be more susceptible to the illusion when completing the rubber hand illusion task a second time. Having gone through the task procedure once, an individual may be more accustomed to and less likely to be distracted by the novelty of the experimental procedure. A significant increase in proprioceptive drift scores, and Rubber Hand Illusion Questionnaire scores and a greater decrease in skin temperature change between Visit 1 and Visit 2 would provide support for this hypothesized effect.

In the current study, it is hypothesized that women with AN will have lower interoceptive awareness than women who do not have AN. Furthermore, it is hypothesized that women who have low interoceptive awareness will be more susceptible to the rubber hand illusion than women have high interoceptive awareness. Participants in the current study will complete the rubber hand illusion task twice during two visits spaced 2-12 days apart.
Although previous studies have not examined whether there is a learning effect associated with multiple administrations of the rubber hand illusion task, I hypothesize that participants will be more susceptible to the illusion on the second visit following the interoceptive awareness task.

Method

Participants

All participants were right-handed, female, over the age of 18, and had normal or corrected-to-normal vision. Since the prevalence of AN is approximately ten times higher in women than in men (Woodside et al., 2001), this study only included women.

The group of healthy control women (N=19) consisted of a convenience sample of female undergraduate students enrolled in an introductory psychology class at a large public university in the Southeast. These students volunteered to take part in the study to fulfill a course requirement. None of the healthy controls reported having a diagnosed eating disorder, and this was confirmed by having participants complete the Eating Disorders Examination-Questionnaire (EDE-Q). No healthy control participants scored higher on the EDE-Q than the cutoff score for healthy behaviors (4.0), so all healthy control participant data were included.

Demographic characteristics of the control and experimental groups are summarized in Table 1.

The Institutional Review Board at a large southeastern university approved study procedures and all participants signed consent before participation.

Experimental Group. Women with AN (N=13) had an average BMI of 16.45 and ranged in age from 18-54 years old. All women had a current diagnosis of AN and were referred to participate in this study through a hospital-based treatment program for individuals with eating
disorders in the southeastern United States. Current diagnoses of women in the AN group were confirmed through medical records. Participants in the AN group were receiving different intensities of treatment (inpatient, partial, or outpatient): nine were in the inpatient unit; three were in the partial hospitalization unit, and one was in the outpatient program.

Materials

A two-compartment box was constructed from fiberglass and lined with black construction paper to eliminate any reflections on the interior surfaces. One compartment of the box was covered by an opaque lid, and the other was covered by a transparent lid. A smooth feminine rubber hand with a Caucasian-skin-color tone was placed in the compartment with a transparent lid. The rubber hand used in the experiments was made by the Debra Lynn Company and was originally designed to serve as a manicure hand for student beauticians and manicurists. The participant placed her right hand in the adjoining compartment with the.

1 Similar to previous studies that involved participants completing the rubber hand illusion task (Botvinick & Cohen, 1998; Ehrsson, Holmes, & Passingham, 2004), skin color of the participant was not matched to the skin color of the rubber hand. Differing skin colors between the participant’s hand and the rubber hand has not been found affect one’s susceptibility to the rubber hand illusion (Holmes, Snijders, & Spence, 2006). Although, the rubber hand illusion has been found more strongly experienced when the hand has a natural skin texture compared to an artificially smooth texture, natural skin texture is not necessary for participants to experience the illusion (Haans, IJsselsteijn, de Kort, 2008).
opaque cover, and her left hand rested on the table. Because the orientation of the hand is essential to a participant’s susceptibility to the illusion, the rubber hand was placed in a position congruent with a possible placement of the participant’s real hand, i.e., not at an awkward, impossible angle (Tsakiris & Haggard, 2005). The rubber hand was placed in the exact position where the participant’s right hand would be resting on the table if both hands were placed side-by-side on the table’s surface. A black cape was used to cover the participants’ arms and hands (see Figure 1).

For the first five healthy control participants, a similar black cape was used to hide the researcher’s arms from the participant’s view. This resulted in difficulties for the researcher because she was unable to view the participant’s hand during the task. So, for the remaining participant trials, a black poster board was attached using Velcro to the side of the box directly opposite from the participant. This method hid the researcher from the participant’s view during the rubber hand illusion task yet allowed the researcher to observe the rubber hand and participant’s hand. The right index fingers of the participant’s hand and the rubber hand were stroked synchronously during the task using two identical paintbrushes.

Skin temperature measurements were taken using a Fluke Model 361 non-contact infrared thermometer (Fluke Corporation, Everett, WA). Skin temperature measurements were taken at three points on the hand: below the second digit, below the fifth digit, and on the wrist (Thakkar et al., 2011; Moseley et al., 2008). These points were marked with a washable marker. During the heart-rate monitoring task, a stethoscope (Prestige Medical, Singlehead Model #S106) was used by the experimenter to record the actual number of heartbeats that occurred during each time interval.
**Procedure**

**Visit 1.** After signing consent forms, the participant was asked to sit at a table upon which a two-compartment box was placed. Before the experimenter began the task, a cover was placed on top of the box, and the participant made her first estimation of the location of her right index finger by indicating the position on an idiosyncratically marked ruler. The ruler was a laminated piece of paper approximately 24 inches long. The markings on the ruler did not have numbers associated with them and were spaced ~1 mm apart. At this time, baseline skin temperature measurements were also recorded using the infrared non-contact thermometer. The poster board was attached to the box blocking the experimenter from the participant’s view.

The right index fingers of the rubber hand and the participants’ hand were stroked synchronously for three minutes. The participant’s skin temperature was measured at 1, 2, and 3 minutes. After the synchronous stroking trial was complete, another measurement of the participant’s perceived hand location was taken by covering the box and asking the participant to indicate on the ruler where she felt like her right index finger was located. The participant completed a self-report questionnaire, the Rubber Hand Illusion Questionnaire (Thakkar et al., 2011), to assess the strength of the illusion. Participants were also asked to complete the Edinburgh Handedness Inventory (Oldfield, 1971) to ensure that each participant was right-handed and the EDE-Q survey to assess eating disorder characteristics.

**Visit 2.** Visit 2 occurred approximately one week (2-14 days; Median: 7 days) after Visit 1. All procedures from Visit 1 were repeated with some minor differences. First, the EDE-Q and
Edinburgh Handedness Inventory were not repeated. Second, an interoceptive awareness measurement task was introduced immediately before the rubber hand illusion task. The interoceptive awareness measurement task used was a heart rate monitoring task modeled after similar procedures used in Shandry (1981), Tsakiris et al. (2011), and Pallatos et al. (2008).

Upon seeing a visual cue, participants were asked to close their eyes and count their heartbeats during four time intervals (25 s, 35 s, 45 s, and 100 s). The time intervals were randomized for each participant. Participants were asked to close their eyes while counting and were not allowed to take their pulse or put a hand to their chest to measure their heartbeats. While participants silently counted their heartbeats, an experimenter recorded using a stethoscope the actual number of heartbeats that occurred within the same time intervals. After the heart-rate monitoring task, participants completed the Body Awareness Questionnaire (Shields, Mallory, and Simon, 1989) to assess their sensitivity to internal body processes. The procedures involving the rubber hand illusion task and the Rubber Hand Illusion Questionnaire were then repeated as described in Visit 1.

Measures

**Proprioceptive drift:** Proprioceptive drift (PD) was defined as the mean difference in the perceived locations of the participant’s right index finger before and after the rubber hand illusion task. Positive numbers indicate that the participant felt her hand’s position shift toward the rubber hand. Proprioceptive drift is calculated by subtracting the first estimation of the location of the right hand on the ruler from the second estimation.
**Skin Temperature:** A mean skin temperature was calculated for each of the three time measurement points (1:00 min, 2:00 min, 3:00 min) by averaging skin temperatures taken at three locations on the participant’s hands. The average of the skin temperature means at the three time points was taken to determine the skin temperature of a participant’s hands during the experiment. The mean skin temperature at baseline was subtracted from the average skin temperature during the experiment to obtain a measurement of skin temperature change. Negative scores indicate a reduction in skin temperature compared to baseline.

**Heart-Rate Interoceptive Sensitivity:** Heart-rate interoceptive sensitivity was calculated by comparing the number of heartbeats counted by the participant to the actual number of heartbeats recorded during each time interval. Heart-rate interoceptive sensitivity scores were calculated for each time interval, and an average interoceptive sensitivity score was determined for each participant. The equation to calculate interoceptive sensitivity based on data from each time interval is:

\[
\frac{1}{4} \sum \left(1 - \left|\frac{\text{recorded heartbeats} - \text{counted heartbeats}}{\text{recorded heartbeats}}\right|\right)
\]

Each participant’s score ranged between 0 and 1 with scores closer to 0 signifying that there were major differences between the counted heartbeats and recorded heartbeats (lower interoceptive awareness). Scores closer to 1 (higher interoceptive awareness) indicated that participants were very accurate at monitoring their own heart beats during the time intervals.

**Edinburgh Handedness Inventory:** This survey measures handedness (right-handed, left-handed, or ambidextrous) by asking participants a series of questions about which hand is used when completing certain normal, everyday tasks such as writing, drawing, or using a
toothbrush. A shorter version of the survey was used in this study and was adapted from Oldfield’s original study (1971). A participant’s right-handedness was confirmed if a majority of the responses were answered using the “right-handed” response.

**Eating Disorders Examination-Questionnaire (EDE-Q):** The EDE-Q is a common measure of eating disorder behaviors and cognitions such as bulimic episodes, dietary restraint, and shape and weight concerns. It is a 38-item self-report measure based on the clinician-administered Eating Disorder Examination (EDE). A score of 4.0 on the EDE-Q marks the cutoff score for clinically severe eating disorder psychopathology. Higher scores on the EDE-Q signify that participants have more disordered eating attitudes and beliefs.

**Rubber Hand Illusion Questionnaire:** The Rubber Hand Illusion Questionnaire is a 9-item survey that uses a 1-7 point Likert scale to measure subjective feelings of ownership of the rubber hand and general strength of the illusion. Two sample items are: “It seemed as if I were feeling the touch of the paintbrush where I saw the rubber hand” and “I felt as if my real hand was drifting toward the rubber hand.” The Rubber Hand Illusion Questionnaire was adopted from Thakkar et al. (2011). Higher scores on the questionnaire indicate increased susceptibility to the illusion.

**The Body Awareness Questionnaire:** The Body Awareness Questionnaire is an 18-item survey that uses a 1-7 point Likert scale to measure sensitivity to internal body processes (Shields, Mallory, and Simon, 1989). Participants were asked to judge how accurate certain statements are regarding their own body sensitivity. Two sample items are: “I know I’m running a fever without taking my temperature” or “I can always tell when I bump myself whether or
not it will become a bruise.” Higher scores on the questionnaire indicate increased sensitivity to one’s internal body.

**Height and Weight:** The weight of healthy controls (HC) was self-reported. Weight and height of participants in the AN group were obtained from medical records. Height and weight values were used to calculate the BMI of each participant with AN (BMI = kg/m²). Since, data on the height of healthy controls was not recorded, I was not able to calculate BMI.

**Statistical analyses**

The statistical software SPSS Version 20 (SPSS Inc., USA) was used to analyze the collected data, and the statistical significance level for the analyses was set at p<0.05. Repeated-measures 2 (Visit 1 vs. Visit 2) x 2 (AN vs. HC) ANOVAs were used to compare mean differences in proprioceptive drift, skin temperature changes, and Rubber Hand Illusion Questionnaire scores between Visit 1 and Visit 2. Heart-rate interoceptive sensitivity scores and Body Awareness Questionnaire scores were used as continuous covariates in the statistical models. Visit (Visit 1 vs. Visit 2) was a within-subjects variable. Group (AN or HC) was used as a between-subjects variable. Independent samples t-tests were used to determine the differences between the Body Awareness Questionnaire, proprioceptive drift, Rubber Hand Illusion Questionnaire, heart-rate interoceptive sensitivity, and right hand skin temperature changes for women with and without AN.
Results

Demographic Characteristics

On average, women with AN had a significantly lower weight (101.14 lbs. vs. 139.07 lbs.; \( t(25) = 4.730, p = 0.000 \)) and were also significantly older (30.17 yrs. vs. 18.67 yrs.; \( t(19) = -2.541, p = 0.020 \)) than healthy controls as shown in Table 1. Because of this significant difference between groups, age was controlled for in the statistical analyses.

Self-Report Measures: Comparing Women with and without AN on body awareness and rubber hand illusion susceptibility

Women with AN reported significantly lower body awareness on the Body Awareness Questionnaire compared to women in the healthy control group (\( t(27) = 2.546, p = 0.017 \); see Table 2). On average, women with AN scored significantly lower on the Rubber Hand Illusion Questionnaire compared to healthy control group women during Visit 1 (\( t(30) = 2.502, p = 0.018 \); see Table 2) and Visit 2 (\( t(27) = 2.158, p = 0.040 \); see Table 2). Lower scores on the questionnaire represent less susceptibility to the illusion, meaning that women with AN endorsed significantly less susceptibility than healthy control women. There was no significant difference between women with or without AN on proprioceptive drift (i.e., how much the participant perceived her right hand position shift toward the rubber hand).
Directly Observed Measures: Comparing women with and without AN on body awareness and rubber hand illusion susceptibility

There was a trend towards decreased heart-rate task interoceptive sensitivity in the women with AN when compared to the healthy control women ($t(28) = 1.957, p < .07$; Table 3), representing lower body awareness. However, this difference was not statistically significant. On average, skin temperature of the right hand decreased in both healthy control women and women with AN during Visit 1 (-0.585°F and -1.325°F, respectively) and Visit 2 (-0.120°F and -0.291°F), respectively, as shown in Table 3. There was no significant effect of group (HC vs. AN) on skin temperature change during either visit (see Table 3).

Self-Report Rubber Hand Illusion Questionnaire: 2 Visit (Visit 1 vs. Visit 2) X 2 Group (Women with AN vs. Healthy Control Women) ANOVA

I first conducted a 2 X 2 ANOVA with visit as a within-subjects factor and group as a between-subjects factor and the Rubber Hand Illusion Questionnaire as the dependent variable. There was no significant difference on questionnaire scores between Visit 1 and Visit 2 (see Table 4). A significant effect of Group ($F(1, 27) = 5.662, p = 0.025$; see Table 4) was found. Women with AN had lower scores on the questionnaire (less susceptibility to the illusion) compared to healthy control women (see Figure 2).

I next conducted a 2 X 2 ANCOVA with visit as a within-subjects factor and group as a between-subjects factor but included body awareness measures (Body Awareness Questionnaire and heart-rate interoceptive sensitivity) as covariates. Both the Body Awareness Questionnaire and the heart-rate interoceptive sensitivity task were used in the study to
provide a subjective and objective measure of participants’ body awareness levels. When controlling for body awareness and interoceptive sensitivity, the previously significant effect of Group on Rubber Hand Illusion Questionnaire scores was now a nonsignificant trend ($F(1, 27)=3.114, p=0.090$; see Table 4). This suggests that body awareness and interoceptive sensitivity are contributing factors to the difference between women with AN and healthy control women on Rubber Hand Illusion Questionnaire scores. There continued to be no other significant main effect or interactions with questionnaire scores (see Table 4).

For the third model, I conducted a 2 x 2 ANCOVA with visit as a within-subjects factor and group as a between-subjects factor but now included body awareness measures (Body Awareness Questionnaire scores and heart-rate interoceptive sensitivity scores) and age as covariates. When controlling for both body awareness, interoceptive sensitivity and age, there was no significant effect or trend of Group on questionnaire scores ($F(1, 27)=0.154, p=0.701$; see Table 4). This suggests that body awareness, interoceptive sensitivity, and age may fully explain the differences between women with AN and healthy control women on the Rubber Hand Illusion Questionnaire scores.

**Proprioceptive Drift: 2 Visit (Visit 1 vs. Visit 2) X 2 Group (Women with AN vs. Healthy Control Women) ANOVA**

I first conducted a 2 X 2 ANOVA with visit as a within-subjects factor and group as a between-subjects factor and proprioceptive drift as the dependent variable. The AN and HC groups on average did not have significantly different proprioceptive drift scores during Visit 1 ($t(30)=0.727, p=0.473$) or Visit 2 ($t(28)=0.928, p=0.362$; see Table 2), and the main effect of visit
was not significant \((F(1, 28)=0.714, p=0.405; \text{see Table 5})\). There were no significant interactions (see Table 5).

I next conducted a 2 X 2 ANCOVA with visit as a within-subjects factor and group as a between-subjects factor but included body awareness measures (Body Awareness Questionnaire scores and heart-rate interoceptive sensitivity scores) as covariates. There were no significant main effects or interactions of Visit, Group, Visit-by-Group, Visit-by-Body Awareness Questionnaire, Visit-by-Heart-Rate interoceptive sensitivity (see Table 5). For the third model, I conducted a 2 x 2 ANCOVA with visit as a within-subjects factor and group as a between-subjects factor and now included body awareness measures (Body Awareness Questionnaire scores and heart-rate interoceptive sensitivity) and age as covariates. There were no significant main effects or interactions of any variable within the model on measures of proprioceptive drift (see Table 5).

**Right Hand Temperature Change: 2 Visit (Visit 1 vs. Visit 2) X 2 Group (Women with AN vs. Healthy Control Women) ANOVA**

I first conducted a 2 X 2 ANOVA with visit as a within-subjects factor and group as a between-subjects factor and right hand temperature change as the dependent variable. There were no significant main effects of Visit \((F(1, 28)=2.806, p=0.105; \text{see Table 6})\) or Group \((F(1, 28)=0.771, p=0.387)\). There were also no significant interactions on right-hand temperature change (see Table 6).

I next conducted a 2 X 2 ANCOVA with visit as a within-subjects factor and group as a between-subjects factor but included body awareness measures (Body Awareness
Questionnaire scores and heart-rate interoceptive sensitivity scores) as covariates. There were no significant main effects or interactions of Visit, Group, Visit-by-Group, Visit-by-Body Awareness questionnaire, or Visit-by-Heart-Rate interoceptive sensitivity (see Table 6). For the third model, I conducted a 2 x 2 ANCOVA with visit as a within-subjects factor and group as a between-subjects factor and now included body awareness measures (Body Awareness Questionnaire scores and heart-rate interoceptive sensitivity scores) and age as covariates.

When controlling for body awareness, interoceptive sensitivity, and age, the main effect of Group ($F(1, 28)=0.734, p=0.400$; see Table 6), which was previously nonsignificant, became a trend ($F(1, 28)=3.320, p=0.090$; see Table 6). Women with AN had a trend towards greater decrease in their right hand temperature, representing a greater susceptibility to the rubber hand illusion. These findings were opposite to their response on the Rubber Hand Illusion Questionnaire, which indicated that they were less susceptible to the illusion. There were no other significant main effects or interactions in this third model.

**Discussion**

During both visits, there was a significant main effect of group on the Rubber Hand Illusion Questionnaire scores (see Figure 2 and Table 4). Contrary to my hypothesis and previous literature findings (Eshkevari et al., 2011), women with AN had lower scores on the self-report Rubber Hand Illusion Questionnaire compared to healthy control women. They were less likely to endorse feeling susceptible to the rubber hand illusion. When body awareness measures (Body Awareness Questionnaire and heart-rate interoceptive sensitivity scores) were
controlled for in Model 2, the effect of Group on the Rubber Hand Illusion Questionnaire scores went from being fully significant to a trend. Further, when body awareness measures and age were controlled for in Model 3, the effect of Group was not significant.

This suggests that body awareness measures and age are likely the contributing factors to the difference between women with AN and healthy control women on the Rubber Hand Illusion Questionnaire. Perhaps older women and/or women with low body awareness (the AN group) are less likely than healthy control women to self-report feeling susceptible to the rubber hand illusion task. Older women may be less susceptible to the illusion because they are unwilling to suspend their beliefs about reality. For example, an older woman knows that her right hand is obviously not a rubber hand and should not feel rubbery. She is unwilling to recognize the odd sensations that accompany the illusion because they are so contrary to the reality she knows to be true. When responding to the questionnaire, she would therefore not self-report feeling susceptible to the illusion.

Women with AN had significantly lower scores on the Body Awareness Questionnaire compared to healthy control women as predicted by my hypothesis (Table 2). This finding may explain the low Rubber Hand Illusion Questionnaire scores of women with AN. Women with AN may be less likely to endorse their response to the illusion via self-report because of low body awareness and interoceptive sensitivity. Women with AN generally have difficulty recognizing cues from their bodies (i.e. feelings of hunger and satiety). Because of this already present low body awareness, women with AN may also be unable to recognize susceptibility to the illusion. If this is the case, they may be incapable of self-reporting feeling the effects of the illusion.
Women with AN generally reported feeling little to no proprioceptive drift. This finding and the low scores of women with AN on the Rubber Hand Illusion Questionnaire could be a result of the dichotomous, “all or nothing”, concrete thinking that often accompanies an eating disorder (Byrne, Allen, Dove, Watt, & Nathan, 2008). When asked to make a post-task judgment of where their right index finger was located, many of the participants with AN did not understand that they could have felt that their finger was in a different location even though they had not moved it. The proprioceptive drift measure requires the ability to think abstractly and hypothetically, and this could have been challenging for the participants with AN, especially for the more severe patients undergoing inpatient treatment who were very underweight during data collection.

There was no significant difference between the AN group and the healthy control group on proprioceptive drift (see Table 2). The methods used to obtain proprioceptive drift in the current study differed slightly from those used in previous studies (Botvinick & Cohen, 1998; Thakkar et al., 2011). In the Thakkar et al. (2011) study, participants reported proprioceptive drift using three rulers labeled with numbers. In the Botvinick & Cohen (1998) study, participants reported drift by actually moving their finger to point to different positions. In the current study, the ruler had no numbers and was idiosyncratically marked, and participants reported their perceived right index finger location only one time before and after the rubber hand illusion task.

In the Thakkar et al. (2011) and Botvinick & Cohen (1998) studies, participants gave three reports of their perceived right index finger location pre- and post-task. The averages of these three perceived locations were used to determine proprioceptive drift. The difference in
methodology of this study compared to these previous studies could have resulted in the unexpected nonsignificant findings. The procedures used in the Thakkar et al. (2011) and Botvinick and Cohen (1998) studies may be more accurate ways of determining drift than the procedure used in the current study because three measurements of perceived right index finger location are taken rather than only one measurement.

Although not statistically significant, there was a trend that suggested that women with AN had lower accuracy on the heart-rate interoceptive sensitivity task compared to healthy control women (see Table 3). This nonsignificant effect of Group on the heart rate task interoceptive sensitivity contradicts the finding by Pollatos et al. (2008) that women with AN were less accurate at determining their heart compared to matched healthy control women. The nonsignificant effect could be a result of the experimenter’s use of a different method in this study to measure heart beats (using a stethoscope rather than an electrocardiogram recording device), or it may be due to low power to detect a difference between women with and without AN. Pallatos et al. (2008) included 28 participants with AN while I only tested 13 participants with AN in this study.

Skin temperature change is an unbiased, objective, and more accurate measure of susceptibility to the rubber hand illusion. There was no significant main effect of Group on right hand skin temperature change during Visits 1 and 2 (see Table 3). However, when controlling for body awareness measures and age in Model 3 (see Table 6), there is a trend to suggest that women with AN and healthy control women differ in their susceptibility to the illusion. During Visit 1 and 2, once body awareness and age were controlled, women with AN had a larger decrease in right hand skin temperature while healthy control women only experienced a minor
change in right hand skin temperature (see Figure 3). If this trend had been significant, this finding would be similar to that reported by Moseley et al. (2008) and would have been predicted by my hypothesis.

In Visit 2, women with AN experienced a smaller decrease in right hand skin temperature while healthy control women experienced a slight increase in skin temperature. The slight increase in temperature in healthy controls and smaller decrease in skin temperature in women with AN suggests that both groups could be less susceptible to the illusion during Visit 2. This may result from two possible explanations: 1) The skin temperature decrease was less during the second visit or nonexistent because participants experienced a habituation effect or 2) the heart-rate monitoring interoceptive sensitivity task was also an interoceptive awareness raising task which led to reduced susceptibility of all women to the illusion during the second visit. To determine which of these explanations is correct, in a future study, participants could be randomly assigned to either complete the heart-rate monitoring task before being exposed to the rubber hand illusion during the first visit or second visit. We did not randomly assign participants in the current study because of concerns with recruitment and a small sample.

The increase in right hand skin temperature change during Visit 2 for the healthy control group is not compatible with previous literature findings (Thakkar et al., 2011; Moseley et al., 2008). In general, the nonsignificant difference between the AN and healthy control group on skin temperature could have resulted from the small sample size and low statistical power. Skin temperature measurements of participants were highly variable as demonstrated by the large standard deviations shown in Table 3. Previous studies had found an average temperature drop
of 0.27°C (Moseley et al., 2008), so a combination of small sample size and the large variability of skin temperature could have masked a significant effect.

**Limitations**

The experimental group of AN patients consisted of patients in many different stages of recovery receiving inpatient, partial, and outpatient care. This could have contributed to the large standard deviations observed in the AN group on skin temperature change, heart-rate interoceptive sensitivity scores, and proprioceptive drift scores. On average, the AN group was also significantly older than the HC group. However, a previous study that reported that women with AN were more susceptible to the rubber hand illusion task had a similar group of AN participants—ranging in age from 18 to 55 years old (Eshkevari et al., 2011). There was no information reported on treatment received by the women with AN who participated in the study (Eshkevari et al., 2011). In the current study, both experimental and control groups had small samples sizes which limits the adequate statistical power.

Some participants informally reported that they were able to feel their heart beat pulsing against the stethoscope on their chest. This could have biased the heart-rate interoceptive sensitivity score. A future experiment should use a different heart-rate-measurement device to avoid this confounding variable. Participants were also aware of their accuracy in the heart-rate interoceptive sensitivity task as the experimenter recorded their counted heart beats next to their actual heart beats in front of the participants. This knowledge could have made the participants less confident and could have unintentionally biased participants’ performance on the task.
Future Directions

Although women with AN did not self-report feeling susceptible to the rubber hand illusion, the decrease in skin temperature of the right hand after exposure to the task seems to suggest that women with AN do experience the illusion. The rubber hand illusion could be a unique therapeutic tool for women with AN because it highlights the disconnect between what you say and what you feel. It also demonstrates the severity and pervasiveness of concrete, all-or-nothing thinking. Based on the results from the current study, healthy women can feel the illusion and will report feeling susceptible to the illusion whereas the group of older women with AN seem to be able to feel the illusion but do not report feeling susceptible.

The disconnect between actual feelings and self-reported feelings is prevalent in women with AN (Cochrane, Brewerton, Wilson, & Hodges, 1993). For example, women with AN may report feeling better about maintaining weight during the recovery process but could have internal emotional struggles with weight gain. These errors in self-report and self-honesty can be detrimental to treatment because therapists are unaware of their patients’ continuing difficulties. The rubber hand illusion could be used as a tool in treatment to spark conversation between patient and therapist about differences between reported feelings and actual feelings.
References


_Neuropsychologia, 9_, 97-113.


_Psychological Medicine, 8_(2), 317-324.


**Table 1.** Demographic characteristics of control and experimental groups.

<table>
<thead>
<tr>
<th></th>
<th>AN Group (n=131)</th>
<th>HC Group (n=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>30.17 (13.47)</td>
<td>18.672 (0.87)</td>
</tr>
<tr>
<td>Handedness3</td>
<td>91.16 (17.89)</td>
<td>96.92 (6.16)</td>
</tr>
<tr>
<td>Weight (pounds)</td>
<td>101.144 (12.53)</td>
<td>139.075 (25.34)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>16.456 (2.39)</td>
<td>--7</td>
</tr>
<tr>
<td>EDE-Q Scores</td>
<td>3.72 (2.08)</td>
<td>1.57 (0.75)</td>
</tr>
</tbody>
</table>

1 Three anorexia nervosa (AN) group participants dropped out and did not complete the second visit.
2 Data regarding health control (HC) group participants’ ages were collected from nine individuals.
3 Edinburgh Handedness Inventory: -100 completely sinistral to +100 completely dextral. Left Handed: R < -40; Ambidextrous: -40 < R < +40; Right Handed: R > +40.
4 Weight from one participant was unable to be collected.
5 Data regarding HC group participants’ weights were collected from 15 individuals.
6 Height from one participant was unable to be collected, so that participant was excluded from the mean BMI calculation.
7 Heights of participants in the healthy control group were not collected and BMI was unable to be calculated.
**Table 2.** Mean and standard deviations of self-report measures of body awareness, rubber hand illusion strength and proprioceptive drift in healthy control (HC) women and women with anorexia nervosa (AN).

<table>
<thead>
<tr>
<th>Measures</th>
<th>HC</th>
<th>AN</th>
<th>t</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body awareness score (S.D.)</td>
<td>78.95(15.897)</td>
<td>62.50(17.740)</td>
<td>2.546</td>
<td>27</td>
<td>0.017*</td>
</tr>
<tr>
<td>Proprioceptive drift score during Visit 1 (S.D.)</td>
<td>3.78(7.38)</td>
<td>4.73(9.74)</td>
<td>0.727</td>
<td>30</td>
<td>0.473</td>
</tr>
<tr>
<td>Proprioceptive drift scores during Visit 2 (S.D.)</td>
<td>1.81(4.38)</td>
<td>1.77(5.33)</td>
<td>0.928</td>
<td>28</td>
<td>0.362</td>
</tr>
<tr>
<td>Rubber Hand Illusion Questionnaire Scores during Visit 1 (S.D.)</td>
<td>33.21(13.151)</td>
<td>20.90(11.298)</td>
<td>2.502</td>
<td>30</td>
<td>0.018*</td>
</tr>
<tr>
<td>Rubber Hand Illusion Questionnaire Scores during Visit 2 (S.D.)</td>
<td>32.05(12.505)</td>
<td>21.50(12.545)</td>
<td>2.158</td>
<td>27</td>
<td>0.040*</td>
</tr>
</tbody>
</table>

*Note* *=p≤0.05. HC=Healthy control women; AN=Women with anorexia nervosa.
Table 3. Mean and standard deviations of directly observed measures of rubber hand illusion strength (change in right hand temperature) and body awareness (interoceptive sensitivity), in women with anorexia nervosa (AN) and healthy control group (HC) women.

<table>
<thead>
<tr>
<th>Measures</th>
<th>HC</th>
<th>AN</th>
<th>t</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate task interoceptive sensitivity score (S.D.)</td>
<td>0.738 (0.119)</td>
<td>0.615 (0.228)</td>
<td>1.957</td>
<td>28</td>
<td>0.060</td>
</tr>
<tr>
<td>Right hand temperature change (°F) during Visit 1 (S.D.)</td>
<td>-0.585 (1.46)</td>
<td>-1.325 (2.20)</td>
<td>1.205</td>
<td>30</td>
<td>0.238</td>
</tr>
<tr>
<td>Right hand temperature change (°F) during Visit 2 (S.D.)</td>
<td>-0.120 (2.26)</td>
<td>-0.291 (0.663)</td>
<td>0.243</td>
<td>28</td>
<td>0.810</td>
</tr>
</tbody>
</table>

Note *=p≤0.05. HC=Healthy control women; AN=Women with anorexia nervosa.
Table 4. Model 1. Rubber Hand Illusion Questionnaire: 2 Visit (Visit 1 vs. Visit 2) x 2 Group (anorexia nervosa (AN) vs. healthy control group (HC)) ANOVA. Self-report on the Rubber Hand Illusion Questionnaire was the dependent variable. Model 2 Body awareness measures (self-report and heart-rate sensitivity) included as covariates in a 2 Visit (Visit 1 vs. Visit 2) x 2 Group (AN vs. HC) ANCOVA. Model 3 Body awareness measures (self-report and heart-rate sensitivity) and age included as covariates in a 2 Visit (Visit 1 vs. Visit 2) x 2 Group (AN vs. HC) ANCOVA.

<table>
<thead>
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<th>Source</th>
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<th>p</th>
<th>df</th>
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</thead>
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<td>Visit</td>
<td>1</td>
<td>0.084</td>
<td>0.774</td>
<td>1</td>
<td>1.649</td>
<td>0.211</td>
<td>1</td>
<td>1.425</td>
<td>0.252</td>
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<td>1</td>
<td>5.662</td>
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<td>1</td>
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<td>1</td>
<td>0.154</td>
<td>0.701</td>
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<tr>
<td>Age</td>
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<td>1</td>
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<tr>
<td>Visit*Group</td>
<td>1</td>
<td>0.832</td>
<td>0.370</td>
<td>1</td>
<td>0.023</td>
<td>0.882</td>
<td>1</td>
<td>0.229</td>
<td>0.640</td>
</tr>
<tr>
<td>Visit*Body Awareness Questionnaire</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>1</td>
<td>1.036</td>
<td>0.318</td>
<td>1</td>
<td>0.879</td>
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<tr>
<td>Visit*Heart-rate sensitivity</td>
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<td>---</td>
<td>---</td>
<td>1</td>
<td>0.592</td>
<td>0.449</td>
<td>1</td>
<td>0.689</td>
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</tr>
<tr>
<td>Visit*Age</td>
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<td>---</td>
<td>---</td>
<td>1</td>
<td>0.574</td>
<td>0.461</td>
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*Note: *= p<0.05. HC=Healthy control women; AN=Women with anorexia nervosa.
Table 5. Model 1. Proprioceptive drift: 2 Visit (Visit 1 vs. Visit 2) x 2 Group (anorexia nervosa (AN) vs. healthy control group (HC)) ANOVA. Self-report on proprioceptive drift was the dependent variable. Model 2 Body awareness measures (self-report and heart-rate sensitivity) included as covariates in a 2 Visit (Visit 1 vs. Visit 2) x 2 Group (AN vs. HC) ANCOVA. Model 3 Body awareness measures (self-report and heart-rate sensitivity) and age included as covariates in a 2 Visit (Visit 1 vs. Visit 2) x 2 Group (AN vs. HC) ANCOVA.

<table>
<thead>
<tr>
<th>Source</th>
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<td>---</td>
<td>---</td>
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<td>0.032</td>
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<td>Visit*Body Awareness Questionnaire</td>
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<td>---</td>
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<td>0.940</td>
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<tr>
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<td>0.029</td>
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<td>0.471</td>
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Note *=p< 0.05. HC=Healthy control women; AN=Women with anorexia nervosa.
Table 6. Model 1. Right Hand Temperature Change: 2 Visit (Visit 1 vs. Visit 2) x 2 Group (anorexia nervosa (AN) vs. healthy control group (HC)) ANOVA. Observed right hand temperature change was the dependent variable. Model 2 Body awareness measures (self-report and heart-rate sensitivity) included as covariates in 2 Visit (Visit 1 vs. Visit 2) x 2 Group (AN vs. HC) ANCOVA. Model 3 Body awareness measures (self-report and heart-rate sensitivity) and age included as covariates in a 2 Visit (Visit 1 vs. Visit 2) x 2 Group (AN vs. HC) ANCOVA.

<table>
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<th>Source</th>
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<th>p</th>
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<td>2.714</td>
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<tr>
<td>Group</td>
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<td>0.771</td>
<td>0.387</td>
<td>1</td>
<td>0.734</td>
<td>0.400</td>
<td>1</td>
<td>3.320</td>
<td>0.090</td>
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<td>Age</td>
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</tr>
<tr>
<td>Visit*Group</td>
<td>1</td>
<td>0.405</td>
<td>0.530</td>
<td>1</td>
<td>0.021</td>
<td>0.886</td>
<td>1</td>
<td>0.096</td>
<td>0.761</td>
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<td>Visit*Body Awareness Questionnaire</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>1</td>
<td>0.000</td>
<td>0.994</td>
<td>1</td>
<td>1.634</td>
<td>0.222</td>
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<td>Visit*Heart-rate sensitivity</td>
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<td>---</td>
<td>1</td>
<td>1.287</td>
<td>0.267</td>
<td>1</td>
<td>1.623</td>
<td>0.223</td>
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<td>Visit *Age</td>
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</tbody>
</table>

Note *p<0.05. HC=Healthy control women; AN=Women with anorexia nervosa.
Figure 1. A picture of the experimental set-up. During the rubber hand illusion task, the participant was seated and placed her right hand in the side of the two-compartment box with an opaque cover. The experimenter synchronously stroked with a paintbrush the participant’s right index finger and the right index finger of the rubber hand for three minutes. A black cape was used to hide the participant’s arms and hands from view.
Figure 2. A graphic depiction of the significant main effect of group on the rubber hand illusion questionnaire. Both groups have significantly different scores on the questionnaire during Visit 1 and 2. The anorexia nervosa (AN) group scores much lower during both visits compared to the healthy control (HC) group. The AN group scores also increase from Visit 1 to Visit 2 while the HC group scores decrease from Visit 1 to Visit 2.
Figure 3. A graphic depiction of the trend of Group (anorexia nervosa (AN) vs. healthy control (HC)) on right hand temperature change. Women with AN had a decrease in skin temperature during Visit 1 while the HC group did not experience a change in skin temperature. Women with AN had a smaller decrease in skin temperature change during Visit 2 compared to Visit 1. During Visit 2, HC women experienced an increase in skin temperature. These findings are not statistically significant (p<0.05); however, these trends could be of interest in a future study. The data depicted in the figure resulted from a 2 Visit (Visit 1 vs. Visit 2) x 2 Group (AN vs. HC) ANCOVA which included age and body awareness as measured by Body Awareness Questionnaire scores (BODYA_SCORE) and heart rate monitoring task scores (HR_FINALISS) as covariates.