Distortion in Body Schema: The Influence of Body Fat and Mass on Perceptions of Personal Size

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Senior Project submitted to

The Division of Science, Mathematics, and Computing

of Bard College

by

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Annandale-on-Hudson, New York

May 2017

Acknowledgements

I have such an abundance of gratitude in my heart to those who have supported me throughout these tremendously rocky four years. You have all played enormous parts in both my education and in this small chapter of my life.

To Timand Bates: Thank you for every word of support and encouragement, for providing the positive outlook that I needed in such a dark time, and for helping me realize that there will always be more than one way to accomplish your goals.

To Amy Winecoff: My passion for psychology grew stronger after each class with you. Thank you for being a phenomenal professor and an adviser. Your understanding and support have allowed me to finally do the same for myself.

To Justin Hulbert: I am enormously grateful to have been your advisee and student. Thank you for giving me the freedom to do what I love and for your patience while working with me through this project.

To Sage Warner: You are the epitome of a true friend. I could not be more grateful to have had you there for me throughout these few years, at Bard; to love like a sister, to battle through the work, and to watch develop into an even more beautiful soul.

To my parents and brother: Your love has no bounds and I will never forget the sacrifices that you have made in order for me to have this beautiful experience. Thank you for cheering me on just as fiercely at my lowest of lows, as you have at every major accomplishment. Without you I would not be where I am nor where I am headed. I love you, ardently, and dedicate this project to you.

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Abstract

Obesity has been linked with a myriad of negative outcomes for both physical and mental health including feeding and eating disorders and cognitive impairments that affect perception of body size. Understanding the cognitive mechanisms and physiological factors that contribute to perception of body size may help us to comprehend how obesity impacts the construction and development of one's mental body representations. Previous research by Scarpina, Castelnuovo, and Molinari (2014) suggests that, compared to those with a normal Body Mass Index, individuals with a BMI greater than 30 (obese) not only inaccurately estimate tactile and mental distances on their own bodies, they also significantly overestimate these distances. While BMI has been shown to be useful in predicting obesity, it fails to measure adiposity, or body fat. This proposed research project seeks to extend upon this past work by examining the independent effects of adiposity and high BMI on body size perception. I hypothesize that, compared to individuals with 30<BMI and low body fat, individuals with 30<BMI and high body fat will exhibit greater inaccuracy in estimating tactile and mental distances on their own bodies. Additionally, this group is predicted to have greater body-part dissatisfaction and more rapid response times on the distance estimation task. These predicted outcomes would further explain previous research that suggested that high adiposity could have deleterious effects on the function of the peripheral nervous system and the sensory cortices involved in body size perception.

Introduction

The concept of a mind and body relationship has been one of significant importance to the practice of medicine for thousands of years. Hippocrates, the “Father of Modern Medicine,” (Malomo et al., 2006; Goldberg, 2006) was a firm believer in the importance of a multifaceted approach to maintaining and optimizing health of the body and of the mind. His regimens supported a balanced diet, regular exercise, the importance of a pleasant environment and emotional wellness (Goldberg, 2006; Savel & Munro, 2014). Hippocrates, as well as other notable contributors in ancient medicine, paved the way for a medical approach that would acknowledge the biological, psychological, and social aspects of the human lifestyle. This approach is known as integrative medicine (Gaudet, 1998).

One of the key elements of this approach is the importance of using medical strategies and treatments that are supported by science and research. Before advancements in research technologies were made, at the start of the 1900s, there had been little reputable work conducted to support this holistic theory. In the 1920s, Walter Cannon, a doctor and researcher at Harvard University, brought to light a physiological explanation for what we know to be the fight-or-flight response (Cannon, W., 1914). His work highlighted the role of catecholamines (hormones), which are produced by the body’s endocrine system. The increased production and presence of catecholamines in the bloodstream cause the brain and body to emit signals of communication between each other by heightening senses so that we can best prepare to respond to dangerous or excessively stressful situations, which threaten to our wellbeing.

Later, more complex research emerged, such as that of Robert Ader. Ader is known as the founder of the field of psychology that is psychoneuroimmunology. This field emphasizes the relationship between our mental strength, neurology, and immune system (Ader & Cohen, 1985; Ader & Cohen, 1993). The immune system communicates and interacts with the brain through electrochemical signals and endocrine substances. Both the brain and immune system access information from one another to better understand present and potential threats that may compromise our health. Ader's findings suggested that, because of this link, the brain is capable of creating "memories," cataloging instances where health had been diminished and the response that was then rendered by the immune system.

More recently in psychology, we hear the word "mindfulness". Mindfulness is a therapy associated with yogic practice, Buddhism, and the holistic wellness of mind, body, and spirit (Langer, 1989; Morgan, 2003). Jon Kabat-Zinn, a professor and researcher at the University of Massachusetts, formulated a therapeutic intervention approach called Mindfulness Based Stress Reduction (MBSR; Kabat-Zinn, J., 1982). Kabat-Zinn attended MIT for research in molecular biology with an emphasis in medicine. During this time, he developed an interest in meditation and pursued the Buddhist practice in addition to his graduate work. His fascination with the physical benefits of this mind-based practice led him to formulate a meditation program (MBSR). MBSR has not exclusively gained support from the medical community; the field of psychology is producing evidence to support the practice due to its ability to diminish the effects of anxiety, stress, and physical ailment (Goldin & Gross, 2010; Irving et al., 2009).

Amongst all of the progress in integrative medicine, MBSR's success best represents a serious deficit that exists within the medical and psychological care used in today's society. Kabat-Zinn said that, "mindfulness—paying attention on purpose in the present moment nonjudgmentally—immediately restores us to our wholeness, to that right inward measure that's at the root of both meditation and medicine" (Kabat-Zinn, 2009). Healthcare (referring to both mental and physical healthcare) solutions in the United States, in addition to that of numerous other countries, is flawed in that it is oriented towards alleviating individual symptoms or characteristics of illness. Integrative medicine disagrees with the notion that health is dualistic; the brain and body are not separate entities, rather they are intertwined. MBSR has been so successful in practice and in research, because it strengthens the "wholeness" that Kabat-Zinn states that we stray away from, sometimes to a point where, "we're not paying attention to its messages; we're not even in our bodies" (Kabat-Zinn & Hanh, 2009).

The long promoted distinction between function, regional location (where in the body), and associated illness in the mind and body has led our society to deviate from a self image that is whole. Issues that arise around body image and body awareness are often associated with parts or areas of our respective "bodies". An example of the effect of this issue is the experiencing of hormonal changes during adolescence, and how we combat skin reactions. Blemishes are treated individually with spot treatments, acid peels, masks, creams, and injections. When these fail us, we attempt to hide the evidence of our changing bodies, which manifests in prominent areas of the face, by using makeup to alter the appearance of the natural structure of our faces. All of these "solutions" fail to address larger underlying factors and focus on addressing individual surface issues. The skin of the face is like the brain; it is a small part of a whole. Unless you choose to invest in strengthening the whole and the systems that it interacts with, you will be burdened with the consequences of smaller issues.

This deviance from the whole self derives from deficiencies and dysfunctions in the way that we form a mental image of our physical being. Paul Schilder (1934) proposed a process by which we construct a self image and how that same process possesses equally capable strength for deconstructing and rebuilding self image. Self awareness is initially achieved when one arrives at a consciousness of their feelings and emotions (Schore, 2015). This is achieved through experience with the self, up to a certain point when we encounter stimuli that we rule to be negative. We become increasingly aware of our vulnerability to objects or experiences that may cause us harm. Memories of positive and negative stimuli influence how we imagine ourselves in both their presence and absence. Schilder (1934) wrote that self image evolves based on somatosensory input, thoughts, emotions, previous knowledge, belief systems, and our physical state. It only becomes increasingly varied from its initial form and current reality. We undergo higher rates of change based on our awareness of stimuli and what emotions they evoke. Feelings of disappointment or dissatisfaction with an aspect of one's self image diminishes their sense of cohesion. Negative emotions create a focus on the lack of total satisfaction with our body as a whole, because we recognize it as not having the "right" body (ideal body) composition. Thus, we appersonate, or draw comparisons between the body parts of others and our own, pulling these into our body image and further distorting it.

Head and Holmes (1911) suggested the notion of *body schema*. This concept is one that has much overlap with self image in that it utilizes a plethora of external and internal stimuli to arrive at decisions about the physical self. Head and Holmes proposed that we have two schemata: the first serves us in our efforts of posture and motor activity, the second for locating and self referencing across the surface of the body. Both aspects give us the capability to mentally and physically function in three dimensional space.

It has become necessary for general practitioners (M.D., D.O.) and counseling psychologists to understand the importance of body schema and how it applies to the conditions of both mind and body, which they work with in practice. The reasoning for this is that there are numerous physical disorders and diseases where a symptomatology may include the expression of abnormal changes to the patient's mentally constructed sense of self. These changes manifest in behaviors, thoughts, and physical imbalances or deficits, which alter one's capacity to process incoming stimuli and apply previously acquired knowledge so that they are able to make informed decisions about their actions and experiences. Additionally, deficiencies and distortions can have enormous impacts on the outcomes of diagnosis and treatment. General practitioners and counselling psychologists are mostly limited to the knowledge and training of their respective fields, the patient's explicit symptomatology, and the experience of the condition that the patient brings to the symptomatology. Without attention to the patient's experience, a diagnosis is only guessable.

The patient-practitioner relationship relies strongly on the mind-body approach. This approach is not always considered by counseling psychologists, likely due to a greater emphasis on only treating issues of the mind. More often, psychologists will take a nature versus nurture approach to treating patients who range from those with severe cases of eating disorders to those with mild body image dissatisfaction. Behavior and environment are both key factors in the development and prolongation of body awareness disorders and feeding and eating disorders. However, physical changes within the body are equally influential and commonly overlooked, because they are not well enough understood by counseling psychologists to investigate.

Both general practitioners and counseling psychologists work with patients who are affected by health conditions such as obesity. However, they are frequently restricted in their ability to address underlying issues associated with the condition. Typically, those in medicine are trained to approach the condition from a physiological perspective, and those in psychology receive training that is focused more so on the social and behavioral aspects of obesity. While it is common for each to receive education within the other's area of expertise, they only scrape the surface as to how the mind and body are intertwined. As a result, opportunities to improve the health of their patients are missed. Interestingly, psychiatrists are one of the few mental health professionals who have an extensive knowledge of both medicine and psychology. Psychiatrists typically have a stronger understanding of the biological and neurochemical aspects of disorders, but they are often seen by patients with conditions that are improved or treated with medication. Considering the limited pharmaceutical treatment options for most feeding and eating disorders and body dysmorphic conditions, it is more probable that patients with these issues will initially seek out the services of a psychologist.

Obesity is known to increase the risk of numerous mental health conditions and it is commonly also a product of of many of those same conditions (Talen & Mann, 2009; Devlin et al., 2000). Amongst them, we see significantly lower body image satisfaction, depression, body dysmorphia, and eating disorders. If we revisit the mind-body concept, we can hypothesize that a relationship might exist between obesity, the condition that affects many internal organs and body systems, and any of these mental health conditions, which all have symptomatology related to a disturbance in mental body representation (American Psychiatric Association, 2013; Uher et al., 2005; Williamson et al., 1993). Medical and psychological research has found that high adiposity has detrimental effects on the body's systems, as well as how it regulates energy expenditure (Reilly et al., 2003; Ferraro & Kelley-Moore, 2003). In excess, its presence triggers a state of distress within these critical systems, many of which are reliant on the brain's regulatory mechanisms, to maintain function (Hall et al., 2001). Numerous regions of the brain may become impaired due to dysfunction within the organ itself, in addition to the rest of the body. Thus, the mind becomes vulnerable to the overwhelming presence of lipids.

As I had discussed earlier, disturbances to the body schema occur from a lack of satisfaction or feeling disappointment in regard to a part or multiple parts of one's body. This leads the mind to further itself from those parts of the body, in some instances undergoing denial about ownership of those parts; the body seems incomplete or unsatisfactory (Heydrich et al., 2010; Gallagher, 2006). Mentally distancing one's self from parts of the body reduces familiarization with those parts as well as the ability to imagine them as they truly exist (Eilan et al., 1995). By mentally distancing, one's mission to change the physical shape of their parts becomes less effective, because those actions are directed towards modifying the distorted, self constructed image. At this point both mental and physical health can significantly decline, because the individual is seeking to make physical changes to features that are not present in reality, but only in the mind.

Obesity poses several rather significant threats to the treatment of body-related mental health conditions (Reilly et al., 2003; Ferraro & Kelley-Moore, 2003). The first is the social threat, or the stigma of obesity. In Western cultures, obesity is frowned upon and it is affiliated with characteristics that have enormous potential to create feelings of guilt and shame, which have been proven to provoke actions that are detrimental to one's physical and mental health

(Puhl & Heuer, 2009; Puhl & Brownell, 2001). There is also the threat of diminished health. Obesity is linked to a multitude of minor to severe health issues (Reilly et al., 2003). Many cause harm to critical regulatory systems throughout the body and have the potential to develop into chronic illness. Both aspects contribute to a greater dissociation between mind and body and have been shown to affect body size awareness in obese individuals (Reilly et al., 2003; Stewart-Brown, 1998).

This project will focus on disturbances in body schema as they relate to several aspects of obesity. Prior research has found that high levels of adiposity are detrimental to various elements of mental and physical well-being, in addition to the negative social experiences that one may deal with from simply having the weight and height dimensions of one who is considered obese. I would like to further understand the strength and significance of the roles that each characteristic plays in body schema. This paper will investigate findings from prior research on body composition and ratio in obesity, as well as the associated mental health outcomes. Analysis focused on body composition will examine the influence of both high and low adiposity, as measured by body fat percentage (BF%) on cognition and body representations (body schema and image). Analysis of ratio will examine the influence of body dimensions, as quantified by Body Mass Index (BMI), on cognition and body representations (body schema and body image). My literature review, in this project, supports the methodology and practice of integrated mental health in both medicine and psychology.

Obesity

Obesity is a condition that is caused by the enlargement of and rise in quantity of fat cells in the body (Mitchell et al., 2011). Diagnosis entails the measurement of body mass index (BMI) and total body fat percentage in the body. BMI is a weight for height ratio, with which doctors can determine if an individual's weight is significantly disproportionate to their height, as compared to that of the average person at that height. BMI merely acts as a predictor of obesity; accurate diagnosis requires additional body composition measurements for adiposity and muscle mass. Obesity has the potential to create serious health complications such as high blood pressure, heart disease, diabetes, sleep disorders, metabolic syndrome, and cancer. Treatment of the condition can be a highly complicated process for some and it is dependent upon the severity of the condition, cause, and any problematic symptomatology. Current approaches to treatment, in the medical field, include medication, surgery, therapy, and changes to diet and physical fitness routine.

Obesity differs from being overweight in that it only concerns excess of fat; the condition of being overweight involves higher amounts of body weight that derives from muscle, bone, fat, and water (National Institutes of Health, 1998). The National Health and Nutrition Examination Study (2009-2010) found that roughly one in every three U.S. adults, age 20 and older, are obese (Fryar et al., 2012). Obesity is also present in one in every six children, ages 2 to 19. This condition is acknowledged as both a national and global health issue, and it is continuously changing the way that we approach public health. Obesity is often described as a disease and an epidemic, which has the potential to lead one to understand its nature to be comparable to an infection or virus. However, the claim of obesity being a disease refers more so to the, sometimes chronic, side effects or outcomes that occur as a result of excessive body fat. As Hippocrates put it, "Corpulence is not only a disease itself, but the harbinger of others" (as quoted by Haslam & James, 2005). This misconception has the potential to lead those who are less familiar with the condition to believe that obesity is incurable or that it requires a pharmaceutical intervention. Obesity is not only capable of being treated in a number of ways, it is preventable (Ofei, 2005).

The human body requires a healthy number of fats to perform physical and mental tasks. Of the fats that we consume, only a percentage are immediately used (Landecker, 2013); the remainder are stored for later use, such as throughout the period of time that elapses while we sleep. While we sleep, the body remains active in carrying out automatic processes such as breathing and perspiration to regulate oxygen levels and body temperature (Parmeggiani, 1980). Many hours elapse while we remain at rest and we may find it necessary to tap into our energy reserves, to prevent hunger until the next meal is consumed (Morselli et al., 2010). The issue that is central to the emergence of obesity is the point at which our fat intake exceeds the rate at which we are able to process them, or the quantity that is immediately demanded. Unless we seek to create balance by exercising to a degree that creates a proportional demand by the body, fats will become stored in white adipose tissue (WAT) deposits until demand becomes extant.

The threat that high adiposity poses to mental health varies by individual but it is largely dependant on the physical ramifications of accumulating lipids in white adipose tissue (WAT) (Spiegelman & Flier, 2001). White adipose tissue (WAT) is situated in numerous areas around the body and is far more common than brown adipose tissue (BAT), which is mostly subcutaneous (found under the skin) (Spiegelman & Flier, 2001). WAT and BAT store lipids that have been consumed in excess, which are later drawn from for their respective functions and other bodily functions. WAT deposits are primarily located around hips, thighs, buttocks, and breasts, in women. In men, it is mostly found in the belly region (Power & Schulkin, 2008). These locations were once evolutionarily advantageous: when men had to venture into the wild to hunt for food and maintain high internal body fat to hold themselves over if they did not expect to return home for extended periods of time. Women's deposits were situated near the womb, so that if she were to be pregnant and needed to sustain herself and the fetus, without food for a prolonged period of time, there would be additional insulation surrounding the womb and proximal energy reserves for easy access (Power & Schulkin, 2008).

Unfortunately, for those of us who live in modern societies, our bodies did not evolve as we made progress in the way in which we obtain food. Additionally, we are no longer exclusively consuming raw foods. Scientists and food companies now have the ability to alter the composition of the products we purchase. The sugars, fats, and proteins on the shelves at the grocery store are molecularly altered variations of those which we find naturally in the foods we harvest (Shahidi, 2009). The human digestive system was not designed to process modern variations nor many of the chemical additives that have been created, only within the past 50 years. We are not simply increasing the natural fat found in our foods but we are introducing entirely new substances into our systems, which present us with a greater challenge in the effort to access lipids for energy (Moubarac et al., 2013).

Certain demographic studies revealed that being of a certain race, socioeconomic status (SES), education level, geographic region, and gender increases the likelihood of developing obesity in a lifetime (Mokdad et al., 2003; Ball & Crawford, 2010). Similar to how obesity is more likely to occur under the aforementioned circumstances, preventative measures and treatments are more effective when conditions are optimal. Unfortunately, in communities where obesity is most prevalent, in the United States, optimal conditions are nearly impossible to meet. Obesity in the United States is most prevalent in low-income communities (McLaren, 2007). Regions plagued with obesity are commonly restricted by their inability to afford quality food, good medical care, and acquire access to physical fitness groups and facilities, all of which are resources that those in optimal conditions have access to (Drewnowski & Darmon, 2005; Drewnowski & Specter, 2004). While the disease remains the same, approaches to combating obesity will be required to evolve to suit the needs of the populations that healthcare providers serve.

Obesity sends the body into a defensive state; a superfluous quantity of body fat provokes bodily systems to respond to the overwhelming presence that is disruptive or hindering to its regular function. This excess creates vulnerability, which allows for an onslaught of issues that pose a threat to our physical and mental wellbeing. As a result, there is an urgent need amongst practitioners to respond to mental health conditions, which are associated with obesity. Amongst these negative health outcomes, researchers and practitioners are reporting higher rates of diagnosis for mental illness and functional deficiencies, such as depression, anxiety, eating and feeding disorders and diminished cognition (Simon et al., 2006; Allison et al., 2009). Causal mechanisms for these outcomes can be difficult to pinpoint due to the plethora of possibilities. In Western cultures, like that in the United States, societal body image standards contribute greatly to the development of body related mental health issues (Rubinstein & Caballero, 2000; Groesz, Levine, & Murnen, 2002). Stigma and discrimination towards individuals with obesity can have detrimental effects on body image satisfaction, which has the potential to inspire them to make changes to their lifestyle that could have dangerous effects on their physical and mental health (Puhl & Brownell, 2001).

Research has defined many damaging weight-based stereotypes that support the idea that obese individuals are lazy, unsuccessful, unintelligent, undisciplined, and unattractive (Puhl & Brownell, 2001; Cramer & Steinwert, 1998; Puhl & Heuer, 2009). Obese individuals are often blamed for their weight issues and many internalize this stigma, which has been linked to higher rates of depression, lower self-worth, and higher body dissatisfaction (Puhl & Brownell, 2003; Friedman et al., 2005; Wardle, Waller, & Fox, 2002). Self-directed weight blame amongst obese persons can lead to the development of depression, anxiety, and several eating disorders (Pearl, White, & Grilo, 2014).

Denying ourselves or exceeding the necessary nutritional intake can have severely unhealthy implications for our mind and body. Neurological function is highly dependent on the efficiency and well being of all of our body systems. From each, the nervous system acquires the necessary nutrients and signals that allow us to selectively and automatically take action to alter our state of being and state of mind. Furthermore, overwhelming the body with lipids could pose a significant threat to the function and wellbeing of our nervous system and its processes.

Obesity (Adiposity) and Cognition

Research has found that in obese individuals, disruptions in the brain's critical regulatory systems are linked to dysregulation in other systems as a result of the increased intake and accumulation of lipids. Primarily, studies have indicated that high adiposity is linked to inflammation, elevated lipid count, and insulin resistance (Yang et al., 2006; Yudkin, Stehouwer, Emeis, & Coppack, 1999; Trollor et al., 2010). Neurochemical lesions, as a product of high adiposity, are thought to be responsible for diminished cognition. Findings from numerous cognitive performance studies amongst obese populations have reported correlations between high adiposity and poor cognitive performance. They report that adiposity is associated with diminished function of processes involved in memory and learning and global-level network function in the brain.

Additionally, dealing with poorer cognitive function during youth, as a result of high adiposity, has far more deleterious effects on immediate and lifetime cognitive development (Smith et al., 2011). Lifespan studies exploring cognition amongst obese individuals, of all ages, have revealed that obesity is related to impaired cognition. Researchers determined that obesity was most likely the cause of this impairment, because they were able to rule out confounds such as cerebrovascular sequelae (Smith et al., 2011; Wang et al., 2016). Cerebrovascular sequelae, which are best defined as chronic health conditions that arise as products of a cerebrovascular event that is damaging to cerebral circulation, were believed to not have been present in any of the younger participant groups (Golding, 2002). These events (i.e. stroke) are far more common in older populations, especially in those with obesity, and are often caused by low grade systemic inflammation. Thus the only common variable between participant groups was obesity.

Low grade systemic inflammation is the result of an immune response to the presence of threatening stimuli. In the case of obesity, negative changes in metabolic functioning trigger secretions of proinflammatory and anti-inflammatory endocrine substances called cytokines. There are many types of cytokines, but those of relevance to this project are tumor necrosis factor (TNF)-α and the interleukins 1β and 6 (Maachi et al., 2004). All trigger responses within the liver that act on metabolism, digestion, detoxification, and hormone balance (Calder et al., 2011). A lack of regulation of pro-inflammatory adipokines such as interleukins 1β and 6, and tumor necrosis factor (TNF)-α is known to contribute to diminished cognition amongst obese individuals (Ferrucci et al., 2006; Misiak et al., 2012; Calder et al., 2011).

By the same processes through which insulin resistance develops, metabolic regulation becomes dysfunctional and gradually incites damage on the major vascular pathways, which supply the nervous system (NS) (Xu et al., 2003). Hormonal balance and regulation are critical to the maintenance of glucose and lipid metabolism (Ouchi et al., 2011). These energy systems are kept in check by insulin. Inhibition at or near the insulin receptor (IR) tyrosine kinase, triggers a cascade of processes that play roles in insulin function (Hotamisligil et al., 1996). When insulin binds with its receptor (IR), it phosphorylates and signals its various messengers; substrate adaptors bind to the IR to initiate activation of glycogen and protein synthesis (Sun & Rothenberg, 1991). Through these syntheses, inhibition and activation of transcription factors initiate insulin activity (Czech, 2000).

Insulin stimulates uptake of glucose (sugar in the blood stream) in muscle and adipocytes (WAT) and inhibits gluconeogenesis (the generation of glucose) in the liver (Cahill et al., 1958; Saltiel & Kahn, 2001). Akt (protein kinase) phosphorylates, resulting in the inhibition of forkhead box O (FoxO) transcription factors, which are essential to metabolic regulatory processes (Barthel et al., 2005). FoxO transcription factors play a role in the upkeep of lifetime tissue homeostasis and have been linked to the development of diabetes in late life (Salih & Brunet, 2008). Insulin activity also stimulates fatty acid synthesis. Greater presence of adipose tissue can increase the likelihood of a cerebrovascular event and, over long periods of time, can lead to vascular blockages that prevent the uptake of glucose from the bloodstream, damaging vascular tissue and disrupting metabolic homeostasis.

Glucose is the primary fuel source of the brain (Mergenthaler et al., 2013). When required for use, it is extracted from the bloodstream. However, in situations such as starvation, glucose may not be available to the body. During starvation, glucose gradually becomes less available, so the liver converts lipids (fats) to sugar in the absence of carbohydrates (Owen et al., 1967; Hasselbalch et al., 1994). The sugars that are produced are called ketones and they maintain a structure that is similar to the compound acetone (Devivo et al., 1978). Ketones are structurally similar to acetone in such a way that they create an effect on the brain akin to acetone, which is an effect like that of alcohol. Alcohol and acetone impair cognition, decision making, and awareness. Thus, when lipids obstruct insulin receptors, they disrupt the processes that stimulate glucose uptake from the bloodstream; the body enters a state metabolic state of ketosis to produce accessible energy for the brain (Glaser et al., 2012). Additionally, higher level of ketones in the bloodstream, due to insulin resistance, has been shown to lower blood pH below 7.3. This can cause increase in thirst due to dehydration from the body's efforts to excrete ketones from the blood (Cameron et al., 2014). In turn one may experience the effects of cognitive impairment from glucose deprivation and lower blood pH.

Studies that have measured cognitive capacity in obese individuals as compared to healthy controls have found diminished capacity to perform executive function tasks (Cserjési et al., 2009; Gunstad et al., 2010). Executive function (EF) is a key aspect of informed behavior; it is the set of abilities required to guide actions toward a goal in an effortful way (Anderson, 2002; Ridderinkhof et al., 2004). Like many neurological processes, EF is multifaceted and consists of several unique processes that include task switching, prioritizing sequences of behaviors, assessing relevance of information to behaviors and goals, and recalling old information about learned behaviors. The loss of control over executive function is known to be attributable to substances, intense changes in emotion, and excessive consumption of high fat foods (Crean et al., 2011; Zelazo & Carlson, 2012; Pistell et al., 2010). As previously mentioned, high blood-ketone levels negatively affect cognitive processes. One may be required to put forth additional effort to assess stimuli and to consider the consequences of interacting with them.

Some studies evaluated if high fat diet, alone, mediated the harmful effects of obesity on cognition, because of the role of high fat intake and the nutritional demands of the body (Pistell et al., 2010). They found that obese participants who consumed a high fat diet exhibited worse executive function than obese participants who consumed an average or low fat diet. Compared to normal weight control groups, regardless of diet, all obese groups scored lower on executive function measures. A diet lower in fat may decrease lipid accumulation and lead to improved insulin sensitivity and greater executive function.

Obesity (Body Ratio) and Cognition

Body mass index (BMI) is often confused for being a measure of adiposity. In each of these studies, BMI has been used to categorize participants into groups that researchers intended to be representative of a high adiposity population (De Lorenzo et al., 2013; Burkhauser & Cawley, 2008). Instead, they have used a measure that determines how appropriately a participant's body assumes a normal ratio of weight and height. While research has found that BMI is capable of predicting obesity, it is considered to be an inaccurate measure of adiposity (Schwartz & Brownell, 2004). By definition, BMI is a weight-for-height ratio measure, and obesity is defined as “abnormal or excessive fat accumulation that may impair health” (World Health Organization, 2000). BMI’s validity in predicting obesity is questionable, because BMI is not representative of body fat percentage. Using this measure gives the impression that individuals with substantially higher BMIs have the same or approximately the same body fat percentage (Rothman, 2008). For example, BMI could be measured on two individuals of equal height and weight and it may be true that they have the same BMI, but they may not have the same body fat percentage. Fat on average, has a density of 0.9 g/mL and muscle density is slightly greater than that at an average of 1.1 g/mL (McCabe, Ricciardelli, Sitaram, & Mikhail, 2006). Thus by volume, fat occupies more space and muscle mass is more condensed.

Multiple studies have found inaccuracies in estimation of body size amongst those who are characterized as severely under and overweight, as compared to healthy, normal weight controls (Matz et al., 2002; Scarpina, Castelnuovo, & Molinari, 2014; Zaccagni et al., 2014). Body size estimation entails a significant cognitive effort that is comprised of aspects of executive function and numerous other perceptual and sensory factors. While the effects of obesity have not been measured using appropriate measures of adiposity, the results of studies that look into the effect that lipids have, on a molecular level, suggest that high adiposity may have deleterious consequences for somatosensory networks that are believed to be associated with body size estimation. In each of these studies, BMI has been used to categorize participants into groups, which determine how appropriately their body assumes the “normal” ratio. These findings also have value, in that inaccurate body size representation might be the result of one or more characteristics of obesity: a) having a high total body fat percentage (high adiposity) or b) a weight for height ratio (BMI) that significantly exceeds a ratio that is considered appropriate.

The physiology of high adiposity clearly has an effect on cognition but the results from the body size estimation studies provoked me to question if an abnormal weight for height ratio has a similar influence. And, if so, what its mechanisms may be and how great is its effect. Proprioceptive awareness, or the collecting of information about body movements and perceptions, is central to the issue of body size estimation. The receipt and processing of feedback from the physical body's interactions with somatosensory stimuli are dependent upon the functioning of its sensory receptors, and their communication with the primary and secondary somatosensory cortices of the brain. Disruptions to these pathways create irregularities in perceptual awareness pertaining to size of receptive fields, their relationship to other body parts and to objects independent of the body. Without this perceptual capacity, we may become completely handicapped or face inadequacies in motor and spatial cognition (Laureys et al., 2002; Jones & Powell, 2016).

Tactile (touch) perception, which is often used in studies examining body size estimation accuracy, is experienced as a result of the stimulation of sensory receptors across the body's surface (Lumpkin & Caterina, 2007). Amongst these are mechanoreceptors, nociceptors, and thermoreceptors. They each serve unique purposes in detecting pain, pressure, heat, and movement stimuli (Lumpkin & Caterina, 2007). This paper will focus on neurophysiological mechanisms as they pertain to the roles of mechanoreceptors in body size estimation acuity. This section exclusively contains information regarding the network through which the physical body receives and processes stimuli in the somatosensory cortices (SI and SII). The relationship between this network and mental representations of the body will be discussed within the section that follows.

The somatosensory cortices, particularly the primary somatosensory cortex (SI), gather input from the aforementioned receptors and encrypt that information in a spatial map. The map is located in the postcentral gyrus and information is organized in a manner, which is inverted in relation to the contralateral side of the body (Hlushchuk & Hari, 2006). Representations of body parts within SI are dependent upon the size of the receptive field (Kaas et al., 1979; Makin et al., 2015). Receptive fields across the body differ based on the amount of information that they relay to the cortices. Larger receptive fields, such as that on the thigh and abdomen, have fewer mechanoreceptors that are distributed sparingly. Whereas smaller receptive fields, such as those of the fingers and toes, have highly condensed distributions of sensory receptors, due to higher frequency of interaction with tactile stimuli (Johnson et al., 2013). Thus, regions which require higher rates of somatosensory processing in SI have larger representations in this cortex.

Regions that are comprehensively represented in SI have been shown to exhibit greater spatial accuracy (Liang et al., 2013). Perceptual accuracy is largely dependent upon clear communications between stimuli and the SI area associated with the respective skin region (Buchner et al., 2000). Disturbances in the somatosensory network may occur, leading to perceptual experiences that deviate from the norm. Amongst the plethora of researched sensory alterations, deafferentation, elongation, and experience are most strongly related to the physiological consequences of obesity (Longo et al., 2010). Deafferentation, elongation, and experience have been linked to lesions in SI as well as in the body schema, which will be discussed in the next sections.

Deafferentation

Deafferentation is more closely related to the properties of obesity mentioned in the previous section, rather than the influence of abnormal weight for height ratio, but its applications will be reviewed here for the sake of fluidity. Deafferentation is defined as the state of having an incomplete afferent connection with the central nervous system (Taub, 1980). In many cases, the nerves, which forward information from the receptors located at the skin surface, are entirely or partially inhibited and cannot execute their role. SI regions related to those sensory receptors may reorganize to gather information from nearby receptive fields, in order to maintain function (Pons & Garraghty, 1991). This outcome appears to be the result of an "unmasking" of synaptic pathways to neighboring SI areas; adjacent receptive fields become available to SI areas with deafferented nerves (Buonomano & Merzenich, 1998).

Studies in medicine have found that obesity may influence the efficacy of mechanoreceptors at the body's peripheral input regions (Teasdale et al., 2013; Hue et al., 2007). Specifically, these findings support the negative effects of high adiposity on perceptual sensitivity, which guides postural stability and balance. They explore the numerous complications of obesity and how they might contribute to somatosensory deficits. Amongst these, two major points of interest were height of differential thresholds as they relate to center of pressure (CoP) and low grade systemic inflammation. As previously mentioned, receptive fields that relay more information to the somatosensory cortices are often more frequently used and therefore more sensitive to sensory input. However, this may not be the case for obese individuals.

While receptive fields that are more extensively represented in SI exhibit greater sensitivity to sensory stimuli, it has been shown that excessive and superfluous weight increases stress on the mechanoreceptors of the foot (Hue et al., 2007). Additionally, these same studies report higher sensitivity thresholds in obese individuals as compared to normal weight controls. Prolonged stress, placed on the mechanoreceptors of the foot, has been found to alter the differential threshold in this receptive field. Reduction in sensitivity to pressure changes, applied the foot, might explain the diminished capacity to control for stability.

An alternative explanation or contributory factor may be increased low grade systemic inflammation. This type of inflammation poses a threat to the sensitivity of mechanoreceptors in the foot, especially via their affiliated nerve systems. Damage to peripheral nerves is known as peripheral neuropathy (PN; Dyck, 2005). Peripheral neuropathy has serious consequences for perceptual capacity due to the malfunction of peripheral nerves and their inability to forward signals to the central nervous system (CNS). PN is usually associated with diabetes, but it has been found in non-diabetic obese individuals (Miscio et al., 2005). Miscio et al. evaluated damage, as caused by obesity, to motor and sensory nerves. Their results supported findings from prior research, which concurred that high adiposity weakens nerve response; lessening perceptual acuity (Dumitru & King, 1995; Dorfman & Robinson, 1997). From what is known, it might be that deafferentation is possible through lesions in differential thresholds (as they relate to pressure sensitivity) and low grade systemic inflammation.

Elongation

Across lifetime development, the body undergoes numerous changes including physical growth. This process is unhurried in nature due to the body's need to acclimate to the overwhelming number of modifications, which transpire from conception through death. As a result of these changes to our structural composition, our somatosensory cortices adapt in order to accommodate nuances in the receptive fields (Jenkins et al., 1990). Elongation, or the stretching or lengthening of the body and its parts, is recognized for its relationship with changes in cognitive representation and plasticity. In fMRI scans, following a surgical intervention which gradually elongated the limbs of two subjects, Di Russo et al. (2006) found that the representation of the limbs in SI reorganized itself to be in accord with the alterations to the physical body. This outcome suggests that the lengthening or stretching of receptive fields, in obesity, may provoke similar modifications to body part representation in SI; perception of somatosensory stimuli is altered so that sensory experience is not representative of reality.

The trajectory of physical development varies from person to person. However, numerous notable health organizations, including the Centers for Disease Control (CDC), the World Health Organization (WHO), and the National Institutes of Health (NIH), recognize a standard measure that determines if an individual's ratio of weight and height is considered to be "normal". This measure is BMI. As previously discussed, BMI is a categorization measure, which determines how appropriately a body assumes the healthy standard of weight for given height. This measure is known to be inaccurate in diagnosing obesity (high adiposity). In numerous tactile awareness, studies, BMI is correlated with tactile estimation inaccuracy (Matz et al., 2002; Scarpina, Castelnuovo, & Molinari, 2014; Zaccagni et al., 2014; Keizer et al., 2011). My analysis of the physical health consequences of high adiposity leads me to believe that BMI ratio is exclusively correlated with tactile estimation inaccuracy in those with a BMI greater than 30 and a high body fat percentage.

Experience

This concept adheres to the saying, “practice makes perfect”. The repeated use of a limb or the repeated experience of tactile stimulation has been shown to enhance tactile acuity, regional sensitivity, and representation of the part in SI. Several studies have produced evidentiary support for the improvement of acuity and sensitivity, as well as for plasticity, which allows for changes in SI representation (Van Boven et al., 2000; Schweizer et al., 2001). Obesity is commonly associated with a more sedentary lifestyle, which entails limited use of the body. Because representations in SI are related to quantity of sensory input, reduced use of body parts (experience) will impact not only their representation in SI, but also the sensitivity of the receptor area to somatosensory stimuli (Cholewiak, 1999; Schweizer et al., 2001).

Underuse of the body may lead to diminished signalling in the peripheral nervous system (PNS); requiring extra effort on the part of the CNS to detect sensory input. When the threshold for detection is so high or signals become unavailable, processes of an automatic nature are activated (Buonomano & Merzenich, 1998). Within body parts, interneurons reorganize so that the electrical signal from the nearest afferent source is directed through the nerves serving the deafferented area. In doing this, the mind accesses an engram, or stored memory of the area prior to the loss of sensory awareness (Wechsler, 1963). This idea first comes from the work of

Richard Semon, who proposed that we store "mnemic traces", memory traces, from experiences of the physical body (Semon, 1921). Twenty years later, Canadian neuroscientist, Donald Hebb (1949) published, *The Organization of Behavior*. In this text, Hebb suggested his theory explaining the neural mechanisms responsible for synaptic plasticity in learning. Hebbian theory, as explained above, is thought to be affiliated with bridging unresponsive areas to the brain and increased tactile acuity through experience.

Relying solely on neighboring neural networks to improve tactile sensitivity, without increasing experience, can lead to changes in the way that regions are represented in SI. The results of Wang et al. (1995) provide some support for the role of interneurons in transmitting sensory input from sensory deprived regions, as well as for the significant implications it has on SI representation. This study found that, in SI, the representations of dually stimulated fingers morphed together. This change could help us explain inaccuracies in size estimation amongst obese individuals; the plastic reorganization sensory networks, due to neuropathy or deafferentation, may lead to grouping of SI regions and therefore overestimation of actual size.

It may be argued that interneurons are beneficial in the process of differentiation of signals in SI. Distinguishing signals involves the inhibition of noise from those that neighbor and interact with a unique pathway. Interneurons aid in the process known as competitive inhibition. Competitive inhibition can best be defined as competition between afferent signals from different body parts or skin regions (Brecht et al., 2003). Sensory perception, in this case tactile sensation, requires a cooperative effort between excitatory signals and interneurons, which inhibit unnecessary noise from unrelated signalling. When the body undergoes significant alterations, such as surgery or the consequences of high body fat, SI representation becomes reorganized as well as the neural pathways that supply the cortex with information. Because sensory experience is bidirectional, use influences SI representation just as much as the physical organization of the receptive field. Thus, we might infer that an overwhelming accumulation of lipids in adipose tissue may trigger reorganization of cortical mapping; changes to cognitive mechanisms in perception.

Body Schema and Body Image

Research in cognitive psychology indicates that individuals process various types of sensory input to assess a situation, and react within the context of their environment. This cognitive process alone, consists of millions of individual neural interactions, which transpire as the stimuli of the outside world engage with our nervous system. One accesses the information gained from these sensory stimuli through numerous cognitive processes and formulates a *body schema*, or a culmination of body representations, developed from somatosensory stimuli, which are then used to construct a dynamic mental image of one's own body (Dijkerman & De Haan, 2007; Sedda & Scarpina, 2012). These representations guide both our manual (conscious) and automatic (unconscious) actions (de Vignemont, 2010). We access these schemas to mentally conceptualize our reactions to stimuli that have engaged with us, and stimuli that we intend to engage.

Most closely related to the body schema, is another representation that is more commonly discussed; this is *body image*. Body image is not believed to be directly responsible for sensorimotor representations, as one's body schema is. The concept of body image is thought to be comprised of all body representations that do not pertain to [the body in] action. These representations may be formed from perceptual, conceptual, and/or emotional stimuli. While these concepts may seem distinct, it is key to note that both are not entirely exclusive of one another; in many ways, they interact and influence one another tremendously.

Dyadic taxonomy (Gallagher, 2005; Rossetti et al., 1995) and triadic taxonomy (Schwoebel & Coslett, 2005) are two of the most widely supported theories regarding the roles of each type of representation and how they engage to contribute to developments in our self concept. Schilder (1934) said that through somatosensory input, we build a self image of our physical body based on somatosensory input, thoughts, and beliefs about our parts and how they exist as an unified entity. Beliefs are also influenced by our emotional state, which is provoked by thoughts, experiences, and previously acquired knowledge about the self and the world. Our body image representation evolves as we grow into conscious awareness about our physical self and how we compare ourselves to other objects, people, and how we see ourselves in the context of space; body schema evolves.

Dyadic Taxonomy

Some researchers in the field of cognitive psychology agree that there are two major representations of the physical self: body schema and body image (Gallagher, 2005; Rossetti et al., 1995; Dijkerman & de Haan, 2007). The dyadic taxonomy is rooted in the work of Paul Schilder (1934). This taxonomy believes that body schema is formed from sensorimotor stimuli we encounter and interpret in the sensory cortices of the body; this information tells us about our physical self and how it relates to action and movement. In contrast, body image focuses on the emotional, theoretical, and affective representations of the body; those that are not used for action. The dyadic concept of body image is far more comprehensive than that of the triadic; places less emphasis on the intricacies of cognition and perception.

Triadic Taxonomy

This model agrees that there are two representations of the body, which are central to our taxonomy. In fact, the triadic taxonomy supports the exact concept of body schema that was established in the dyadic system (Schwoebel & Coslett, 2005). Triadic taxonomy differs in that it believes body image to be a two part system. Here, the cognitive aspects of body image are deconstructed into two main functions. The first suggests that body image has a structural representation of the body, which is more specifically a visuospatial relationship between body parts, boundaries of the body, and the proximity and position of one part to another. This is strongly influenced both by vision and corporeal perception. The second aspect of body image focuses on body semantics between the functional purpose of parts (conceptual) and how they are categorized (linguistic).

While the disassembling of the numerous functions of body image has provided useful insight into our understanding of body-related cognition, it has also created a great deal of confusion due to a lack of general consensus regarding how these functions apply to each representation. Since the initial suggestion of a dyadic taxonomy, more complex representations have been brought into question, and in doing so have only made it more difficult for us to define the specific roles of body image and body schema (De Vignemont, 2010). Because of its comprehensive approach, this project will focus on the representations supported by the dyadic taxonomy.

Obesity, Cognition, and Body Schema

While all disorders of body awareness are not caused by abnormalities in body weight composition, they are often found to be comorbid with obesity (Hudson et al., 2007). Following my assessment of current and former research surrounding obesity and mental health, I have arrived at the conclusion that lipids in excess pose many threats to our cognitive regulatory systems (which are crucial to the function of the nervous system and all of the body's systems). A primary example of the deleterious effects of high adiposity on the nervous system is the development of Type II Diabetes. When lipid intake surpasses what is necessary, fatty acids build up within muscle. An overwhelming build up of fatty acids can clog insulin receptors, which initiate the process that allows glucose (sugar) to exit the bloodstream and be used as an energy source in muscles. Accumulation of glucose in the bloodstream can directly affect the nervous system by damaging the lining of vessels and block flow of blood to nerves, resulting in conditions such as peripheral neuropathy (Majumder et al., 2013).

Findings from multiple studies have found that there are inconsistencies and inaccuracies in estimation of body size amongst those who are characterized as severely under and overweight, as compared to healthy, normal weight controls (Matz et al., 2002; Scarpina, Castelnuovo, & Molinari, 2014; Zaccagni et al., 2014). While it has not been directly measured, their results suggest that an unhealthy body fat percentage may contribute to these discrepancies.

Research Question

In this senior project, I propose a study investigating whether high adiposity or high BMI contribute more so to the cognitive processes involved in the development of body taxonomies (body schema and body image). Specifically, I hope to assess the individual effects of obesity and high BMI on a) tactile perception (tactile size estimation task) and b) non-stimulus based schematic processing (distance comparison task). The distance comparison task requires participants to draw conclusions regarding distances *between* parts of their bodies; no direct sensory stimulus is utilized. On the other hand, the tactile size estimation task will involve participants making estimations about distances *within* single body parts; sensory pathways and cortices must be involved. Lastly, I intend to examine body part satisfaction and how it is associated with body size estimation accuracy, adiposity, and BMI. Body part satisfaction will be assessed using a Likert questionnaire, on which participants rate their degree of satisfaction with characteristics of specific body parts.

The methodology of this study has been adapted from Scarpina, Castelnuovo, & Molinari (2014). They found that, compared to normal weight controls (as determined by BMI), obese participants tended to overestimate distances on both the tactile size estimation task and the distance comparison task. Additionally, obese participants were significantly more dissatisfied with body parts (arm and abdomen), and higher dissatisfaction amongst this group was related to less accurate body size estimation. My proposal utilizes many aspects of this study. However, it differs in that both experimental groups have a BMI greater than 30 and they are distinguished from one another by body fat percentage; one being abnormally high (40%<) and one being ideally low (10%<18%).

Due to the aforementioned health consequences of high adiposity, I anticipate that participants with 40%< Total Body Fat Percentage will exhibit less acuity on both tactile and non-stimulus based schematic processing tasks. Additionally, I hypothesize that tactile and mental body representation will differ between obese groups and that percent body fat will mediate this difference. As found in Scarpina, Castelnuovo, & Molinari (2014), I believe that inaccurate estimations of size and distance will be correlated with participant group. High adiposity participants are expected to have the greatest dissatisfaction with body parts, followed by the control group, and finally the low adiposity group.

In the event that these hypothesized outcomes are found to be accurate, their implications would contribute largely to our knowledge of biopsychosocial mechanisms of mental and physical health conditions, such as eating disorders. Inaccurate estimation on the distance comparison task may be explained by overestimation on the tactile size estimation task; possibly suggesting a physiological impairment in processing touch-based stimuli--SI reorganization due to deafferentation caused by high adiposity. Additionally, greater dissatisfaction with body parts may be indicative of dissociation from one’s full sense of self; straying away from the “wholeness” of mind and body as one system.

Methods

This study has been approved by the Institutional Review Board at Bard College in Annandale-on-Hudson, New York. [See Appendix A]

Participants

I plan to recruit 150 participants. Of these, 50 age and gender matched participants will make up each group. Power estimates in this proposed project are based on the average sample size used in relevant current research, which is approximately 40-50 in each group, with a power of 0.80. In the two experimental groups, all participants will have a body mass index score (BMI) of 30 or greater. 30<BMI is indicative of "obesity", or a weight for height ratio that suggests that one may have a high total body fat percentage (McCabe et al., 2006). Those in the control group will all be required to have "normal weight" BMI scores, which range between 18.6 and 24.9.

BF% of all female *OLF* participants will fall between 14-20% and *OLF* males will meet a BF% between 6-13%. *OHF* females will fall above 40% and all male *OHF* participants, above 30%. *HC's* will have BF% between 25-30% for females and 17-21% for males. Body fat percentages follow those categorized by the American Council on Exercise (Muth, 2009). These percentages represent the average body fat percentages for males and females based on their fitness level. *OLF* participants are categorized as "athletes", *OHF* participants are categorized as "obese", and *HC* participants are categorized as "average". Additionally, variance in percentage between genders is explained by physiological differences in the human anatomy. In comparison to males, females naturally have higher total body fat (Jackson et al., 2002).

All participants will have met the inclusion criteria, which require them to identify with their assigned gender (Male or Female), be between the ages of 18 & 30, have normal or corrected-to-normal vision, be fluent in the English language, have never received a clinical diagnosis for an Eating Disorder, Body Dysmorphia, Major Depression, or a degenerative muscle condition, and have never used hormones or anabolic steroids. Prior studies have show these to influence one or many variables, including: body image, body size, cognitive function, and sensory perception (Paxon & Franko, 2010; Blouin & Goldfield, 1995; Kanayama et al., 2013; Abbruzzese & Berardelli, 2003).

Recruitment of participants will take place on Bard's campus, in the surrounding community (including neighboring colleges/universities), and at numerous fitness facilities (CrossFit). In addition to eligibility criteria, participants will be screened for potential signs of disordered eating behavior, using the SCOFF questionnaire (Hill et al., 2010), and for normal cognitive functioning, using the Mini Mental State Examination (MMSE) (Pangman, Sloan, & Guse, 2000). The criteria scores for each assessment require the participants to achieve less than 2 on the SCOFF and greater than 24 on the MMSE. The SCOFF is a 5 question detection questionnaire for eating disorders that has high sensitivity to the symptomatologies of various disorders (Morgan et al., 1999; Wade, 2016). Each question requires a yes or no response. If there are two or more "yes" responses, then the participant is considered to screen positive for a possible eating disorder. The Mini Mental State Examination (MMSE) is a cognitive test that is typically used in clinical settings to diagnose dementia and significant cognitive impairment (Folstein et al., 1975; Mitchell, 2009). MMSE scores ranging from 25-30 suggest significant cognitive impairment. Additionally, those who do not meet any of the aforementioned criteria or those who correctly guess the intentions of this study, will be excluded. All participants will receive two (2) entries into a lottery for a chance to win two (2) $100 Visa gift cards.

Table 1

Participant groups and their respective body characteristics.

Controls (*HC*)	High BMI/High Adiposity (*OHF*)	High BMI/Low Adiposity (*OLF*)
18.6 < BMI < 24.9	30 < BMI	30 < BMI
(f) 25-30% body fat (m) 17-21% body fat	(f) 40% < body fat (m) 30% < body fat	(f) 14-20% body fat (m) 6-13% body fat

Procedure

Physical Assessment Measure

Percent Body Fat (BF%) was assessed using the Yuhasz Skinfold Test (Carter & Yuhasz, 1984). Unlike most skinfold techniques, which use 3-4 fold sites, the Yuhasz Skinfold Test uses 6 sites. Four locations: triceps, subscapular, suprailiac, abdomen, and front thigh, are taken in both men and women. Measurements at the chest are exclusive to males, and measurements on the rear thigh are only taken on females. The test requires a skinfold caliper (in millimeters). At each site, measurements (in millimeters) are taken three times, then averaged to determine the score for that site. All site scores are added and their sum is processed through an assessment tool, which accounts for age and gender.

Likert Questionnaire

Procedure for completion of the Likert style questionnaire was similar to that done in Scarpina, Castelnuovo, & Molinari (2014). Participants were asked to rate their satisfaction with particular qualities of the body parts being measured (arm & abdomen). Unlike Scarpina, Castelnuovo, & Molinari (2014), the questionnaire included two questions regarding concern with gaining more muscle mass. All questions allowed participants to rate their feelings on a scale of 1-7, where 1 was "not worried" and 7 was "highly worried". Prior to completion of the tactile size estimation task, participants answered questions 1 & 2 of the Likert style questionnaire; they rated "dissatisfaction with the physical aspects of their arm/abdomen" and "concern with arm/abdomen slimming down". Following completion of the tactile size estimation task, the remaining four questions were answered; participants rated "concern with [their] arm/abdomen slimming down/becoming more muscular".

Tactile Size Estimation Task

This task followed the procedures used in Scarpina, Castelnuovo, & Molinari (2014), which had been modified from Keizer et al. (2011). This task sought to measure tactile perception and how tactile stimuli contribute to formation of and use of one's body schema in determining distance on one's body.

Disposable blindfolds were fitted to the participant's face and were worn until the task was completed. Using a caliper, two points were touched to the skin on the participant's arm/abdomen. The participant was instructed to approximate the distance between the two points using the first and second digits of their right hand. The approximated distance was then measured using a standardized ruler. Both Keizer et al (2011) and Scarpina, Castelnuovo, & Molinari (2014) found relationships between the body parts measured and ratings of dissatisfaction on their likert questionnaires. I hypothesize that the greatest concern about slimming down will occur in the *OHF* group, followed by the control group, and then the *OLF* group. It is also assumed that the *OLF* group will have the greatest concern with becoming more muscular, followed by the *OHF* group, and the *HC* group.

Participants completed the tactile size estimation task on two body parts: the arm and abdomen. These parts were selected Measurements taken on the arm, the distal body part, took place on their left forearm. Arm measurements were completed in a lengthwise or longitudinal direction (hand to elbow). Abdominal measurements, proximal body part, were taken on the upper abdomen and in a horizontal direction (left to right). Each distance (1, 2, or 3 inches) was performed 15 times on each body part (arm, abdomen) resulting in an overall total of 90 measurements. Body parts were counterbalanced and the order in which distances were presented to participants was randomized.

Distance Comparison Task

Mental body image perception was assessed using a task that had been adapted from Smeets et al. (2009). This task utilizes image-scanning to provide an estimation of how an individual constructs a mental image of their body. The first part involved the experimenter and the second part involved a computer task with only the participant.

During part one, participants were asked, while standing, to close their eyes and imagine looking into a full-length mirror. They were then verbally guided by the experimenter to focus on their imagined horizontal distances between their actual body parts, being their ears, shoulders, armpits, elbows, waists, hips, thighs, and knees. Distances were presented in a horizontal manner such that the participants were asked to imagine distance between left shoulder and right shoulder, left thigh and right thigh, or left armpit and right armpit.

Part two of the distance comparison task was presented on a desktop computer using E-Prime 2.0 (Psychological Software Tools, Pittsburgh, PA). In each trial, of which there were two, two word pairs consisting of two identical body parts (representing the left and the right parts) were shown consecutively. Parts were organized into two categories: sensitive and insensitive. “Sensitive” body parts are parts that are recognized as problem areas, or areas of concern, for most people. “Insensitive” body parts are those that are not commonly recognized as problem areas for most people; control areas. Word pairs consisting of the body parts waist, hips, and thighs were considered sensitive pairs while word pairs with ears, shoulders, armpits, elbows, and knees represented insensitive pairs.

In each of the two trials, two word pairs were consecutively shown. A total of 20 word-pair combinations were created. Each combination was presented twice in order AB (for example first waist–waist and then hip–hip) and twice in order BA (first hip–hip and then waist–waist). Overall 80 word-pair combinations were presented in two different blocks, in counterbalanced order. participants were presented initially with a fixation cross screen. After 2000ms, the first word pair of body parts appeared for 500ms and was followed with a blank screen for 250ms. The second word pair of body parts appeared for 500ms, followed by a blank screen. At this time, using the keyboard, a participant indicated if the first pair of body parts had a greater distance between them, with respect to their own bodies, than those in the second word pair. Participants were asked to provide responses as rapidly and accurately as possible.

Answer accuracy and reaction times (RTs) were recorded. Following completion of the experiment, the relevant distances were measured on each participant's body.

Data Analysis

Likert questionnaire

A one-way ANOVA was performed to find differences in means of satisfaction scores for each body part (arm, abdomen) between the 3 participant groups (*OLF*, *OHF*, *HC*). Paired sample *t*-tests were used to assess for potential differences between body parts (arm, abdomen) within each participant group. These same measurements were used to analyze mean dissatisfaction and concern for weight loss and becoming more muscular in relation to the arm and abdomen independently.

Tactile size estimation task

Estimation of distance was measured by calculating difference between approximated distance and actual distance. Negative error is indicative of underestimation of tactile distance and positive error indicates overestimation.

A mixed, repeated measures analysis of variance was used with the variable of group (*OLF*, *OHF*, *HC*) as the between-subjects factor and the variables of body part (abdomen, arm) and measure (1”, 2”, and 3”) as the within-subjects factors. The errors for the three different measures (1”, 2”, and 3”) were collapsed together, for the arm and the abdomen independently. For each group (*OLF*, *OHF*, *HC*), independent t-tests were conducted with the variables of gender (males, females), in order to explore a possible effect of gender on estimation acuity for the arm and the abdomen. Pearson product moment correlation coefficients were calculated in order to examine a potential relationship between the estimation error in relation to the arm and the abdomen independently with BMI, BF%, with the rates of dissatisfaction and concern for weight loss and muscularity in the arm and the abdomen, as measured by the Likert questionnaire.

Distance Comparison Task

Accuracy was measured by comparing actual to estimated horizontal distances on each body part. This measure was quantified by the percentage of a participant’s responses that were correct.

A mixed, repeated measures analysis of variance was also conducted here with variable of group (*OLF*, *OHC*, *HC*) as a between-subjects factor and variable of body part category (sensitive, insensitive) as a within-subjects factor. Within each participant group (*OLF*, *OHC*, *HC*), an independent t-test was conducted with variables of gender (male, female), to determine if there were any effects of accuracy in relation to body part estimation accuracy on the arm and abdomen. Additionally, Pearson product-moment correlation coefficients were used to inspect for a potential relationship between accuracy and the variables BMI and BF%. Time of reaction was also evaluated using the same tests.

Predicted Results

Demographics

It is predicted that there will be no significant differences found between age and gender amongst participants, as they will be both age and gender matched. Those in the *OLF* group will have similar BMI scores to those in the *OHF* group, and both will differ significantly from the BMI scores of participants in the *HC* group. Body fat percentage (BF%) is expected to significantly differ between all participant groups, such that *OHF* participants will have the highest BF%, followed by *HC* participants, and lastly *OLF* participants.

Likert Questionnaire

Participants will be asked to rate satisfaction with particular qualities of their arm and abdomen. It is predicted that a Levene's test for equal variance will indicate that variable of rate for arm and abdomen will be normally distributed for the *HC* group and *OLF* group ($p > 0.05$), but not for the *OHF* group ($p < 0.05$). A Kruskal-Wallis test is predicted to conclude that the *OHF* group would reveal significantly greater dissatisfaction with both the arm and abdomen compared to the *HC* group and *OLF* group, and the *HC* group will show greater dissatisfaction than the *OLF* group (Appendix G, Figures 1-3). The results of the Friedman's test should report no significant difference between the score for the arm and abdomen for the *OHF* group. This finding is expected to be confirmed by a one-way ANOVA. Similar results are predicted for concern about the arm and abdomen not slimming down and concern about becoming more muscular in the arm and abdomen.

Tactile Size Estimation Task

Here, I intend to explore the possible independent effects of body fat percentage and BMI in the estimation of tactilely perceived distance using two unique body parts, the arm and abdomen. Estimation of distance will be measured by calculating difference between approximated distance and actual distance. Negative error will be indicative of underestimation of tactile distance and positive error will indicate overestimation.

It is predicted that a Levene's test will indicate that at all levels of the independent variable, estimation error is normally distributed ($p > 0.05$). Additionally, I predict a significant main effect of *group* on estimation error such that *OHF* is expected to have the highest error, followed by *HC*, and finally *OLF*. Bonferroni-corrected estimate marginal mean comparisons would reveal that *OHF* differs significantly from *HC* ($p < 0.05$) and *OLF* ($p < 0.001$), but the latter do not differ significantly from each other (Appendix G, Figure 4). A significant main effect of *body part* on estimation error is also expected: distances on the arm will be overestimated more than distances on the abdomen. No interaction is expected to emerge between *group* and *body part.* Furthermore, *OHF* is expected to show the most positive error in estimation (overestimation), on both body parts, compared to *HC* and *OLF*. It is predicted that *OHF* will make the greatest overestimations on the arm, compared to the abdomen. *HC* and *OLF* will also overestimate distances on both body parts but these will not reach significance, nor will there be any significant differences in their estimation error across body parts.

It is also predicted that the mixed ANOVA will reveal a significant main effect of *measure*. After applying a Bonferroni correction, estimated marginal mean comparisons are expected to show significant overestimation of 1” and 2” distances compared to 3” distances. 1” distances are expected to be slightly more overestimated than 2” distances, but no significant difference is expected to be found between them. This effect is expected to independently interact with *group* and *body part*. Bonferroni-corrected estimated marginal mean comparisons for *measure***body part* would be expected to reveal a significant difference in overestimation of 1” and 2” distances compared to 3” distances perceived by the arm, but not relative to the abdomen. Additionally, it is predicted that corrected estimated marginal mean comparisons for *measure***group* would indicate that overestimation of 1” and 2” distances in the arm is significantly more common amongst *OHF* participants than both *HC* and *OLF* participants, and more common in *HC* participants as they compare to *OLF* participants.

If these hypothesized results were to be found accurate, it might suggest that a) less distance between simultaneously administered tactile points may result in a larger error in estimated distance, b) perception of tactile stimuli is more susceptible to distortion in body parts that frequently engage with action-oriented stimuli, such as arms, compared to body parts that typically engage less often with action-oriented stimuli, such as the abdomen, and c) high adiposity may impair cognitive processes involved in evaluation of tactilely perceived stimuli; likely in relation to action-oriented representations (body schema; Gallagher, 2005; Dijkerman & de Haan, 2007). It may be useful to look at a second order interaction between *measure*, *group*, and *body part* to better understand the relationship between the three variables.

Independent t-tests for *OLF*, *OHC*, and *HC* are predicted to reveal no effect of gender or BMI in relation to estimation error on the arm or the abdomen. No effect of rates of body part dissatisfaction, concern about body parts slimming down, or concern about increase in muscularity of body parts is expected to be found in relation to the arm or the abdomen, for all groups. A significant positive correlation between BF% and estimation accuracy is predicted to emerge in the *OHF* group. No correlation between BF% and estimation accuracy is predicted to arise for *HC* group or the *OLF* group.

Distance Comparison Task

Accuracy will be measured by comparing actual to estimated horizontal distances on each body part. This measure was quantified by the percentage of a participant's responses that are correct. It is predicted that a Levene's test will not reveal a normal distribution of variance for accuracy ($p < 0.05$).

A Kruskal-Wallis test would be expected to indicate that the *OHF* participants are least accurate, followed by the *HC* participants, and lastly the *OLF* participants. Mean inaccuracy is predicted to be greater for sensitive body parts than for insensitive body parts, which would be expected to emerge as a result of a Friedman's test. A Kruskal-Wallis test is predicted to find that, relative to accuracy for both sensitive and insensitive body parts, *OHC* participants are less accurate than *HC* participants and *OLF* participants. Additionally, *HC* participants are expected to perform with significantly less accuracy than *OLF parti*cipants (Appendix G, Figure 5). It is predicted that all groups will exhibit less accuracy on sensitive body parts compared to insensitive body parts.

Given these findings, the mixed ANOVA is predicted to find a significant effect of *category*, which would show that mean estimation accuracy for sensitive body parts was much lower than that of insensitive body parts. A significant interaction between *group* and *category* is expected and Bonferroni-corrected estimated marginal mean comparisons should show that *OHF* participants' estimation accuracy for sensitive body parts was significantly lower than that for insensitive body parts. *HC* participants are expected to exhibit greater accuracy than the *OHF* group, and *OLF* participants are expected to exhibit greater accuracy than both *OHF* and *HC* participants. Furthermore, if these hypothesized results are found to be accurate, they suggest that a) in general, mentally created representations of distance on sensitive body areas are less accurate, b) high adiposity may impair cognitive processes involved in evaluation of emotional and conceptual stimuli; likely related to non-action oriented representations (body image; Gallagher, 2005; Dijkerman & de Haan, 2007).

Within all groups (*OLF*, *OHF*, *HC*), it is expected that independent t-tests will find no effect of gender on estimation accuracy. A significant positive correlation with BMI is expected for *OHF* and *OLF* groups. Additionally, it is predicted that a significant positive correlation with BF% will arise for the *OHF* group. This finding would suggest a type I error, and that high adiposity is a more likely to be associated with lower estimation accuracy.

Time of reaction (RT) will also be evaluated using the same tests. Levene's test should indicate a normal distribution of the independent variable at each its levels ($p > 0.05$). No significant difference is expected between the RT means of all participant groups. However, a significant difference is predicted to emerge between mean scanning times (time to RT) of categories, such that response times for sensitive body parts are expected to take longer to arrive at compared to response times of insensitive body parts. This effect is predicted to occur for all groups, but most strongly for the *OHF* group (Appendix G, Figure 6).

No effect of gender on RT or significant relationship with BMI is expected to emerge for any participant group.

Discussion

Summary of Findings, Possible Mechanisms, and Explanations

Results in support of my proposed hypotheses would suggest that high adiposity has deleterious effects on both tactile and non-stimulus based schematic processing, and that efforts to maintain lower adiposity could result in improved function of cognitive processes involved in the construction of personal body representations. Additionally, these negative effects differ in how they manifest with respect to type of body representation, and as a result, they differ by body part. Findings supporting these differences in the effects of obesity on independent body parts would contribute to previous research on the unique functions of body representations in a dyadic taxonomy. Furthermore, high adiposity would be expected to act as a mediating factor in the relationship between tactile and non-stimulus based perceptual stimuli and estimation error in mental and tactile body representations, respectively.

Results of the Tactile Size Estimation task would not only promote the idea that high adiposity may impair cognitive processes involved in evaluation of tactile stimuli, they would support the theory of a dyadic taxonomy. Concerning the dyadic taxonomy, estimation error for perception of tactile stimuli should be greater for the arm than for the abdomen, suggesting that distortions are more likely to occur in body parts that frequently engage with action-oriented stimuli, such as arms, compared to body parts that typically engage less often with action-oriented stimuli, such as the abdomen. This would imply that somatosensory input is largely influential relative to action-based representations of the body, or the body schema (de Vignemont, 2010). This would be confirmed by a finding that all participant groups exhibited less accuracy in estimation of tactilely perceived distances on the arm compared to the abdomen.

However, *OHF* participants would have performed significantly worse than *HC*'s and *OLF* participants.

Significantly greater tactile distance estimation error in the arm, displayed by *OHF* participants may be suggestive of partial deafferentation in communicative pathways between sensory receptors in the peripheral nervous system and the primary somatosensory cortices (SI) in the central nervous system. This effect of adiposity on the peripheral nervous system would be reinforced by both a main effect of measure, where less distance between simultaneously administered tactile points resulted in larger error in estimated distance, and independent interactions between measure*body part and measure*group. Estimations of shorter tactile distances (1" & 2") are expected to be less accurate, especially within the *OHF* group, concerning the arm. This outcome could be best explained by noise caused by excessive adiposity, which interferes with regular communication between sensory receptors and SI. This effect would be expected to be amplified in the arm compared to the abdomen, due to a higher reliance on the interpretation of somatosensory input in forming mental body representations.

Hypothesized results from the Distance Comparison task indicate that, in general, mentally created representations of distance on sensitive body areas are less accurate. This may be the result of greater consideration of non-action oriented input, such as emotional and conceptual stimuli, related to beliefs about one's body. These findings would also support the theory of dyadic taxonomy that considers that mental representations of sensitive areas, or body parts that are typically areas of concern based on physical characteristics, are more reliant upon non-action oriented input (de Vignemont, 2010). Furthermore, predicted results suggest that the stigma of high adiposity may affect cognitive processes related to non-action oriented mental body representations, which are believed to be dependent on emotional and conceptual stimuli (body image; Gallagher, 2005; Dijkerman & de Haan, 2007).

Results in favor of predicted response times (RT) support my hypothesis that high adiposity has significant implications for cognitive processes involved in judgement of mental body representations. More specifically, longer RTs would be associated with better accuracy in both categories. However, compared to *HC*'s and *OLF* participants, *OHF* participants will have shorter RTs for both categories, especially the sensitive category. This finding is expected to be related to and greater distance comparison error displayed by *OHF* participants, which may indicate a tendency to make impulsive decisions when longer judgement is required, leading to less accuracy.

Excess lipid accumulation could be linked to disturbances in one's body schema and body image. Increasing the frequency of exercise and consuming a low fat/high carb diet have been suggested as ways to improve the efficacy of many of the body's systems. Efforts to maintain low body fat and decrease fat intake may improve somatosensory and non-stimulus based processes associated with construction of mental body representations.

Findings in favor of predicted outcomes on the Likert questionnaire should indicate significant dissatisfaction with body parts amongst high adiposity participants, compared to controls and low body fat participants. A similar pattern of results would be expected to emerge for questions inquiring about rate of concern about body parts slimming down and concern about body parts becoming more muscular. These results may provide support for theories proposing that disturbances in somatosensory perception are related to detachment from the self as a whole.

These findings suggest that improvements to health and body composition may have beneficial effects on cognition, specifically the construction of one's self image. In addition to exercise and diet, current treatments for the symptomatology of obesity involve medication, surgery, and psychological and physical therapy. These should not be ruled out as methods of treatment, but they may be more effective if used in combination with low fat diet and exercise.

Comparison with Relevant Findings From Other Studies

In comparison to normal weight controls (BMI), prior studies have reported inaccuracies in estimation of body size amongst those characterized as severely underweight and obese (Matz et al., 2002; Scarpina, Castelnuovo, & Molinari, 2014; Zaccagni et al., 2014). While their studies do not directly measure the influence of body composition, specifically adiposity, their results suggest that an unhealthy body fat percentage may contribute to these discrepancies in tactile and mental estimations of personal body size.

Studies in medicine have found that damage to the peripheral nervous system, even in non-diabetic obese individuals, has deleterious effects on the activity between the PNS and CNS. Miscio et al. (2005) evaluated damage, as caused by obesity, to motor and sensory nerves. Their results supported findings from prior research, which concurred that high adiposity weakens nerve response; lessening perceptual acuity (Dumitru, 1995; Dorfman & Robinson, 1997). Additionally, medical research has indicated that high adiposity is linked to inflammation, elevated lipid count, and insulin resistance (Yang et al., 2006; Yudkin, Stehouwer, Emeis, & Coppack, 1999; Trollor et al., 2010). Neurochemical lesions, (as a product of high adiposity) are credited as threats to normal cognition. Findings from these aforementioned cognitive performance studies, amongst obese populations, have reported correlations between high adiposity and poor cognitive performance. They report that adiposity is associated with diminished function of processes involved in memory and learning and global-level network function in the brain.

Studies that have suggested a link between high adiposity and low grade systemic inflammation have found that resulting damage to the cardiovascular system could lead to peripheral neuropathy. This could explain results suggesting partial deafferentation in the arm. Due to complications associated with this condition, nerve pathways may be required to reorganize to allow for the passage of signalling in damaged areas, by firing relevant action potentials from adjacent receptive areas (Pons & Garraghty, 1991; Jones & Powell, 2016). This has been shown to change the sizes of a receptive area's representation in SI (Liang et al., 2013; Kaas et al., 1979; Taub, 1980). This may support the finding of significant overestimation of shorter distances in *OHF* participants.

While previous research has found that judgement of personal size, especially with regard to sensitive body areas, is related to the processing of emotions, beliefs, and concepts pertaining to one's body, physiological consequences of obesity on cognition may also be responsible (Devivo et al., 1978). Metabolic ketosis (MK) has been found to occur as a result of high fat consumption in both diabetic and non-diabetic obese individuals. MK creates an effect on the brain similar to alcohol; impaired judgement and impulsive decision making (Cameron et al., 2014). Individuals with high body fat may be more inclined to make rapid decisions about sensitive body areas due to a combined effect of negative emotions and beliefs out their bodies and impaired cognitive processes that result in higher impulsivity.

Alternative Explanations if Results Do Not Support Hypotheses

Results that are unfavorable toward my hypotheses may be related to several factors within the study, as well as external confounds. Firstly, we may not have an entirely accurate understanding of the mechanisms of body schema or body image. In fact, there are not solidified definitions of either term, nor is every intricacy of their mechanisms confirmed. Secondly, body image may be affected by the type of group that we selected and psychological issues affiliated with beliefs about one's body shape and size.

The types of participant groups that I would been working with are undoubtedly controversial, due to issues regarding ecological validity. Participants would have been college students, college faculty, and athletes primarily recruited from local CrossFit and regular gyms. Different sports build different athletes, with different physical needs to support their involvement in the sport. Although not a traditional "sport", CrossFit develops athletes in a way that focuses on strength training and the betterment of the whole body. Those who attend regular gyms, with similar physiques, are also affected by their environment. While CrossFit may focus on a holistic body for motivation, regular gym goers with low fat and high muscle mass, such as body-builders, tend to place a greater emphasis on appearance and improvement of parts of the body, rather than the whole. Inaccurate body size estimation may be contributable to what beliefs one has about their body; the mind becomes detached from the body in a fight to attain the ideal.

The SCOFF questionnaire is an assessment used to detect the presence of symptomatology of bulimia and anorexia. While the SCOFF touches on distortions in perception of body size, it only questions feelings of fatness, which could suggest the presence of Body Dysmorphic Disorder (American Psychiatric Association, 2013). However, it is possible that certain participants in the *OLF* group were not dismissed during intake, because this assessment fails to account for distortions in perception of body size related to drive for muscularity. According to the DSM-5 (2013), muscle dysmorphia involves a preoccupation with the idea that one's body build is too small or insignificantly muscular. In some cases, the preoccupation is restricted to a specific body part or region.

Strengths and Limitations

My proposal is novel in that it seeks to evaluate the specific role of adiposity in developments and access of the body schema and body image. Scarpina, Castelnuovo, and Molinari (2014) attempted to measure this. However, they failed to measure obesity in terms of body fat, and many of their participants had comorbid mental health conditions, such as Binge Eating Disorder (BED). Not only is my population devoid of severe eating and feeding conditions, it is also a non-clinical population, which allows for the findings to be more applicable to the general population.

In the design, I made strong efforts to correct any methodological errors noted in prior studies for use of this model. The effects of external stimuli (i.e. visual), that are known to alter tactile perception, have been removed to the best of my ability (blindfolds). The Likert questionnaire should also be administered in a fashion that allows participants the most privacy while responding to questions regarding personal feelings about their body. This would hopefully reduce participant bias caused by discomfort or embarrassment if it had been conducted orally, in the presence of a researcher.

While there are many strengths to the study, there are several limitations due to the demands of the study design. I attempted to diminish participant bias in every way that I could, but it is still possible that the emphasis on body size and composition might lead participants to respond in a way that they hope that researchers would prefer, or in a way that they feel comfortable responding to personal questions about their bodies. Additional factors including location of participant recruitment, measurements used to acquire participant demographics, and study design could impact findings.

Any number of characteristics of my participant group could have influenced the outcome of the study. Specifically, that the location from which I gathered participants was both at and around a privileged, liberal arts college in the northeastern United States. College populations are often ridden with body image issues, primarily amongst females, but males are also affected by the pressures to achieve the ideal body (Thompson & Stice, 2001; Furnham et al., 2002; McNeill & Firman, 2014; Paasch et al., 2014). These social vulnerabilities, amongst the collegiate population, might be confounds that are not so extreme that they meet diagnostic criteria for a feeding and eating or dysmorphic disorder, but they are significant enough to influence outcomes on one or several tasks.

The Yuhasz Skinfold Test has been found to produce more accurate estimations of body fat percentage amongst males, compared to females (Ballard et al., 2014). Estimations for female body fat percentage may have been less accurate due to potential error. Ballard et al. (2014) found that various assessments, including the Yuhasz, are better suited for assessing specific body types, genders, and age groups. Future studies may want to consider using multiple or alternative assessments when acquiring the body fat percentages of female participants.

Lastly, the design of the study is not longitudinal, nor does it assess the dependent variables at numerous times. Body image has been shown to be susceptible to change after as little time as a few minutes (Webb, 2015). Although body schema is not as easily altered, some studies have found that after several hours of practice with, or experience of stimulation within a receptive region, the mapping of representations in the somatosensory cortices can be changed; how large the SI representation may be as well as changes to parts that are represented within those regions (fusion of SI representations). Future studies should seek to acquire somatosensory input at multiple times to gain a better understanding for the long term effects of high adiposity on perceptual experience.

Additionally, improvements to the present study could be made by eliminating restraints regarding access to alternative technological methods of weight and cognitive assessment, as well as the consult of a licensed psychologist.

Clinical and Research Implications

If the results support my hypotheses, it would be useful to perform replications of this study, because the tasks that I selected have only emerged within the last seven years and have not been widely used. New outcomes could shed light on the reliability of the study's methodology, as well as the validity of results. It might also be prudent to apply this design to new subject populations and at different levels of body fat. One example is exploring the implications of high and low adiposity on underweight individuals. Outcomes could contribute to our understanding of metabolic processes on cognition in low-weight, disordered eating and dysmorphic populations.

Alternatively, future studies could apply changes to the design. Obesity is a condition that could be developed at any point throughout the lifetime. Point of onset, or stage of obesity, might contribute to variance in body experience and damage to cognition. Having been obese or not obese in adolescence or childhood could have caused long-term damage to the nervous system, or have negatively impacted aspects of body image (i.e. emotional coping mechanisms) that persist after weight loss. Controlling for these confounding variables or further investigating them may explain inconsistencies in research in this area of study.

Additionally, obesity is often comorbid with numerous physical and mental health conditions; as I had discussed in my introduction. Conditions affecting the health of one region of the body are frequently accompanied by a multitude of associated problems, in other body parts and systems. Implementing and studying the outcomes of new clinical treatment strategies, inspired by these findings, may provoke researchers to take to new lines of questioning regarding the benefits and efficacy of integrated medicine on body-related mental health conditions and cognitive processes involved in the construction of mental body representations.

Conclusion

This project focuses on the physiological relationship between brain and body. It applies findings from various studies that support a potential mediation scenario involving physical and mental health. Hypothesized results support the notion that excessive adiposity has detrimental effects on the sensory communication systems that allow us to interpret somatosensory stimuli in relation to our physical self, which is believed to be constructed and changed by these same mechanisms. Replication of this study may provide insight into the implications of these findings and the work of others in the fields of medicine and psychology. Future studies might consider applying this design to different, general (i.e. age, gender, sexuality, culture) and clinical populations (i.e. anorexia, bulimia, EDNOS, body dysmorphia, muscle dysmorphia). Researchers may want to use a longitudinal approach in investigating various stages of obesity; specifically, changes in body schema and body image as the disease worsens and improves.

Additionally, advancements in gender reassignment procedures and greater acceptance of genders outside of the traditional binary are likely to be followed by a rise in transgender procedures. Many involve the introduction of new hormones into the body, which alter the body's architecture; relocation or change in quantity of adipose deposits is known to coincide with hormone therapy (Aloi et al., 1995; Tchernof, Poehlman, & Despres, 2008). Changes to the gender assigned body have the potential to change the entire body experience. I presuppose that the experiences of these individuals have the potential to be significantly valuable to researchers seeking to uncover the functions and development of body representations.

While researchers do not have a complete grasp on the functions of body image or body schema, we proceed to conduct studies about them. This project, in addition to many others, brings to light the necessity for consensus on how we choose to define the mechanisms that we study, as well as the implications of the results, which manifest from the interpretations we opt to apply. All interpretations should be well understood by those who seek to investigate the characteristics of these representations, and their commitment to a unique interpretation should be clearly stated. When one fails to acknowledge the specifics of their intentions, in a situation where more than one interpretation is possible, it denies that research the ability to support its relevant theory; delaying arrival at an accurate consensus.

Nevertheless, this research is important to health fields that extend outside of psychology. As the world around us changes, we make modifications to the way that we live; deciding how we maintain our bodies is dependent upon our relationship to the context we find ourselves in.

For that same reason, health care professionals must adapt to best deal with the issues they face each day. Considering the number of known conditions that accompany obesity (comorbidities), it would be of interest to practitioners in both medicine and psychology to take note of the ramifications of this study, with respect to current knowledge. Maintaining awareness of the physical and mental health consequences of high body fat could improve accuracy in forming diagnoses and selecting appropriate treatments. This includes a recognition of when it may be necessary to refer patients to specialists outside of your field. Because of the emphasis that integrative medicine places on treating the issue as it affects the entire body, an increase in a practitioner's understanding of the benefits of holistic treatment should lead to better health care practices; positive progress in achieving all around well-being. It would be useful for professionals in related fields to undergo additional training that focuses on comorbid conditions, so that they might better their work.

If my proposed results are indeed accurate, there are a number of key takeaways from this study. Most important is the understanding that accumulating and storing large amounts of body fat negatively affects mental and physical health. Additionally, in the context of psychology, these findings support the use of exercise and healthy diet to improve the efficacy of therapy and medication, in treating conditions related to cognitive function. This project emphasizes the need to put an end to the notion that the brain and body are exclusive of one another, and should be treated in the same way. This research contributes to our understanding of the mind-body relationship and how we might utilize it to improve somatosensory perception and mental body representations.

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APPENDIX A: INSTITUTIONAL REVIEW BOARD PROPOSAL

Title: Distortion in Body Schema: The Influence of Body Fat and Mass on Perceptions of Personal Size

Research Question (250 words or less):

I am interested in the influence of body fat percentage and BMI on how people use their mental image of themselves (body schema) to estimate their actual size. If when I look at my data, I find that those with high BMI's (body mass index) and low body fat percentage significantly overestimate or underestimate distances on their arm and abdomen, this would tell me that significant inaccurate estimations of distance on their body may be due to their high BMI (>30). These findings would be revealed by both the Tactile Size Estimation task and the Distance Comparison task. The study design is slightly modified from Scarpina, Castelnuovo, & Molinari (2014) in which they measured the representation of tactile and mental body parts in clinically obese individuals. Their findings suggested that, compared to healthy controls, obese participants were more likely to significantly overestimate and underestimate distances on and between their own body parts. They attributed this to the effects of obesity. However, this study was not performed without participants who have BED. While they attribute these findings to the effects of obesity, they cannot rule out the influence of BED. I am wondering if this inaccurate estimation of distance and body size is the effect of obesity (which is merely represented by high BMI), body fat %, or if these results are only occurring in obese individuals with Binge Eating Disorder (BED). I plan to build from their findings by further examining the roles of both body fat percentage and BMI (body mass index) in producing a distorted mental representation of one's body size.

Briefly describe how you will recruit participants. (e.g., Who will approach participants? What is the source of the participants?)

All participants would be adults between the ages of 18 and 30 who are either current undergraduate or graduate students at Bard College or members of the surrounding community. Participants must identify with their assigned gender (Male or Female), be fluent in English, have normal or corrected-to-normal vision, have never received a clinical diagnosis for an Eating Disorder, Body Dysmorphia, or Major Depression, have never used hormones or anabolic steroids, and have never been diagnosed with a degenerative muscle condition. All of the above information will be included in the recruitment script, emails, and posters, which are attached to this proposal in Appendix A.

Since the experiment relies on the participation of those with a specific body type, these participants will be recruited at local gyms and fitness facilities, because they are typically bodybuilders. Control participants will be recruited through flyers posted around campus, in the local towns, and on Facebook.

Procedures:

Following pre-study intake, which is included in Appendix G, and having received informed consent, which is included in Appendix F, participants would complete the demographics questionnaire (Appendix D), I would take their measurements for weight, height, and body fat percentage. Participants would take the SCOFF and MMSE questionnaires to screen for signs of disordered eating behaviors and to assess their cognitive functioning (Appendices B & C). Once they have completed these questionnaires, they will answer the likert style questions that assess their disatisfaction with and desire to change the size and shape of their arm and abdomen. These questionnaires should take between 10-12 minutes to complete.

After completing the likert questionnaire, participants will proceed to a cushioned, table-like surface where they will complete the Tactile Size Estimation task. A blindfold will be fitted to their face in a way that ensures that they cannot see and that they are experiencing no discomfort from the tightness of the blindfold. This task will involve two trials where participants are touched with a caliper (two-points) set at 1, 2, and 3 inches, on their arm and abdomen. They will be asked to use the index finger and thumb of their dominant hand to show the experimenter the distance that they perceived. The experimenter will use a measurement instrument to record the distance perceived by the participant. Each distance (1, 2, or 3 inches) will be performed a total of fifteen (15) times on each body part (arm, abdomen) resulting in 90 measurements. This task should take approximately 15-20 minutes.

Participants will be allowed to take a 5 minute break before continuing to the next task, which is the Distance Comparison task. To begin, participants will be asked to close their eyes and imagine their body. The experimenter will invite them to imagine distances between multiple pairs of body parts (i.e. foot to hip, shoulder to ear) before explaining the computer part of the task. On the computer, they will be presented with one pair of body parts, then a second pair of body parts, and, using the keyboard, they will indicate which word pair is the pair of body parts with the greater distance between them. They will be presented with two trials of 20 pairs each, that will be separated by a 1 minute break between trials. This task should take 15-20 minutes to complete.

Participants are expected to spend approximately 40-50 minutes completing the experiment, with 5 minutes for debriefing and 5 minutes for any questions they might have.

Please describe any risks and benefits your research may have.

There are no major risks known to be associated with any of tasks explained above. However, it is possible that participants could experience anxiety or discomfort with their body image. The SCOFF and other intake questions screen for any existing disorders or potentially concerning behaviors. Those who receive a SCOFF score greater than 2, or who answer intake questions in a way that suggests that their participation in the study could lead them to experience distress, will not be allowed to take part in the study. Their scores on the MMSE and the SCOFF questionnaire will be kept confidential and will only be seen by the primary experimenter, during and after the study has been completed. All participants undergo a debriefing where they will be informed of the nature of the study and will be able to express any concerns they may have.

All Bard College participants will be provided with the phone number for BRAVE, a crisis counseling hotline that provides services to students free of charge. All participants will be given a list of mental health professionals in the area who specialize in anxiety, depression, and eating disorders. This information would be provided in their consent form, which they will retain a copy of. Furthermore, participants will be told that they may withdraw from the study at any time.

While there is no direct benefit to participants for completing this study aside from potential compensation in the gift card draw, we hope that the research will benefit others and society by providing a better understanding of how obesity, BMI, and body fat affect the way we perceive ourselves. Participation in this study would offer a better understanding and insight to the influence that these factors may have on individuals with eating disorders. Participants may also experience this insight and may leave the study feeling as though they have a better understanding of the potential physiological and mental effects.

Please include here the verbal description of the consent process (how you will explain the consent form and the consent process to your participants).

Welcome to the Psychology Lab at Bard College! Thank you for coming in to participate in my study. In today's experiment, you will be asked to complete a variety of tasks, including a few screening questionnaires and a Tactile Perception task where you will be blindfolded and asked to estimate distances between two points touched to your body. You will also complete a computer task that will prompt you to estimate differences between multiple distances on your body. I will provide you with instructions for each task as we move along and at any point that you feel you may need me to. This study will take about 50-60 minutes to complete. There are no explicit risks associated with being involved in this study, but as with any other study you may participate in, you may choose to end your participation and withdraw your data at any time, without any penalty to you. During some tasks I will be in an adjoining room. If you need me at any point during the study, just call out my name, "Kat", and I will come to you. If at any point you feel uncomfortable, please let me know and I will do what I can to maximize your comfort. Your participation is entirely confidential, and none of the information that I collect will ever be publicly connected to your name or other identifying information. I'm going to have you read through this consent form, which I just summarized. Please feel free to look over the form, ask any questions that you may have, and sign it if and when you feel comfortable. It's an important part of my research process that ensures that participants understand their rights if they are participating in a study, so please make sure that you carefully read through this page before you decide to sign. You will find that there are two copies of the consent form; one is for you to sign and return to us, and the other is for you to keep.

What procedures will you use to ensure that the information your participants provide will remain confidential?

Participants will be assigned an ID number and this ID number will act as an identifier for all of their data. Only researchers associated with the experiment (myself and Bard faculty advisor Dr. Justin Hulbert) will have access to the data. Data will not be kept with information that could identify participants. The only place where participant names will be matched with their corresponding ID numbers will be on a master list that will be kept in a cabinet in a locked room in Preston Hall, which will only be used to confirm consent, and will only be accessible by myself and Dr. Hulbert. Participant names will never be mentioned in any publication or presentations that may result from the results of this experiment. Electronic data will be stored on one main password protected laptop computer and backed up onto an encrypted external hard drive used solely for this experiment, and raw questionnaire data will be stored in a locked cabinet in Dr. Hulbert's lab, separate from the cabinet holding the consent forms. The only people with access to the data will be myself and Dr. Hulbert.

If the resulting data obtained from the experiment were to be published, then following the guidelines of the American Psychological Association, materials/data will be kept for a period of seven years after the end of the study, after which they will be removed from their digital and physical storage locations to be destroyed. Master lists, consent documents, and any other materials with identifying information on them will be stored separately from all other materials.

For projects not using deception, please include your debriefing statement.

(Administered orally)

"Thank you so much for coming in to participate today. Before I tell you about our specific research hypotheses, what do you think this experiment was about?"

[If similar, make a note]

"Thank you. I can now tell you about what I was looking to measure in today's experiment. So, in this study, I was interested in the influence of body fat percentage and body mass on how people think about the size of their body. Specifically, I want to know if

body fat, excessive weight, or a mental health condition primarily contribute to how people use their mental image of themselves to estimate their actual size. If when I look at the data, I find that those with high BMI's (body mass index) and low body fat percentage significantly overestimate or underestimate distances on their arm and abdomen, this would tell me that significant inaccurate estimations of distance on their body may be due to their high BMI. These findings would be revealed by both the Tactile Size Estimation task and the Distance Comparison task. Previous studies, in clinical populations, have found that obese individuals (BMI > 30) tend to overestimate and underestimate distances on their bodies. However, these studies have not been performed without participants who have Binge Eating Disorder (BED). While they attribute these findings to the effects of obesity, they cannot rule out the influence of the eating disorder. I am wondering if this inaccurate estimation is the effect of obesity (which is merely represented by high BMI), body fat %, or if these results are only occurring in those with Binge Eating Disorder (BED).

"I hypothesize that tactile and mental body representation will differ between obese groups, where obese group 1 (OLF) will have more accurate estimations than obese group 2 (OHF), that will show greater overestimation. Their differences in body fat percentage will mediate this difference. Additionally, I believe that overestimations of size and distance will be correlated with participant group (OLF, OHF, Control) and body part (Arm, Abdomen). I predict that the OHF participants will be less satisfied with sensitive body areas than the OLF and control condition participants, and that this will lead to an inaccurate estimation of distance on both tasks."

"If true, these results would suggest that inaccurate estimation of distance on the body is not due to the condition that is Binge Eating Disorder (BED) or excessive body fat. Rather, this estimation flaw would be attributed to high BMI; inaccurate estimation would be due to mass that exceeds that which is deemed "healthy" for an individual's height. These findings would support the notion that BMI is flawed in its purpose; BMI is not a measure that we should rely on so heavily in determining healthy weight."

"Do you have any questions for me about my hypotheses or any part of the experiment that you completed today?"

"Wonderful! Again, thank you for your participation in my study, today. If you happen to think of any questions or concerns regarding the study, please don't hesitate to email me (Kat) at the email address provided in your consent form. I just want to remind you that the last page of the consent form also contains the contact information for the IRB and faculty advisor Dr. Hulbert, should you wish to speak with someone other than myself (Kat)." [Bard Students Only: *"On the same page you can also find the number for BRAVE, should you feel*

any distress or anxiety as a result of this study."] *"I also have a form for you that is a short list of some clinicians, who are located in the Hudson Valley, that practice as specialists in anxiety, depression, body image, and eating disorders. Should you want or need to speak with a professional, they are the most qualified."*

APPENDIX B: CONSENT FORM

This research study is designed to examine the effects of body fat and body mass on the way in which we mentally create images our bodies, and how we apply that mental image to our understanding of physical distances on our bodies. This research is being conducted as part of a senior project for Katarina Ferrucci, under the supervision of Professor Justin Hulbert, PhD., in the Department of Psychology, at Bard College. In the first part of this study, you will answer some demographic questions regarding age and gender, then have your weight, height, and body fat percentage measured. Next, you will take part in three (3) tasks: a questionnaire, a tactile estimation task, and a distance comparison task. The questionnaire will ask you to rate where you see yourself on several body related questions. The tactile estimation task will require you to be blindfolded and estimate distances based on two points that will be gently touched to your abdomen and arm. Lastly, in the distance comparison task, you will be presented with word pairs of body parts and will respond to them regarding length in relation to distances on your body.

Why have I been selected for participation?
You are being asked to take part in this study because you are an adult between the ages of 18 and 30.

Why is this study being done?
The purpose of this study is to assess the relationship between an individual's body fat, body mass, and how they perceive size on their own body. The findings may contribute largely to the understanding of eating disorders and body image satisfaction.

How many people will take part in this study?
Approximately 150 people will take part in this study.

What will happen if I take part in this research study?
If you agree to participate in this study, the following procedures will occur:
You will respond to a questionnaire that will ask you you rate your satisfaction with certain aspects of your arm and abdomen. Following this questionnaire, you will undergo an estimation task in which you are to estimate distances between two (2) points that will be touched to your body using a caliper (measurement tool). Lastly, you will complete a distance comparison task where you will be presented with word pairs, of body parts, that appear on a computer screen and will estimate which word pair is an example of a larger distance on your body.
Combined, these tasks will take about 45-50 minutes to complete.

How long will this study take?
Participation in this experiment is expected to take about one hour (60 minutes).

Can I withdraw from the study?

Yes. PARTICIPATION IN ALL RESEARCH IS VOLUNTARY. You may opt to end your participation in the study at any time, which will not affect your compensation for taking part in this study. If you feel uncomfortable at any time during the experiment, please tell the experimenter immediately so that they can either address the situation or stop the experiment, if you so wish. You are free to withdraw your consent and discontinue participation at any time without any penalties.

Additionally, the experimenter may stop you from taking part in this study at any time if they believe it is in your best interest, if you do not follow the study rules, or if the study is interrupted for another reason. If you decide to opt out, all personal and study data will be destroyed and will not be reported in the study findings.

What side effects or risks can I expect from being in the study?

While there are no known risks associated with this study, it is possible that you may experience general anxiety or body image related anxiety. If at any point this presents a problem to you, please let the experimenter know immediately. All participants will receive a list of general psychologists and specialists, located in the Hudson Valley, to reference if they feel that they would like to reach out to a professional.

Are there benefits to taking part in the study?

While there is no direct benefit to you of completing this study, we hope that the research will benefit medical professionals and those who suffer from specific, clinically diagnosed psychological conditions.

What other choices do I have if I do not take part in this study?

You are free to choose not to participate in the study. If you decide not to take part in this study, there will be no penalty to you.

Will my information be kept private?

All of the information that we obtain from your session will be kept confidential. An ID number will be used to identify your records in our data analysis. The information linking your name to its code number will be kept in a separate and secure location that is only accessible to the main experimenter. If information from this study is published or presented at scientific meetings, your name and other identifying information will not be used.

For the raffle drawing, your name will be kept separate from the data we obtain, which will be completely removed from the research. Following the drawing, these records will be destroyed.

What are the costs of taking part in this study?

There is not a cost to you for taking part in this study.

Will I be paid for taking part in this study?
To thank you for your participation, your name will be entered into two (2) raffles for a $100 Visa gift card.

What are my rights if I take part in this study?
Taking part in research experiments is entirely your choice. You may choose whether or not you participate in this study. If you decide to take part in this study, you may leave the study at any time. If you choose to do so, there will be no penalty whatsoever. You will not be subject to physical harm or pain during the study. If you do choose to take part in the study, you should know that you will be asked to raise your sleeve to reveal your forearm and raise your shirt enough to reveal your upper abdomen. If you are wearing a dress, or other type of clothing that may involve you revealing more skin, a clean sheet will be provided to you, so that you may cover your body in a way that makes you feel more comfortable.

Who can answer my questions about the study?
If you have any questions about the research experiment, please contact the main experimenter: Katarina Ferrucci at kf2626@bard.edu.

If you wish to voice any problems or concerns you may have as a result of this study, or to discuss any problems with the procedures of this study with someone other than the experimenter, please feel free to contact the Bard College IRB at irb@bard.edu, or Dr. Justin Hulbert at jhulbert@bard.edu.

If you are a Bard College student and are seeking help or support with emotional or psychological distress as a result of this study, please call BRAVE at (845) 758-7777, and ask to speak with a BRAVE counselor.

PARTICIPATION IN RESEARCH IS VOLUNTARY.

_______ I understand that I have the right to decline to be in this study, that I may withdraw from it at any point without penalty, and I have acknowledged and understood the information written above.

Participant Name (Print): ________________________________ Date ____________

Signature: _____________________________________ Date _____________

Researcher Signature: ______________________________________ Date ______________

APPENDIX C: INTAKE QUESTIONNAIRE

Participant ID

____

Demographics

Full Name:	
Age (#):	Gender (M/F):
Highest Education Earned: (circle one)	

High School GED College: Some College Associates Bachelors Masters PhD/Doctorate

Measurements (For researcher use only)

Weight:	
Height:	Calculated BMI:
Body Fat %:	
SCOFF Score:	
MMSE Score:	

APPENDIX D: INVENTORIES

SCOFF Questionnaire

(Useful Eating Disorder screening questions)

The **SCOFF** Questionnaire is a five-question screening tool designed to clarify suspicion that an eating disorder might exist rather than to make a diagnosis. The questions can be delivered either verbally or in written form.

S – Do you make yourself **S**ick because you feel uncomfortably full?

C – Do you worry you have lost **C**ontrol over how much you eat?

O – Have you recently lost more than **O**ne stone (6.35 kg) in a three-month period?

F – Do you believe yourself to be **F**at when others say you are too thin?

F – Would you say **F**ood dominates your life?

An answer of 'yes' to two or more questions warrants further questioning and more comprehensive assessment

A further two questions have been shown to indicate a high sensitivity and specificity for bulimia nervosa. These questions indicate a need for further questioning and discussion.

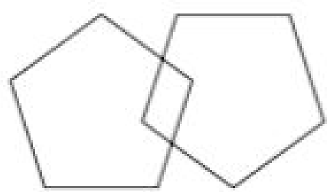
1. Are you satisfied with your eating patterns?
2. Do you ever eat in secret?

Luck, A.J., Morgan, J.F., Reid, F., O'Brien, A., Brunton, J., Price, C., Perry, L., Lacey, J.H. (2002), 'The SCOFF questionnaire and clinical interview for eating disorders in general practice: comparative study', *British Medical Journal*, 325,7367, 755 - 756.

The Mini-Mental State Exam

Patient______________________________ Examiner ________________________ Date__________

Maximum	Score	
		Orientation
5	( )	What is the (year) (season) (date) (day) (month)?
5	( )	Where are we (state) (country) (town) (hospital) (floor)?
		Registration
3	( )	Name 3 objects: 1 second to say each. Then ask the patient all 3 after you have said them. Give 1 point for each correct answer. Then repeat them until he/she learns all 3. Count trials and record. Trials __________
		Attention and Calculation
5	( )	Serial 7's. 1 point for each correct answer. Stop after 5 answers. Alternatively spell "world" backward.
		Recall
3	( )	Ask for the 3 objects repeated above. Give 1 point for each correct answer.
		Language
2	( )	Name a pencil and watch.
1	( )	Repeat the following "No ifs, ands, or buts"
3	( )	Follow a 3-stage command: "Take a paper in your hand, fold it in half, and put it on the floor."
1	( )	Read and obey the following: CLOSE YOUR EYES
1	( )	Write a sentence.
1	( )	Copy the design shown.



_____ Total Score

ASSESS level of consciousness along a continuum ___________

Alert Drowsy Stupor Coma

APPENDIX E: LIKERT QUESTIONNAIRE

Questionnaire - Likert

Instructions: For each question, please select the number that you feel best reflects yourself.

Rate how *dissatisfied* you are with the physical aspects about your *arm*:

Very Satisfied — Dissatisfied

1 2 3 4 5 6 7

Rate how *dissatisfied* you are with the physical aspects about your *abdomen:*

Very Satisfied — Dissatisfied

1 2 3 4 5 6 7

Rate how concerned you are with your *arm* not slimming down:

Not Worried — Highly Worried

1 2 3 4 5 6 7

Rate how concerned you are with your *abdomen* not slimming down:

Not Worried — Highly Worried

1 2 3 4 5 6 7

Rate how concerned you are with your *arm* not becoming more muscular:

Not Worried — Highly Worried

1 2 3 4 5 6 7

Rate how concerned you are with your *abdomen* not becoming more muscular:

Not Worried — Highly Worried

1 2 3 4 5 6 7

APPENDIX F: DEBRIEFING & RESOURCE LIST

"Thank you so much for coming in to participate today. Before I tell you about our specific research hypotheses, what do you think this experiment was about?"

[If similar, make a note]

"Thank you. I can now tell you about what I was looking to measure in today's experiment. So, in this study, I was interested in the influence of body fat percentage and BMI (body mass index) on how people think about the size of their body. Specifically, I want to know if body fat, excessive weight, or a mental health condition primarily contribute to how people use their mental image of themselves to estimate their actual size. If when I look at the data, I find that those with high BMI's and low body fat percentage significantly overestimate or underestimate distances on their arm and abdomen, this would tell me that significant inaccurate estimations of distance on their body may be due to their high BMI. These findings would be revealed by both the Tactile Size Estimation task and the Distance Comparison task. Previous studies, in clinical populations, have found that obese individuals (BMI > 30) tend to overestimate and underestimate distances on their bodies. However, these studies have not been performed without participants who have Binge Eating Disorder (BED). While they attribute these findings to the effects of obesity, they cannot rule out the influence of the eating disorder. I am wondering if this inaccurate estimation is the effect of obesity (which is merely represented by high BMI), body fat %, or if these results are only occurring in studies using those with Binge Eating Disorder (BED).

"I hypothesize that tactile and mental body representation will differ between obese groups, where obese group 1 (O1) will have more accurate estimations than obese group 2 (O2), that will show greater overestimation. Their differences in body fat percentage will mediate this difference. Additionally, I believe that overestimations of size and distance will be correlated with participant group (O1, O2, Control) and body part (Arm, Abdomen). I predict that the O2 participants will be less satisfied with sensitive body areas than the O1 and control condition participants, and that this will lead to an inaccurate estimation of distance on both tasks."

"If true, these results would suggest that inaccurate estimation of distance on the body is not exclusive to those obesity and Binge Eating Disorder (BED). Rather, this estimation flaw would be attributed to high BMI; inaccurate estimation would be due to mass that exceeds that which is deemed "healthy" for an individual's height. These findings would support the notion that BMI is flawed in its purpose; BMI is not a measure that we should rely on so heavily in determining healthy weight."

"Do you have any questions for me about my hypotheses or any part of the experiment that you completed today?"

"Wonderful! Again, thank you for your participation in my study, today. If you happen to think of any questions or concerns regarding the study, please don't hesitate to email me (Kat) at the email address provided in your consent form. I just want to remind you that the last page of the consent form also contains the contact information for the IRB and faculty advisor Dr. Hulbert, should you wish to speak with someone other than myself (Kat)." [Bard Students Only: *"On the same page you can also find the number for BRAVE, should you feel any distress or anxiety as a result of this study."*] *"I also have a form for you that is a short list of some clinicians, who are located in the Hudson Valley, that practice as specialists in anxiety, depression, body image, and eating disorders. Should you want or need to speak with a professional, they are the most qualified."*

*List of Hudson Valley Mental Health professionals who specialize in Eating Disorders. This will be given to **all** participants.*

AREA MENTAL HEALTH PROFESSIONALS WHO SPECIALIZE IN EATING DISORDERS AND BODY IMAGE RELATED ANXIETY/DEPRESSION

(Insurance information changes often. Please check with the therapist and your own insurance company for eligibility.)

HPA/Livewell (Outpatient Clinic)
260 Washington Ave Ext #101
Albany, NY 12203
(518) 218-1188
Insurance: (in network) Capital District Physicians Health Network (CDPHP), Beacon Health Options (formerly Value Options)/ MVP/ Empire Plan, Blue Cross and Blue Shield (Empire, BlueShield of Northeast NY, Anthem, Excellus, Highmark), & Optum (United Behavioral Health, United HealthCare). (Single case agreements) Cigna, Aetna, & Fidelis.

Megan Barbera, LCSW-R
6423 Montgomery St, Suite 16B,
Rhinebeck, NY 12572
Phone: 845-233-1409 Fax: 845-698-0387
www.meganbarbera.com
Insurance: Bard Insurance, United Behavioral Health, BCBS PPO. Hours: by appointment

Cindy Dern, LCSW
15 Pine Grove St.
Woodstock, NY 12498
167 Green St. Kingston, NY 12401 Phone 845-679-8184

Richard Gordon, PhD
7575 Old Post Rd.
Red Hook, NY 12571
Phone: 845-758-5080
Fee: $125 per Session. Insurance accepted; co-pay: depends on insurance. Hours: Thursday & Friday hours

Natalie Korniloff, LCSWR
4 Liberty St.
New Paltz, NY 12561
Phone: 845-943-0175
Insurance: accepts Magna-Care & Aetna; Fee: Sliding Scale starting at $75

Glenn Marron, PhD, PLLC (female)
Firehouse Plaza
7472 S. Broadway, Suite 5A
Red Hook, NY 12571
Phone: 917-608-8482
Email: glenmarronphd@gmail.com www.glennmarron.com
Insurance: Accepts some insurance plans including the Bard insurance
Hours: day and evening hours and Saturday's Skype and phone sessions as well Spanish

Jamie O'Neil, LCSW-R
30 East Market St.
Rhinebeck, NY 12572
Phone: 845-876-7600
Fee: sliding scale fee, based on need: Insurance: Out of network provider/ Bard Insurance.
Hours: flexible

Susan Manly Pelosi, LCSWR
7472 Broadway, Suite 5A
Red Hook, NY 12571
Phone: 646-236-3077
Email: susan.manly@gmail.com www.susanpelosi.com. Fee: $120: Sliding scale available. Hours: Mondays

Meg F. Schneider, LCSW-R
7582 N. Broadway, Suite 202
Red Hook, New York 12571
Office: (845) 876-8808
megswebpage@aol.com
Insurance: BC/BS

Juliet Wolff, LCSW-R
7582 N. Broadway, Suite 202
Red Hook, NY 12571
Phone: 845-853-3976
Email: julietwolfftherapy.com
Fees: sliding scale. Insurance accepted: Bard, BC/BS, CDPHP

APPENDIX G: GRAPHS FOR PREDICTED OUTCOMES

Likert Questionnaire

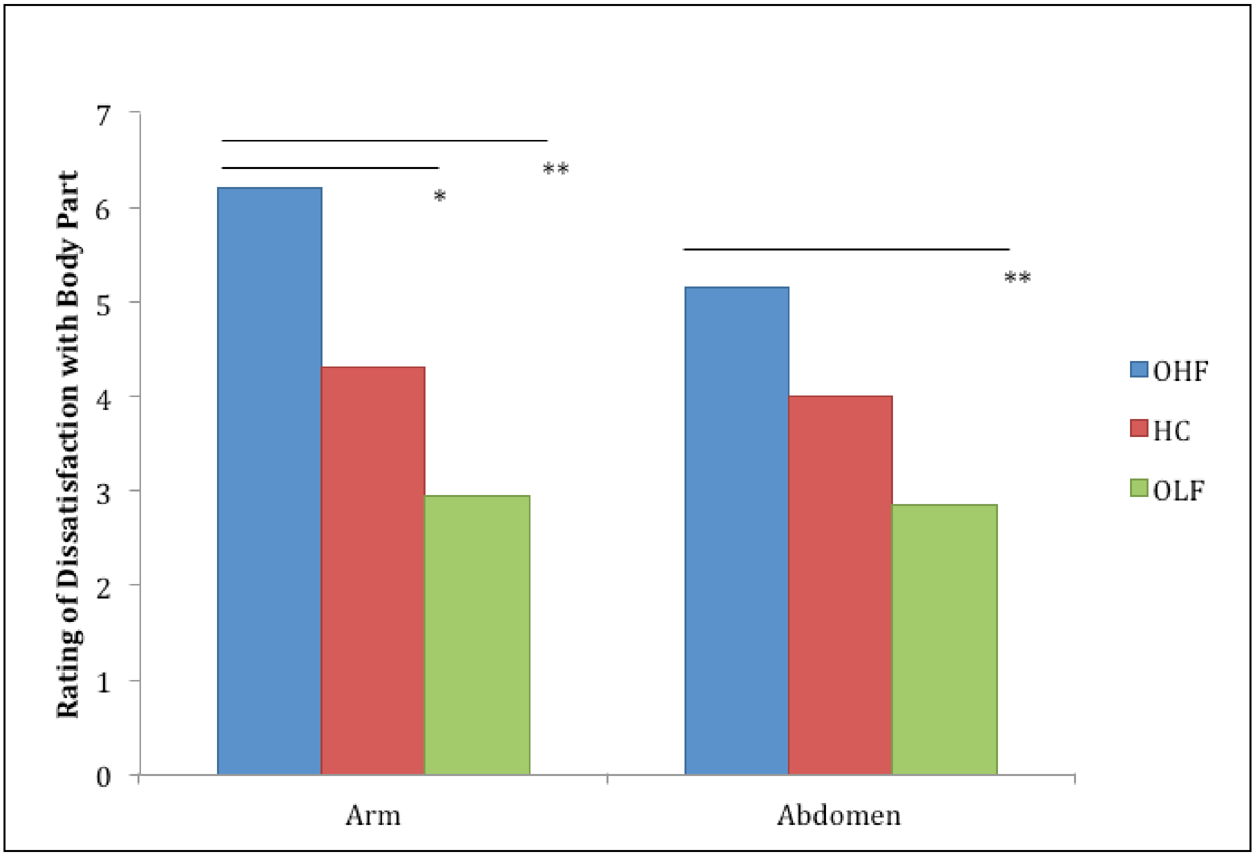


Figure 1. Mean estimates of dissatisfaction with body part, by participant group.
* = $p < 0.05$
** = $p < 0.001$

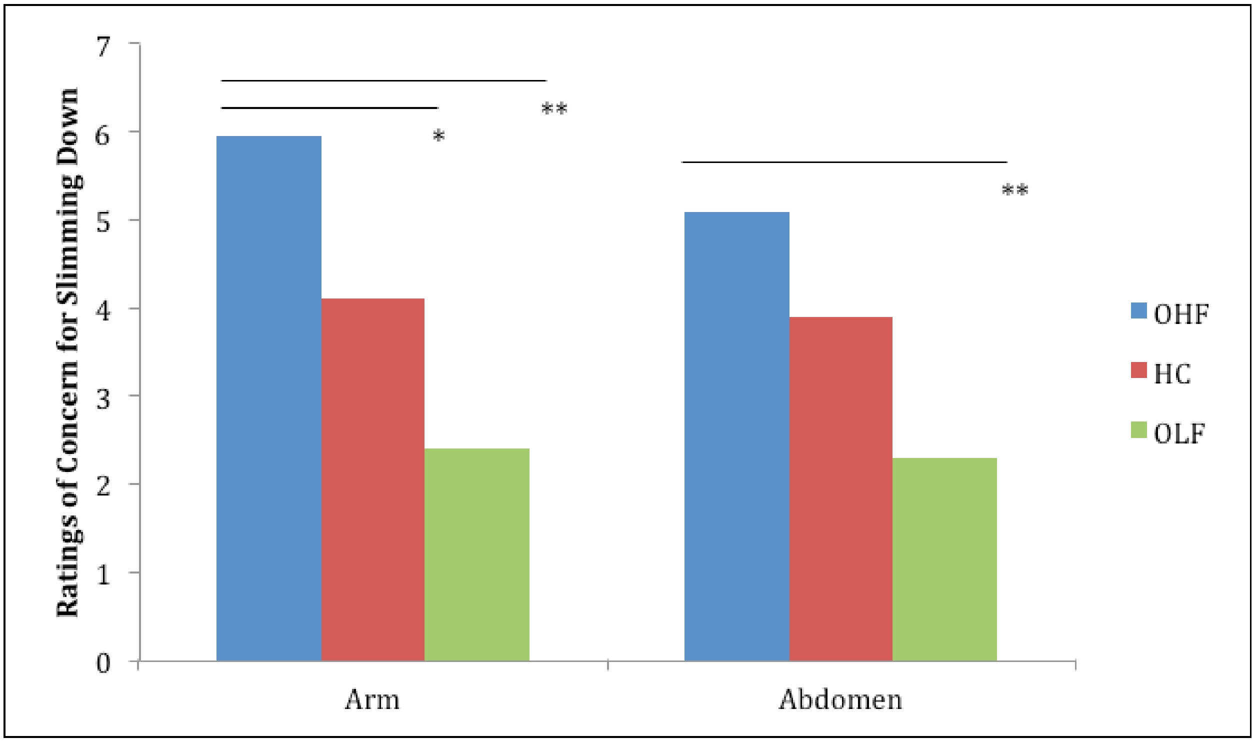


Figure 2. Mean estimates of concern with body part slimming down, by participant group.
* = p < 0.05
** = p < 0.001

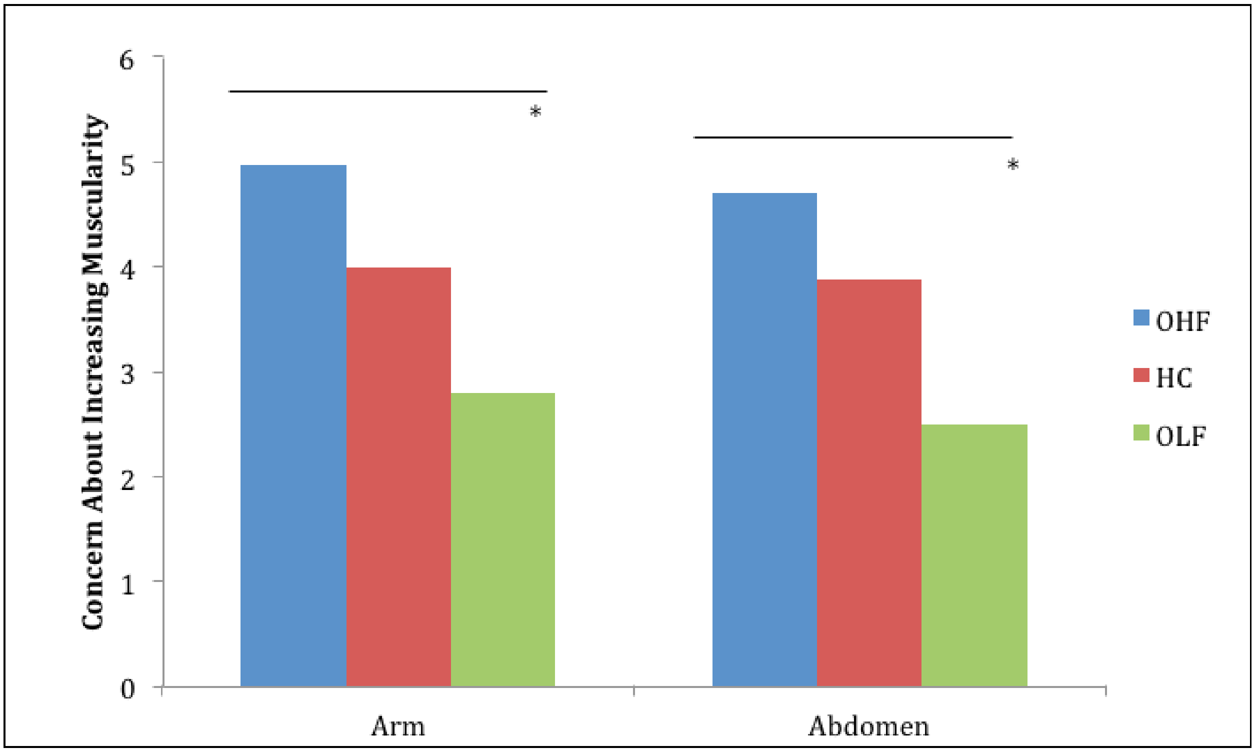


Figure 3. Mean estimates of concern with body part becoming more muscular, by participant group.
* = $p < 0.05$

Tactile Size Estimation Task

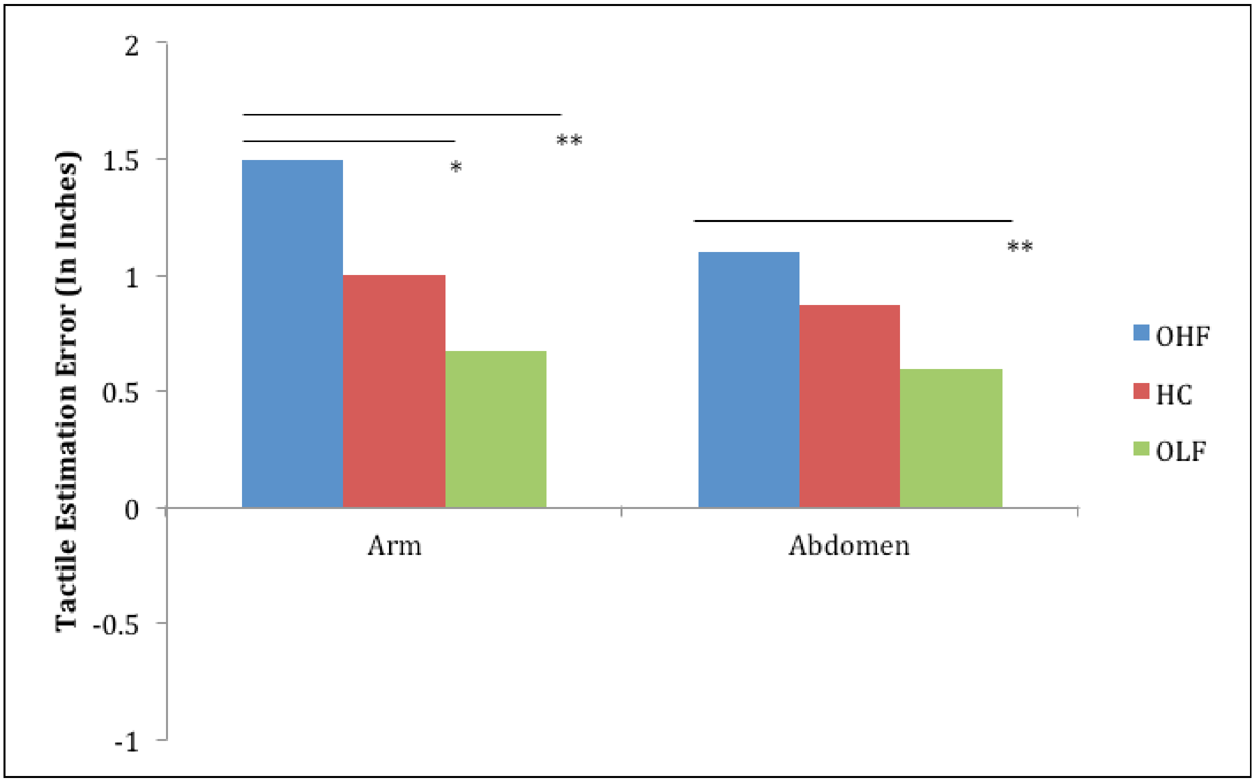


Figure 4. Predicted means for tactile estimation error (in inches).

* = p < 0.05

** = p < 0.001

Distance Comparison Task

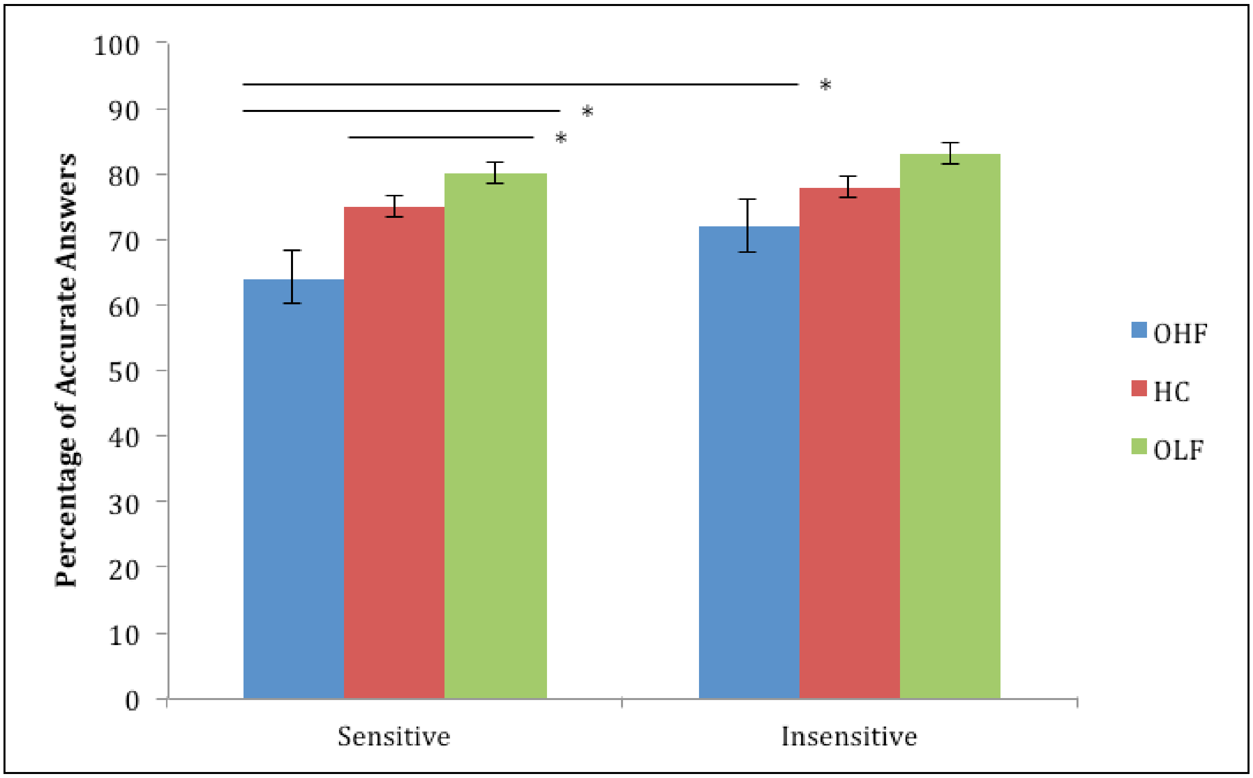


Figure 5. Predicted means for percentage of accurate distance comparison answers for each body part category.
* = p < 0.05

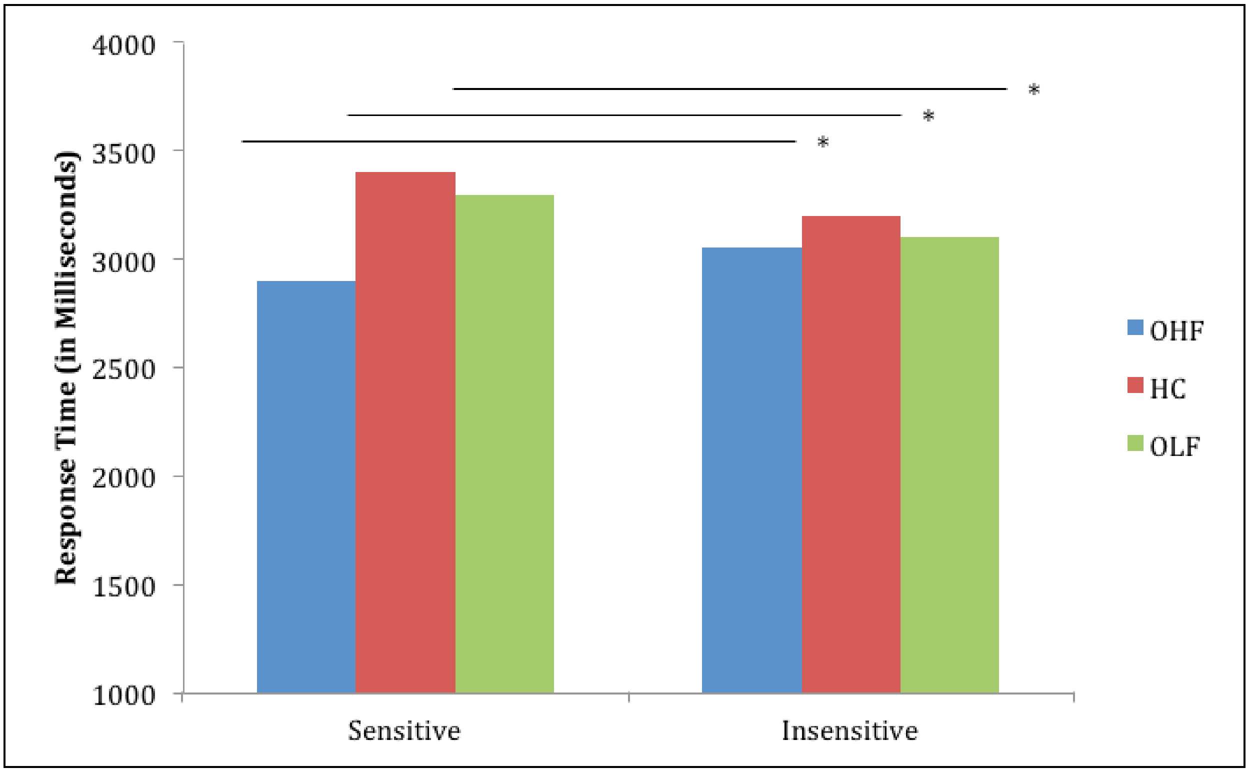


Figure 6. Predicted means for response times (RT) in milliseconds for body part category.
* = $p < 0.05$