AN INVESTIGATION OF THE RELATIONSHIP BETWEEN WEIGHT STATUS AND POSTERIOR NEUROPSYCHOLOGICAL FUNCTIONING

by

Andrea Davis

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Thesis Committee:

Kimberly Ujcich Ward, Ph.D., Committee Chair

Paul S. Foster, Ph.D., Committee Member

James P. Loveless, Ph.D., Committee Member

ABSTRACT

The present study examined the relationship between weight status and posterior brain functioning. Included in the final analyses were 38 (29 women and 9 men) undergraduate college students. Participants were weighed and measured then asked to complete several measures of body image and several neuropsychological measures. Data were analyzed using one-way ANOVAS (weight status group [i.e., normal or overweight] by performance on neuropsychological test) and Mann-Whitney U tests. Results showed that participants who had a higher BMI were more likely to be dissatisfied with their bodies. Results did not indicate any significant difference between weight group and performance on neuropsychological tests when using a one-way ANOVA. Mann-Whitney U Tests indicated a significant difference between the weight groups on a measure of verbal fluency.

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CHAPTER I

INTRODUCTION

Obesity is a medical condition that affects nearly three times as many people today as it did in 1975 (World Health Organization [WHO], 2018). Obesity is diagnosed when there is an excess of body fat based on the ratio of weight in kilograms to height in meters (BMI). Although BMI is not a direct measure of body fat, it appears to be correlated with several adverse health outcomes (e.g., Flegal & Graubard, 2009). There are a host of medical conditions that are associated with obesity; people who are obese are at higher risk for cardiovascular disease, diabetes, and certain cancers (WHO, 2018). Links between obesity and these associated conditions are agreed-upon and well-studied. What is less clear are the links between excess body fat and brain function. Due to the rising rates of obesity, it is important to understand the differences in brain function between normal-weight and obese individuals. Understanding brain function in obese individuals may give insight into neurocognitive disorders people with obesity may be more likely to develop as they age, and it may inform intervention strategies. The following review describes the empirical findings assessing the relationship between obesity and neuropsychological functioning, particularly frontal lobe functioning, Methodological implications are discussed, and a project is proposed to further investigate the relationship between obesity and neuropsychological functioning, particularly parietal lobe functioning.

Obesity and Executive Functioning

Several studies have examined the link between obesity and executive function. Executive functioning is comprised of many different cognitive skills, including planning, decision making, and logical reasoning (e.g., Gray & Thompson, 2004, Stuss & Levine, 2002). If there are deficits in executive function, there are a host of potential negative consequences, including difficulties with self-monitoring and impulse control (Martin, Carlson, & Buskit, 2010). Executive function can be measured in different ways, but commonly used are mazes, computer-based tasks, and brain imaging methods, such as fMRI.

Planning and forethought are often assessed using applied tasks, such as a maze task or the Trail-Making-Test (TMT; Reitan & Wolfson, 1985). The maze task requires participants to solve a maze without getting trapped in a dead end (i.e., making an error in planning) and has been used in research assessing obesity and executive function (e.g., Galioto et al., 2013; Gunstad et al., 2007; Stanek et al., 2013). All three of these studies obtained data on cognitive functioning from the Brain Resource International Database (BRID), an internet database that has compiled standardized cognitive tests, demographics, and health data on a large sample of healthy participants (*n* = 5000) and a clinical sample (*n* = 1000) (The BRAINnet Database, n.d.). Stanek et al. (2013) found that performance on the maze task was significantly negatively correlated with BMI. Gunstad et al. (2007) found that maze task errors were significantly positively correlated with BMI. Galioto et al. (2013) combined results from the TMT, Digit Span Backward, and a switching of attention task to create an attention/executive function variable that also was positively correlated with BMI. Differences in results may be due to the sample that each study pulled from the overall BRID database.

Another way planning is assessed is using the Trail-Making Test (Reitan & Wolfson, 1985). On this task, participants must connect dots in numerical order, alphabetical order, or in alternating numerical-alphabetical order. Cserjési et al., (2009) found that obese participants tended to complete this task significantly more slowly (though not within a clinical range) than their normal-weight counterparts, but that they did not make significantly more errors. However, Wu, Nussbaum, and Madigan (2016) did not find a significant time difference between groups on the TMT. This contrast in results may be due to age differences in participants between the two studies; the mean age in the study by Cserjési et al. (2009) was 44.8 years old, and in the study by Wu et al., the mean participant age was 21.3 years old. Therefore, age may be a confounding variable in the analysis of performance on the TMT as it relates to obesity.

The Iowa Gambling Task (Bechara et al., 1994) is a measure of decision-making wherein participants are given four decks of cards that are either rewarding or penalizing, and the goal is to learn which cards are which in order to gain as much money as possible. Fagundo et al. (2012) compared obese to normal weight women on this task and found that the obese women had a mean score of 7.7 (*SD* = 30.1), while the healthy controls scored an average of 16.5 (*SD* = 28.8). These results indicate that the obese women did not learn from nonrewarding trials as well as their normal-weight counterparts did. Instead, they continued to choose the nonrewarding cards and did not learn as quickly from their mistakes as the normal-weight participants.

Other studies have investigated executive functioning deficits by assessing brain function physiologically. Willeumier, Taylor, and Amen (2011) used brain SPECT imaging to investigate blood flow to the prefrontal cortex in overweight and obese versus normal weight participants. They found that overweight and obese participants had less blood flow to the prefrontal cortex, as measured by brain SPECT imaging, than did participants of a normal weight. Behavioral effects of decreased blood flow to the prefrontal cortex include higher impulsivity and reduced capacity for decision-making (Willeumier et al., 2011). Li et al. (2018) used MRI assessments to compare obese control participants to obese participants who were undergoing bariatric surgery. They tested both groups of participants at baseline, 12 weeks after the surgery group had the surgery, and 24 months after the surgery. Obese participants who had not undergone bariatric surgery (i.e., the control group) had higher resting state functional connectivity in the prefrontal cortex, indicating that obese individuals may be more sensitive to reward cues due to changes in brain structure. The experimental condition, after bariatric surgery, showed decreased functional connectivity whereas the obese controls did not change, indicating that the deficits may be rectified after significant weight loss. García-García et al. (2013) also examined reward processing, this time using fMRI. Obese and normal-weight participants were shown highly rewarding food, less rewarding food, rewarding nonfood items, and neutral nonfood items. fMRI analyses showed that obese participants had lower activation in the frontal and occipital areas than the normal-weight participants, indicating that the obese participants had heightened sensitivity to food and nonfood rewards. Also using fMRI analyses, Stoeckel et al. (2013) asked participants (100% obese) to complete a delay discounting task (e.g., would participants prefer $20 today or $50 in 2 weeks). Results showed that participants who had greater impulsivity (e.g., preferring the money now) had less activation in the prefrontal cortex, indicating lessened executive functioning in this sample of obese participants.

These studies utilizing brain imaging may help to explain the results of the other studies assessing relationships between executive functioning and body size. If there is less blood flow to an area of the brain, it may explain why the functioning of that area may be compromised. Furthermore, if obesity affects frontal neuroanatomy, as the study by Li et al. (2018) suggests, the changes in brain structure may account for some of the deficits in executive functioning demonstrated by obese individuals. However, as not all of the studies showed decreased executive functioning (e.g., Wu et al., 2016), changes in neuroanatomy cannot be the sole explanation for the reduced performance.

Obesity and Memory

Memory is another cognitive function that research suggests may be related to overweight and obese body size (e.g., Alosco et al., 2014; Coppin et al., 2014; Stingl et al., 2012). Several studies have examined the effects on obesity and learning. Stingl et al. (2012) compared the performance of 34 lean and 34 obese participants on a visual working memory task. Participants were presented with images of food and non-food stimuli and asked if the second image shown belonged to the same category (food or non-food) as the previous one. They measured brain activity during this task using magnetoencephalography (MEG). They found a significant main effect for reaction time, such that the lean group responded more quickly than the obese group for both food and non-food stimuli. MEG data showed that obese participants had more neuronal activity in the early period of processing (0 to 100 ms). This early period is associated with encoding, so the increased activity suggests that more cognitive resources were being allocated to encoding in the obese group as compared to the normal-weight group. Results also showed that the increased activity was associated with lower performance on the task. The researchers suggest that this could be evidence for "augmented disinhibition" in the obese participants. That is, obese participants may be less inhibited than normal-weight counterparts.

Coppin et al. (2014) also investigated working memory in normal weight, obese, and overweight individuals. Participants in all three groups were administered the Abstract Design List Learning (ADL) and Immediate Recall task, in which participants must copy 13 abstract designs and then immediately re-draw the designs from memory after all 13 designs have been seen. They also assessed delayed recall after 60 minutes had passed. They assessed working memory a second way as part of the Conditioned Cue Preference Task (CCPT), which is a learning task that assesses conditioned preference to an originally neutral stimulus. Participants are instructed to find the red balls hidden behind blocks. Red balls are rewarding, and black balls are non-rewarding. After each block of trials, the researchers asked participants to recall how many red balls had been presented and their location in the task. Results of the ADL showed no significant effects for BMI on recall of the designs. However, when working memory was assessed as part of the CCPT, results showed that both overweight and obese participants made significantly more errors than the normal-weight controls. Overweight and obese groups were not significantly different from each other.

Verbal list-learning tasks are also used to assess immediate recall, delayed recall, and recognition. Galioto et al. (2013) assessed memory using a list-learning task and found that, compared to normal-weight controls, overweight and obese participants remembered fewer words. Stanek et al. (2013), however, also assessed memory through a verbal list-learning task and did not find any significant effects for weight status. Both of these studies used the BRID, a database of neuropsychological information that was collected from 5,000 healthy individuals and 1,000 clinical participants, with disorders such as major depressive disorder, Alzheimer's disease, and obesity. Galioto et al. divided participants into normal weight, overweight, and obese, while Stanek et al. used a sample that was normal-weight on average. Although the average weight of those participants fell within the normal range, it is possible that some of their sample was overweight. This could explain why Galioto et al. found significant results and Stanek et al. did not. These differing results indicate the need for more research to be conducted with both obese and overweight groups in this area of cognitive functioning.

In a study comparing obese patients to those who had undergone bariatric surgery, Alosco et al. (2014) assessed verbal recall using a verbal list-learning task to all participants. The bariatric surgery candidates and obese controls had similar baseline memory functioning, but patients who underwent bariatric surgery showed significant memory improvement 12 weeks and 24 months after the baseline assessment. The obese control group did not show any improvements in memory functioning over that same period, suggesting that the memory improvement was likely due to some effect of weight loss. This study suggests that at least some of the cognitive deficits, particularly memory-related, observed in obese participants may be reversible when changes in body shape and size occur.

The results of these studies suggest that memory, particularly working memory, is negatively related to overweight and obesity (Coppin et al., 2014; Galioto et al., 2013; Stingl et al., 2012). Stanek et al. (2013) did not find any significant differences, but that may be due to methodological differences. Additionally, deficits in memory have been shown to improve with significant weight loss (e.g., Alosco, et al., 2014). All of these studies assessed verbal memory, and the study that also assessed memory for figures did not find a significant result. This indicates a need for further research in this area, particularly recall of stimuli presented visually.

Obesity and Cognitive Flexibility

Cognitive flexibility can be defined as how easily a person can adapt their way of thinking to different situations. One method for measuring this construct is the Wisconsin

Card Sorting Task (WCST). In this task, participants are given four cards, each with a different number of colored shapes (e.g. one yellow star, three red triangles, etc.). The researcher draws a new card from the deck and asks the participant to sort the card based on an unspecified rule. The rule might be color, shape, or number. Once the participant guesses the rule correctly and sorts 10 cards according to that rule, the rule changes without warning or explanation and the participant must figure out the new rule. People who have good cognitive flexibility make fewer errors on this task than those with poor cognitive flexibility. Fagundo et al. (2012) found that obese groups needed more trials to complete the task than healthy weight controls. They also showed that healthy weight participants made an average of 15.6 errors on the WCST, while the obese participants made an average of 37.2 errors. A similar pattern of significant group differences was found by Gameiro et al. (2017). Obese participants made significantly more errors (M = 51.29, SD = 24.53), and took more time to complete the task (M = 131.8, SD = 32.41) than the normal weight participants (errors M = 22.89, SD = 14.01; time M = 85.45. SD = 21.16). These results indicate that obese participants are less capable of changing their existing schema for this task as their healthy-weight counterparts.

Meemken et al. (2018) investigated cognitive flexibility using a reversal-learning task. This type of task is similar to the WCST in that it requires participants to learn a rule and then adapt to a rule change. In this study, either a red or a blue square was associated with either a food or a monetary reward. Which square resulted in a reward was counterbalanced throughout the task. Participants were assessed on active or passive learning. In active learning, participants were asked to predict which color square would lead to a reward. In the passive learning trials, participants were asked to rate how likely it was that each color square would lead to a reward. They found that obese participants performed better than normal-weight participants on the passive learning trials when the reward was food, but not when the reward was money. In the active learning task, there were no differences between obese and lean participants in the food or money reward conditions. These data suggest that people with obesity are more successful in a learning task when the reward is food.

A 2011 study by Mobbs et al. investigated set-shifting, an aspect of cognitive flexibility, in obese and normal-weight individuals using a food/body mental flexibility task, modified from the affective shifting task. Participants were instructed to press the space bar of a keyboard when a word belonging to a target category is presented, and to do nothing when a distractor word was presented. Participants completed two trials: one in which food-related words and neutral objects alternated as targets, and one in which body shape/size related words and neutral words were targets. Mobbs et al. found that obese participants responded more quickly to food-related targets than to body-related targets. Obese participants also had a significantly higher likelihood of making an error on both sections of this task (food and body-related targets) than normal-weight controls. Furthermore, obese participants were more likely to make omissions (i.e., not pressing a key at all when a target was displayed) than normal-weight controls in both the food and the body target sections. All participants (obese and normal weight) were more likely to make errors in the shift conditions than in the non-shift conditions, indicating that the task did require some degree of mental flexibility.

As some of these studies suggest, cognitive flexibility is another domain that may be adversely related to obesity, although results are not consistent. Results suggest that people with obesity may be less quick to learn new cognitive sets (e.g., Fagundo et al., 2012; Gameiro et al., 2017) and may make more errors on tasks that require quick discrimination between stimuli (e.g., Mobbs et al., 2011). However, the results from Meemken et al. (2018) suggest some circumstantial influences. They found that learning was facilitated in obese participants when the stimuli were food-related. This difference may be related to the food content of the task; none of the other studies used food as a focus factor on the tasks. This result suggests that learning and flexibility may be facilitated by food rewards, as they are of a higher salience to people with obesity.

Obesity and Attention

Attention is another cognitive construct that research suggests is related to obesity. Focusing on visual attention, Nijs, Franken, & Muris (2010) administered a modified Stroop task in which the word was either food related or office related (neutral). Participants were asked to name the color ink in which the word was printed. The researcher also recorded the brain activity of participants during the task using EEG analysis. They found a significant slowing in reaction time when the word was food-related rather than office related for all participants, but there was no significant difference in reaction time between the obese and normal-weight participants. EEG data showed a larger amplitude of P200 waves in obese participants when the word was food related than when the word was office related. This result shows that, in the early stages of information processing, obese participants were allocating more resources to the food-related words than the neutral words.

Another way to measure attention is by visual tracking. Castellanos et al (2009) and Doolan et al., (2014) both gathered eye-tracking data in response to food and non-food images as they relate to obesity. Castellanos et al. (2009) recruited obese women and normal weight women and had them complete a visual probe task on two different days. One of the days, the participants were instructed to come after having eaten a meal, and the other day they were instructed to come fasted. The researchers presented participants (obese and normal-weight women) with either a food image or a nonfood image for 2000 ms, after which participants were asked to choose which side of the screen the food image had appeared on by pressing a button. Both of these studies found that food that is high in energy (i.e., calories) is more attention grabbing to both groups. Castellanos et al. (2009) found that both groups of participants (obese and normal-weight women) were more likely to look at food images than nonfood images when in a fasted state. However, obese participants were also more likely to shift their gaze to food images when in a fed state as well. Normal weight participants did not show the same visual bias when they were in the fed condition. This result indicates an attention bias in obese individuals towards food-related stimuli. The researchers posit that this may be due to an increased sensitivity to food-related rewards in obese individuals.

On the contrary, Doolan et al. (2014) did not find any differences in visual attention in obese and normal-weight women in their study. Both groups of women displayed more attention to high-energy foods than low-energy foods. Obese men, however, had significantly greater maintained attention to high energy foods than low energy foods. These differing results may be due to the fact that Doolan et al. used images of low and high rewarding foods, while the Castellanos et al. used images of food and objects.

A final study on attention and obesity by Carters, Reiger, and Bell (2015) examined obese and normal weight women to see if weight status was related to inhibition of return (IOR). The IOR effect indicates that it takes some participants longer to return their attention to a neutral point (the fixation cross) once attention has been engaged elsewhere. These researchers hypothesized that obese women would show less IOR when the image was food-related, based on studies such as Castellanos et al. (2009) and Doolan et al. (2014). The stimuli were pictures of high-energy foods and neutral images. Results confirmed the hypothesis, as obese women did take significantly longer than normal weight women to disengage their attention from the food images than the non-food images.

These studies suggest that there is a significant negative relationship between obesity and visual attention, such that obese individuals are more likely to devote more attentional resources to food-related stimuli regardless of physiological hunger, and they have more difficulty disengaging their attention from those stimuli than do normal weight individuals (e.g., Castellanos et al., 2009; Nijs et al., 2010) . However, more research is needed to determine how men and women may be differently affected by this potential attentional bias, as suggested by Doolan et al., 2014.

Obesity and Body Image

Previous literature has shown that obesity has a negative effect on body image, such that an elevated BMI results in a more negative body image (e.g. Grilo et al., 2019; Radwan et al., 2019; Schwartz & Brownell, 2004). Body image disturbance and body image processing is an ability that is located in the right parietal region (e.g. Hatch et al., 2011, Suda et al., 2013). Also located in the parietal lobe is the somatosensory cortex, which contains the homunculus, a representation of body regions. Literature has suggested that people with overweight and obesity may have increased activation in the somatosensory cortex, resulting in greater brain activation in response to food (e.g., Stice et al., 2011). It has also been shown that people with overweight and obesity have lower interoceptive sensitivity than normal weight counterparts (e.g., Herbert & Pollatos, 2014). Interoceptive awareness refers to the ability to perceive internal signals such as hunger and satiety. The deficit in interoceptive sensitivity may affect the regulation of food intake and may be an etiological factor related to the development and maintenance of overweight and obesity.

Summary and Purpose

People with obesity have been shown to be more likely to develop certain other medical conditions such as hypertension, type II diabetes, and cardiovascular disease

(WHO, 2018). These conditions can certainly affect cognitive functioning. Hypertension has been shown to adversely affect performance on measures of cognitive functioning, particularly tasks that require executive function (e.g., Elias et al., 2003; Gorelick & Nyenhuis, 2012; Harrington et al., 2000). Furthermore, untreated hypertension can cause microvascular damage over time (Triantafyllidi et al., 2009). The implications of microvascular are varied; they include development of cognitive impairment, brain volume change, and dementia if untreated. Obesity may also cause neuroinflammation in the brain throughout the central nervous system, and particularly in the hypothalamus (Guillemot-Legris & Muccioli, 2017). These etiological factors may be implicated in the cognitive performance on the posterior measures of neurocognitive functioning. Specifically, the effects of obesity on the brain (i.e., due to microvascular changes and hypertension) may be shown to affect performance on measures of posterior brain functioning as well.

Empirical studies assessing the relationship between obesity and neuropsychological functioning suggest specific areas of deficit. Obesity has been associated with difficulties in planning and decision-making (e.g., Cserjési et al., 2009; Fagundo et al., 2012; Galioto et al., 2013; Gunstad et al., 2007; Stanek et al., 2013). There also may be differences in working memory, particularly verbal working memory, such that obese and overweight participants may make more errors on a working memory task than those of normal weight (e.g., Coppin et al., 2014) and may show delayed reaction times when completing working memory tasks (e.g., Stingl et al., 2012).

However, obese and normal weight participants did not differ in nonverbal working memory (Coppin et al., 2014). Furthermore, there are conflicting results for verbal list learning tasks. Galioto et al. (2013) found obese participants had a reduced performance compared to normal-weight controls on a verbal list learning task, while Stanek at al. (2013) did not find a difference between the groups. It may be more difficult for people with obesity to demonstrate cognitive flexibility on rule-based tasks or learning activities (e.g., Fagundo et al., 2012; Meemken et al., 2018; Mobbs et al., 2011). They may attend to information differently than people without obesity (e.g., Castellanos et al., 2009 & Doolan et al., 2014), and be more distracted by visual stimuli relating to food (e.g., Nijs, et al., 2010).

As a whole, these studies identify some of the areas in which obesity is associated with decreased or delayed cognitive functioning, with almost all focusing on frontal lobe functioning. Results in some areas, however, are mixed. The relationship between obesity and executive function remain unclear, as evidenced by the differing results on the maze task and the TMT. Cognitive flexibility also may be facilitated in obese participants when food stimuli is involved (e.g., Mobbs et al., 2011), in contrast to studies that show performance is negatively affected when food reward is not present (e.g., Fagundo et al., 2012; Gameiro et al., 2017). Results also show mixed support for memory, as working memory has been shown to be negatively associated with a high BMI in some tasks, but not in others. Methodological differences may account for part of the variability in results. For example, some studies used samples of women only (e.g., Cserjési et al., 2009; Fagundo et al., 2012; Stoeckel et al., 2013; Castellanos et al., 2009), while other studies used a mixed-gender sample (e.g., Coppin et al., 2014; Gameiro et al., 2017; García-García et al., 2013; Stanek et al., 2013). Additionally, there are differences in the classification of participants into weight groups. Although all studies used BMI to categorize participants, some studies included overweight participants in the obese group (e.g., Doolan et al., 2014; Willeumier et al., 2011), some studies included overweight participants in a separate category (e.g., Coppin et al., 2014; Galioto et al., 2013; Meemken et al., 2018), and some studies did not include overweight participants at all (e.g., Castellanos et al., 2009; García-García et al., 2013; Stingl et al., 2012). These methodological differences may explain part of the variability of results across these studies. Therefore, further investigation into how these factors may be associated with the obesity and neuropsychological outcomes warrants further investigation.

The current empirical literature focuses heavily on obesity and the neuropsychological functioning of the frontal lobe. It is limited in studies assessing the functioning of other brain areas, such as the parietal lobe, where the somatosensory cortex is located. The somatosensory cortex may be implicated in obesity (Wang et al., 2002). Additionally, the literature has primarily looked at verbal memory, and results from a figure memory task were nonsignificant as related to obesity. Considering the patterns of negative frontal lobe functioning on those who are overweight or obese, neuropsychological theory suggests potential impact on other brain areas.

Denny-Brown's model of mutual inhibition (1956) suggests that if there are deficits in frontal lobe functioning, performance in the posterior areas of the brain (i.e., the parietal lobe) may be enhanced. That is, the frontal lobe is known to inhibit the parietal lobes (e.g., Denny-Brown, 1956; Foster et al., 2013). According to Denny-Brown's model, the parietal lobes also have an inhibitory influence over the frontal lobes. These influences rely on connections between the frontal and the parietal lobes. As discussed above, frontal lobe functioning has been shown to be impaired in obese participants as compared to normal-weight participants. Therefore, the primary purpose of the study was to assess the relationship between obesity, body image, and parietal lobe functioning. The model of mutual inhibition (e.g., Denny-Brown, 1956) would suggest that, because reduced frontal lobe functioning has been observed in obese participants, performance on tasks associated with posterior activity, such as body perception, spatial orientation, and categorical fluency may be enhanced. Specifically, it was predicted in the current study that obese and overweight participants would show more body dissatisfaction than normal weight participants. It was also predicted that normal weight participants would be higher in interoceptive awareness than overweight and obese participants. Finally, it was predicted that obese participants would show enhanced performance on left parietal tasks compared to normal weight individuals.

CHAPTER II

Method

Participants

Thirty-eight participants were recruited from the Middle Tennessee State University psychology research pool (*N* = 22) and from undergraduate psychology courses (*N* = 16). Participants who signed up for the study through the research pool earned course credit in introductory psychology for their participation; other participants earned extra credit in their undergraduate psychology class. The age of participants ranged from 18 to 35 years (*M* = 20.92, *SD* = 3.21). Participants were divided into two groups based on Body Mass Index (BMI): normal weight (BMI $\leq$ 24.99), and overweight (BMI 25+). Seventeen participants were included in the normal BMI group who ranged in age from 18 to 28 years old (*M* = 20.59, *SD* = 2.48). There were 21 participants in the overweight group who ranged in age from 18 to 37 years old (*M* = 21.19, *SD* = 3.74). See Table 1 for full demographic information by full sample and by BMI group.

Measures

Demographics. Demographic information including age, ethnicity, and education level was gathered. Participants also completed a brief medical history questionnaire to identify health related factors that may be associated with the dependent measures in this study (see Appendix A). Participants were asked about any recent head injury (e.g., concussion, loss of consciousness). None of the participants endorsed a recent head injury

Table 1

Demographics by full sample and BMI group

	Full Sample		Normal BMI group		Overweight BMI group	
	n	%	*n*	%	*n*	%
Gender						
Female	29	76.3	12	70.6	17	81
Male	9	23.7	5	29.4	4	19
Total	38		17		21	
Ethnicity						
Asian/Pacific Islander	6	15.8	2	11.8	4	19
Black/African American	7	18.4	3	17.6	4	19
Hispanic	4	10.5	1	5.9	3	14.3
Multiracial	1	2.6	1	5.9	0	0
White	20	52.6	10	58.8	10	47.7
Education Level						
Freshman	11	28.9	5	29.4	6	28.6
Sophomore	10	26.3	5	29.4	5	23.8
Junior	9	23.7	2	11.8	7	33.3
Senior	8	21.1	5	29.4	3	14.3
Handedness						
Left	5	13.2	3	17.6	2	9.5
Right	33	86.8	14	82.4	19	90.5

or concussion (one participant reported a concussion six months prior), and, therefore, no participants were excluded from analyses.

Anthropometrics. Height in feet and inches and weight in pounds to the nearest .5 lbs were measured for all participants. BMI was calculated using the standard formula: (body weight in pounds/height in inches^2) x 703. Additionally, body fat percentage was be measured using the 1 by one smart scale (1byone Inc., 2018). This scale measures body fat by assessing body bioelectrical impedance.

Eating Disorders Inventory – 3 (EDI-3; Garner, 2004). The EDI is a self-report tool designed to assess eating disorder symptoms for individuals 15 to 53 years of age. It consists of 91 self-report items that comprise 12 subscales: Drive for Thinness, Body Dissatisfaction, Bulimia, Low Self-Esteem, Personal Alienation, Interpersonal Insecurity, Interpersonal Alienation, Interoceptive Deficits, Emotional Dysregulation, Perfectionism, Asceticism, and Maturity Fears. The EDI- 3 has shown good internal consistency (alpha coefficients ranging from .91 to .97), and also good test-retest reliability, with an alpha coefficient of .98 (Clausenet al., 2011). Factor analysis showed high reliability for women with eating disorders (r = .75 -.92) and healthy control women (r = .59 - .91) (Clausen et al., 2011). The EDI – 3 also demonstrates acceptable validity (Cumella, 2006). This study used the body dissatisfaction and interoceptive deficits subscales to assess their relationships with cognitive factors and with body shape and size.

Body Figure Perception Questionnaire (BFPQ; Stunkard, Sorenson, and Schulsinger, 1983). The BFPQ consists of two versions: a male and a female version.

Each version has nine drawings of body silhouettes, ranging from underweight to obese (see Appendix B). Each successive figure represents an increase in body weight. These figures have corresponding BMI values (Stunkard et al., 1983). Participants are asked to identify the figure that most closely represents their current body shape/size, and which figure most closely represents their ideal body shape/size. A body satisfaction score on this measure is derived from calculating the difference between the current and the ideal estimations for each participant. Body image accuracy can also be assessed by comparing the current body choice to the actual body size based on BMI comparisons (i.e., current choice – actual body size based on BMI = accuracy). Both the body satisfaction and the body image accuracy scores were used in the current study.

Controlled Oral Word Association Test (COWAT; Strauss et al., 2006). The COWAT is a measure of phonemic fluency, which is one aspect of verbal fluency. Participants are asked to generate as many words that begin with a certain letter (i.e., F, A, and S) of the alphabet as possible in 1 minute. Scores are derived from the summation of the total number of words generated for each letter of the alphabet minus errors. Proper names and repeat words with different endings (e.g., say and saying) are counted as errors. The COWAT has good internal consistency, with an alpha coefficient of .83 (Tombaugh, Kozak, & Rees, 1999). The COWAT also shows high test-retest reliability (r exceeding .7 as reported by Strauss et al., 2006). This measure also has good construct validity; scores on the COWAT are positively correlated with Verbal IQ scores (Henry & Crawford, 2004). This test has been shown to be a measure of left frontal lobe functioning, as studies cited by Strauss et al. (2006) show that patients with frontal lobe lesions are impaired on this task. The COWAT was used as a measure of left frontal lobe functioning in this study.

Animal Naming (AN; Strauss et al., 2006). AN is a measure of semantic fluency, another aspect of verbal fluency. The participant must generate as many animal names as possible in 1 minute, and a score is derived from the total number of original animal names generated. AN shows acceptable test-retest reliability coefficients, although scores are susceptible to practice effects (Bird et al., 2004). Performance on semantic fluency tasks has been associated with left temporal lobe functioning. Semantic fluency tasks activate left temporal structures more so than left frontal structures, and, like on the COWAT, left hemisphere lesions are associated with impaired performance on AN (e.g., Gourovitch et al., 2000; Henry & Crawford, 2004). Scores on the AN were used to assess left posterior functioning in the current study.

Judgement of Line Orientation (JLO; Benton, Varney, & Hamsher, 1978). The JLO is a task that assesses visuospatial functioning controlled primarily by the right parietal lobe. This task has 30 items. Each item has two lines oriented in different directions but that originate from a central point. Associated with each item is a key that shows 11 numbered lines that also originate from a central point. The participant must choose which of the numbered lines on the key correspond to the two original stimulus lines. One point is given for each item that the participant correctly identifies the correct corresponding line. The maximum score on this task is 30. The JLO has high internal consistency coefficients, ranging from .84 to .91 (Strauss, et al., 2006). Scores on the JLO are also positively correlated with items on the Wechsler Adult Intelligence Scale – IV (WAIS – IV) that require visuospatial processing (Trahan, 1998). Participants with right parietal damage perform less well on the JLO than participants with left parietal damage (Benton et al., 1994). The JLO was used in this study to assess right parietal lobe functioning differences between the two weight groups.

Mass Overlapping Figures Test (MOFT; Foster 2019). The mass overlapping figures test is a newly developed measure of visuospatial perception, thought to be controlled primarily in the right parietal lobe. The task stimuli are comprised of overlapping figures that participants must disembed. The task consists of three trials. The first trial consists of 25 overlapping line drawings on an 8.5" x 11" sheet of paper. The participant must identify as many figures as possible in 15 seconds. The second trial is presented on the same size sheet but has 50 overlapping line drawings. Participants have 30 seconds to name as many figures as possible. The final trial is an 11" x 17" sheet of paper with 75 line drawings, and participants must name as many as possible within 45 seconds. No figure is presented more than once. Total scores are derived from the summation of figures named in across all three trials.

The MOFT has been administered to a sample of 28 participants ranging in age from 56 to 93 (M = 72.7, SD = 10.66). Trial 1 scores range from 4 to 13 (M = 8.92, SD = 2.70), scores for Trial 2 range from 9 to 28 (M = 19.96, SD = 5.41), and scores from Trial 3 range from 21 to 70 (M = 47.74, SD = 12.65) (P. Foster, personal communication, October 15, 2019). The MOFT was used in the current study as a measure of right posterior functioning.

Global Focal Attention Task (GFA; Foster, 2019). The GFA is a task that measures attention in both hemispheres of the brain. Global attention is thought to be controlled primarily in the right hemisphere, and focal attention in the left (e.g., Halligan & Marshall, 1994). This task uses Navon figures as the core stimuli and is modeled after the Stroop Color-Word Interference task. The GFAT task stimuli is presented on an 11" by 17" sheet of paper with stimuli presented across 16 columns and 10 rows. The first trial is a control trial that consists of letters of the alphabet printed in 72-point Arial font. The second trial is comprised of letters that are the same size as the letters in the control trial. However, the letters in trial 2 are made up of smaller letters (.1 inch in height). The participants are asked to name the smaller letter. Participants have 45 seconds to name as many as possible. This trial measures focal attention. The second trial uses the same type of stimuli (smaller letters comprising larger ones), but the participant is asked to name as many of the larger letters as possible in 45 seconds. Trial 1 and Trial 2 contain different letters as stimuli, and the letters are not more than 4 places apart in the alphabet (i.e., "A" cannot be made from smaller "C" letters). If the participant makes a mistake, it is pointed out and the participant resumes once the correct letter is named. The time does not stop if a participant makes a mistake.

There are two scores derived from this task: a focal score and a global score. The Focal Percent Interference score is derived from dividing the number of correct responses on trial 1 by the control score and then subtracting the percentage from 100. The same process is used to derive the Global Percent Interference score. This test has been administered to a sample of 98 participants (mean age: 69.7, *SD* = 9.76). Scores on the control trial range from 64 to 139 (*M* = 92.95, *SD* = 17.71). Scores on the focal trial range from 27 to 90 (*M*= 57.6, *SD*= 13.05), and a range of 7 to 97 (*M* = 40.76, *SD* = 15.59) for the global trial. The focal percent interference scores range from 12.86 to 70.97 (*M* = 37.65, *SD* = 10.57) and the global percent interference scores range from 4.35 to 92.00 (*M* = 55.9, *SD* = 15.36) (P. Foster, personal communication, October 15, 2019). This measure was used in this study to investigate both right and left hemisphere functioning.

Lateral Graphesthesia Memory Examination (LGME; Foster, 2019). The LGME is a test of haptic learning and memory. A figure is drawn on the participant's hand using a stylus, and then the target figure is presented as a drawing to the participant with distractor figures. There are ten points on the palm and fingers that may be used by the examiner as reference points, and each figure is comprised of four of these points. All target designs begin at the distal phalange and end at the palm. There is approximately a one second pause between all four points. There are five targets designs for each hand, and the target designs for the right and left hand are different. The task consists of three learning trials and a recognition trial. In the learning trials, the five target designs are presented one after another in the same order each time. Then, the target designs are presented along with seven distractor designs. Five of the distractor designs are similar to the targets, in that they begin at the fingers and end at the palm. Two are unrelated, in that they begin and end at the palm. Participants are asked to say “yes” if the design was one of the original targets, and “no” if it was not. A score is derived for each trial by subtracting the number of false positives (i.e., recognizing the distractor designs) from the true positives (i.e., recognizing the target designs). Also, a total score is derived from summing the scores from all three trials. Finally, a recognition trial is presented 20 to 25 minutes after the learning trials. The total learning trial score was used in this study to assess right parietal functioning.

CHAPTER III

Results

The two BMI groups were compared across demographic variables to assess factors to consider covarying in subsequent analyses. An independent samples *t*-test indicated no significant age difference between the groups, $t(1, 36) = .325$, $p = .572$. Chi square analyses showed no significant group differences for either gender $X^2(1, N = 38) = .56$, $p =.45$, or ethnicity, X^2 $(3, N = 38) =2.98$, $p =.39$. No variables were used as covariates in the group comparisons.

First, it was hypothesized that overweight individuals would report higher body dissatisfaction scores on the EDI- 3 and have greater discrepancy scores on the BFPQ, indicating a greater difference between their desired and actual body size. It also was predicted that overweight individuals would have a higher score on the interoceptive deficits scale of the EDI – 3 compared to the normal BMI group. Table 2 shows means and standard deviations for the three body image measures. A one-way ANOVA showed that body dissatisfaction scores on the EDI -3 were not significantly different between the normal weight and overweight groups, $F(1, 36) = 3.88$, $MSE = 67.88$, $p = .057$. A one-way ANOVA also indicated that discrepancy scores on the BFPQ were significantly different between the normal and overweight groups $F(1, 36) = 22.76$, $MSE = 1.08$, $p <.001$, with the overweight BMI group reporting more dissatisfaction with their current body size . There was no difference between the two groups on interoceptive awareness $F(1, 36) = .62$, $MSE = 28.03$, $p = .44$. Due to small sample size, independent-samples

Table 2

Descriptive statistics and group differences for body dissatisfaction measures

	Normal Weight	Overweight
	M(SD)	M(SD)
Body Dissatisfaction	10.71 (6.84)	16.0 (9.21)
Interoceptive Awareness	5.12 (5.86)	7.48 (4.79)
BFPQ score	2.65 (.77)	4.67 (1.46)*

*$p < .05$

Mann-Whitney U tests also were conducted. The Mann-Whitney U-test indicated that body dissatisfaction scores were significantly higher in the overweight group (*Mdn* = 16) than the normal weight group (*Mdn* = 9), $U = 106$, $p = .03$. No other body dissatisfaction comparisons were significant using Mann-Whitney tests.

It further was hypothesized that scores on measures of posterior brain functioning (e.g., JLO, LGME, GFA, and MOFT) would be higher in the overweight BMI group than in the normal BMI group. One-way ANOVA analyses were conducted to compare the performance of both groups on measures of neuropsychological functioning (see Table 3). Analyses showed no significant differences between the two groups on any measure of neuropsychological functioning. Mann-Whitney U-tests were also conducted due to the small group sizes. These analyses showed a significant difference on COWAT scores between normal BMI (*Mdn* = 58) and overweight BMI individuals (*Mdn* = 45), $U = 92.5$, $p = .02$, with the normal BMI group scoring higher than the overweight BMI group. No other differences were significant.

Pearson correlations revealed a significant positive relationship between BMI and body fat percentage ($r = .82$), BMI and BFPQ discrepancy scores ($r = .62$), and BMI and body dissatisfaction scores on the EDI -3 ($r = .55$). There was also a significant correlation between body fat percentage and body dissatisfaction ($r = .46$) and body fat percentage and BFPQ score ($r = .66$). See Table 4 for body image correlations for the full sample.

Table 3

Descriptive statistics and group differences for weight status and neuropsychological measures

	Normal Weight	Overweight
	M(SD)	M(SD)
Body Mass Index	21.44 (1.49)	31.39 (5.86)
Body Fat Percentage	22.56 (8.56)	31.39 (7.88)
COWAT	58.82 (11.25)	50.48(15.46)
JLO[a]	.06 (.69)	-4.86 (20.90)
Mass Overlapping Figures Test	11.35 (3.61)	10.62 (2.73)
GFAT[a]		
Control	-.08 (1.26)	.60 (.82)
Focal	.45 (1.32)	.88 (.85)
Global	1.83 (1.05)	1.72 (1.16)
LGME		
Right Hand	4.52 (3.92)	4.57 (3.4)
Left Hand	5.47 (4.36)	5.29 (4.13)

*$p < .05$. [a]scores reported as z scores

Table 4

Descriptive statistics and group differences body distortion and neuropsychological measures

	Not Distorted	Distorted
	M(SD)	M(SD)
EDI -3		
Body Dissatisfaction	13.39 (7.83)	14.30 (10.77)
Interoceptive Awareness	6.86 (5.52)	6.90 (4.72)
COWAT	54.79 (14.89)	52.60 (12.59)
JLO[a]	-3.65 (18.12)	.12 (.582)
Mass Overlapping Figures Test	10.93 (3.15)	11.00 (3.23)
GFAT[a]		
Control	.30 (1.05)	.27 (1.22)
Focal	.65 (1.13)	.79 (1.04)
Global	1.82 (1.08)	1.62 (1.18)
LGME -Right Hand	4.36 (3.39)	5.10 (4.60)
LGME- Left Hand	5.04 (3.92)	6.30 (4.79)

[a]scores reported as z scores.

Pearson correlations were also conducted between BMI and body fat percentage and the neuropsychological measures (see Tables 5, 6 and 7). There was a significant correlation between BMI and COWAT score (r = -.34). There was also a significant correlation between body fat percentage and COWAT score (r = -.36). No other correlations between either BMI or body fat percentage and other neuropsychological measures were significant.

Although not hypothesized, additional analyses were conducted to assess cognitive differences between participants with accurate and inaccurate body perception. Participants were grouped together based on distortion in body image using scores from the Body Figures Perception Questionnaire (BFPQ). Participants' calculated BMIs were used to find their actual corresponding body figure on the BFPQ (i.e., which of the body figure cards their body most resembled). Then, the numbered figure (i.e., 1-9) of what they perceived their actual body size to be was subtracted from the numbered figure card (i.e., figure 1-9) of their actual body size. This discrepancy was used to determine a "distortion" score. Because there are 9 figures on the BFPQ, body distortion scores ranged from -8 to +8, with scores further from 0 indicating more distorted perception. If participants chose the body figure card that was most like their actual body size or was one figure away from their actual body size (i.e., score of -1, 0 or 1), they were categorized into the "not distorted" group. If participants were two or more body figures away from their actual body size, they were included in the "distorted" group. After grouping participants in this way, there were 28 participants in the "not distorted" group

Table 5

Correlations for body image variables

Variable	1	2	3	4	5
1. BMI	—				
2. Body Fat Percentage	.82**	—			
3. Body Figures Discrepancy Score	.62**	.66**	—		
4. Body Dissatisfaction (EDI -3)	.55**	.46**	.55**	—	
5. Interoceptive Awareness (EDI –3)	.17	.11	.13	.34*	—

*$p < .05$. **$p < .01$.
Note. $n = 38$

Table 6

Correlations between BMI, body fat, and right hemisphere neuropsychological variables

Variable	1	2	3	4	5	6	7	8
1. BMI	—							
2. Body fat %	.82**	—						
3. JLO	-.02	−.02	—					
4. MOFT	-.12	-.24	.22	—				
5. LGME Right Hand	.10	.05	.05	.06	—			
6. LGME Left Hand	.02	-.06	.03	.1	.61**	—		
7. GFA: Global	-.05	-.20	.04	.13	-.04	.20	—	
8. GFA: Global Percent Interference	.06	.12	.77**	-.05	-.04	-.12	-.32	—

*$p < .05$. **$p < .01$.
Note. $n = 38$

Table 7

Correlations between BMI, body fat percentage, and left hemisphere neuropsychological variables

Variable	1	2	3	4	5
1. BMI	—				
2. Body fat %	.82**	—			
3. COWAT	-.34**	−.36*	—		
4. GFA: Focal	-.002	-.03	.22	—	
5. GFA: Focal Percent interference	.10	.09	-.06	-.55**	—

*$p < .05$. **$p < .01$.
Note. $n = 38$

(mean distortion score = -.54, *SD* = .64) and 10 participants in the “distorted” group (*M* = -.9, *SD* = 2.02). It was hypothesized that, since body awareness is primarily controlled in the left parietal lobe, participants who were less accurate in judging their actual body size would also perform less well on measures of parietal functioning (i.e., Animal Naming, JLO, MOFT, LGME).

One-way ANOVAs and Mann-Whitney U-tests were conducted to compare the distorted and not distorted groups on the 4 measures of parietal functioning. One-way ANOVA analyses indicated that there were no significant differences between the distorted and non-distorted groups on any of the measures. See Table 4 for means and standard deviations. Mann-Whitney U-tests also did not indicate any significant differences between the distorted and non-distorted groups.

CHAPTER IV

Discussion

The purpose of this study was to investigate aspects of brain function, specifically in the parietal lobe, in normal and overweight individuals. Previous literature has demonstrated that individuals with obesity may show reduced executive functioning as compared to normal weight individuals (e.g., Galioto, et al., 2013; Gunstad et al., 2007; Stanek et al., 2013). However, the literature thus far has been limited to frontal brain functioning. The aim of this study, therefore, was to investigate differences between overweight and normal-weight participants on certain measures of posterior brain functioning. Specifically, it was hypothesized that functioning in the parietal lobe may be enhanced in overweight individuals. Denny-Brown's (1956) model of mutual inhibition posits that reduced functioning in one area of the brain may result in the enhancement of functioning in another area. Therefore, this model might suggest that performance on tasks associated with posterior activity, such as body perception, spatial orientation, and categorical fluency may be enhanced in overweight individuals. A further aim of this study was to investigate differences between overweight and normal weight participants on measures of body dissatisfaction and interoceptive awareness. Thirty-eight college students participated in this study completing several measures of cognitive functioning and body image.

It was hypothesized that participants in the overweight group would have higher scores on the BFPQ, indicating they reported a larger difference between actual and desired body size. A one-way ANOVA did show that participants in the overweight group did have higher scores on the BFPQ. These results must be interpreted with caution, however, due to small sample size. Mann-Whitney tests did not detect a difference in BFPQ scores. Mann-Whitney tests did, however, indicate that the overweight group had higher body dissatisfaction scores on the EDI-3. Based on these results, it seems that the overweight group did have more body dissatisfaction, as predicted. However, there was no difference in interoceptive awareness between the two groups.

Results from the study indicated that the overweight group had reduced performance on the COWAT, a measure of lateral frontal lobe functioning. None of the studies discussed previously used verbal fluency as a measure of executive functioning, however, literature has found differences in executive functioning between overweight and normal weight participants (e.g., Galioto et al., 2013; Gunstad et al., 2007; Stanek et al., 2013). Therefore, this finding is consistent with previous literature and suggests that verbal fluency may be another frontal lobe domain that may be negatively impacted by increased body weight. The Denny-Brown model of mutual inhibition suggests that the frontal and parietal lobes are connected through fibers that allow them to exert a reciprocal influence. It is possible that relatively few fibers connect the lateral frontal lobe to the parietal lobe. If this is the case, the model of mutual inhibition may not be the ideal theoretical model to interpret these results.

Results on the measures of posterior brain functioning were nonsignificant. There were no group differences on measures of posterior brain function when participants were grouped by BMI or by body distortion. Given that the MOFT is a measure of right parietal functioning, this nonsignificant result was expected. The lack of difference on the left parietal measures may be related to the small sample size of this study. The current study may be too underpowered to detect differences in posterior brain functioning between the two groups. It may also be that higher BMI is not negatively related to posterior brain functioning.

Limitations and Future Directions

There are several limitations to the current study. First, due to unprecedented university closures, data collection ended prematurely. Data collection for this study was in progress during the spring of 2020 when the COVID-19 pandemic occurred. After recommendations from the Center for Disease Control, Middle Tennessee State University ceased all in-person research studies Therefore, only 38 participants were able to be included in the study, rather than the goal of 60 participants. With a larger sample size, differences between the groups on the neuropsychological tools may have been more evident, if such differences do exist.

Furthermore, the study included 29 women and 9 men. A sample that is more balanced in gender would be desirable. Also, the brains of women have been shown to be more symmetrical in function than the brains of men (e.g., Kovalev et al., 2003; Tomasi & Volkow, 2012; Yuecel et al., 2001). Due to these preexisting gender effects, it is difficult to draw conclusions about asymmetry. For example, it may be that the representation of the body in the brain is more symmetrical for women than for men. As a result, it may be difficult to see effects, or it may be more likely to see effects for men than for women. Assessing these gender differences in brain asymmetry on neuropsychological functioning and body image is an area that is need of further study.

The effects of hypertension have been shown to affect cognitive function, primarily executive (e.g., Elias et al., 2003; Gorelick & Nyenhuis, 2012; Harrington et al., 2000). Blood pressure was not measured or controlled for in this study. While the neuropsychological tools in this study were primarily designed to measure cognitive functions other than the executive functions, it is still possible that the effects of hypertension in the sample may have presented a confound.

When separating participants into the distorted and non-distorted groups, it was discovered that only one participant had a discrepancy score of three or more. If more participants in the sample had a more distorted body image, there may have been more significant findings on performance on neuropsychological tests. This study also included two measures of parietal brain functioning (i.e., MOFT and LGME) that are new and do not yet have much psychometric support yet. More research is needed to validate and norm these tools.

Conclusions

This study provides an initial, exploratory investigation of how body weight may affect posterior neuropsychological functioning. There are several future directions that may broaden our understanding of how excess body weight may affect posterior brain functioning. Firstly, it is difficult to know from this study whether the null findings are due to small sample size or there is truly no difference in posterior brain functioning between the weight groups. Further research with a larger sample size is necessary to determine if differences in performance do exist between normal and overweight individuals.

Secondly, it was originally planned to separate participants into three groups: normal weight, overweight, and obese. Due to time constraints, it was not possible to gather enough participants to make this group distinction. However, in future studies, it may be valuable to compare the cognitive performance of the overweight and obese groups. This would allow us to ascertain at what point cognitive performance begins to be affected by excess body weight and may help to inform intervention.

In conclusion, in this initial investigation of how posterior brain functioning and body image are related to body size, significant results were limited. It does, however, provide a basis for future projects evaluating this area of health psychology. Conducting studies with a larger, more gender diverse sample combined with psychometrically sound measures of psychophysiology and neuropsychological functioning will help to further our understanding of the relationships between these factors and body size. This discernment would be valuable data to further promote health and psychological wellness with weight-risk populations.

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APPENDICES

Appendix A

Demographic Form

Please answer each of the following questions.

1. My current age is: _____ yrs

2. I am: _____Male _____Female ____Other: _____I prefer not to respond.

3. My ethnicity can best be described as (circle one):
   a. African American
   b. Caucasian
   b. Hispanic
   c. Other: _______________

4. Which of the following best describes your college education (circle one):
   a. I am currently a college Freshman
   b. I am currently a college Sophomore
   c. I am currently a college Junior
   d. I am currently a college Senior

6. I am _______ handed. (circle one):
   a. Right
   b. Left
   c. Both

For each of the following conditions, please put a mark beside any that you have personally experienced or have been diagnosed with at any time in your life (check all that apply):

_______ Concussion

If so, please explain (How recently, how severe, etc):

_______ Head Injury with a loss of consciousness

If so, please explain (how recently, how long was loss of consciousness, etc):

_______ Stroke

If so, please explain:

Other neurological condition: ______________________________

APPENDIX B

INFORMED CONSENT

IRB
INSTITUTIONAL REVIEW BOARD
Office of Research Compliance,
010A Sam Ingram Building,
2269 Middle Tennessee Blvd
Murfreesboro, TN 37129

IRBF016: INFORMED CONSENT

(Use this consent template when recruiting adult participants not considered as "vulnerable")

A. INFORMATION AND DISCLOSURE SECTION
(Participant Copy)

Primary Investigator(s)	Andrea Davis		**Student** ☒
Contact information	616-692-2303, ald5i@mtsu.edu		
Department Institution	Psychology		
Faculty Advisor	Dr. Kim Ujcich Ward	Department	Psychology
Study Title	An Investigation of Posterior Brain Function Across the Weight Spectrum		
IRB ID	**20-2081**	**Expiration: 12/31/2020**	**Approval 12/19/2019**

The following information is provided to inform you about the research project and your participation in it. Please read this disclosure carefully and feel free to ask any questions you may have about this study and the information given below. You must be given an opportunity to ask questions, and your questions must be answered. Also, you must receive a signed copy of this disclosure.

Your participation in this research study is voluntary. You are also free to withdraw from this study at any time. In the event new information becomes available that may affect the risks or benefits associated with this research study or your willingness to participate in it, you will be notified so that you can make an informed decision whether or not to continue your participation in this study.

For additional information about giving consent or your rights as a participant in this study, please feel free to contact the Middle Tennessee State University (MTSU) Office of Compliance (Tel 615-494-8918 or send your emails to irb_information@mtsu.edu. Please visit www.mtsu.edu/irb for general information on MTSU's research participant protection policies.

Please read this section and sign Section B if you wish to enroll in this study. The researcher will provide you with a copy of this disclosure form for you to keep for your future reference.

1. **Purpose of the study:** You are being asked to participate in this research study because we are investigating the possible relations between aspects of neuropsychological functioning and body size and shape.

2. **Classification of procedures to be followed and approximate duration of the study:**
   - ☒ 2.1 ***Educational Tests –*** Study involves either standard or novel education practices which consists educational testing and such studies expose the participants to lower than minimal risk
   - ☒ 2.2 ***Behavioral Evaluation –*** Although the study may or may not involve educational tests, the specific aim is to understand behavioral characteristics. .
   - ☐ 2.3 ***Psychological intervention or procedures*** ☐ 2.4 ***Physical Evaluation or Procedures***
   - ☐ 2.5 ***Medical Evaluation or Clinical Research*** ☐ ***2.6 OTHER***

   You will be asked to complete some questionnaires and assessments of cognitive functioning, and to be weighed and height measures, all of which will provide us with information about your perceptions, your cognitive skills, and your body size.

3. **What are procedures we intend on doing in this study?**
   As a participant in this study, you will be weighed and your height will be measured. You also will complete a few questionnaires and several nueropsychological (cognitive) assessments to help us understand your current state and skills.

4. **What will you be asked to do in this study?**
   You will be asked to complete several psychological tools measuring cognitive functioning and body image.

5. **What are we planning to do with the data collected using your participation?**
   We will use this data to investigate possible links between weight status and neuropsychological functioning.

6. **What are the expected results of this study and how will they be disseminated?**
   We anticipate the group data to demonstrate how one's body shape and size is potentially related to how they think, understand and perceive the world around them. We expect to get a clearer picture of how our perceptions of our bodies is related to how certain areas of our brains function. Only group data (no individual data) will be reported in final reports (e.g, thesis document, presentations/publications) from this study.

7. **What are your expected costs to you, your effort and your time commitment?**
   There are no expected costs to you except your time; this study will take approximately a 45 minutes to one hour of your time.

8. **What are the potential discomforts, inconveniences, and/or possible risks that can be reasonably expected as a result of participation in this study?**
   You will be weighed, which for some people may not like doing. We will have you step on the scale backwards to avoid exposure to your weight in case that might be uncomfortable.

9. **How will you be compensated for your participation?**
   You will receive credit (2) for the Psychology Research Pool for your participation.

10. **What are the anticipated benefits from this study?**
    a. **The benefits to science and humankind that may result from this research:**
       T knowledge we will gain from this study may benefit science and society by increasing our understanding of how cognitive functioning and body image may be related
    b. **The direct benefits to you which you may not receive outside the context of this research:** There are no direct benefits to for participating in this study other than your course credits earned.

11. **Are there any alternatives to this study such that you could receive the same benefits?**
    You may complete an alternative assignment for research credit for your psychology class.

12. **Will you be compensated for any study-related injuries?**
    N/A

13. **Circumstances under which the researcher may withdraw you from this study:**
    As long as your are between the ages of 18 and 40 and consent to participate, you will not be withdrawn from the study.

14. **What happens if you choose to withdraw your participation?**
    If you choose to withdraw your participation all study activities will cease and you will be free to leave. You will still receive your research credits for participation.

15. **Can you stop the participation any time after initially agreeing to give consent/assent?**
    Yes.

16. **Contact Information.** If you should have any questions about this research study or possibly injury, please feel free to contact Andrea Davis by telephone 615-898-2188 or by email ald5i@mtmail.mtsu.edu OR my faculty advisor, Dr. Kim Ujcich Ward, at kimberly.ward@mtsu.edu; 615-898-2188. For additional information about giving consent of your rights as a participant in this study, to discuss problems, concerns and questions, or to offer input, please feel free to contact the MTSU IRB by email: compliance@mtsu.edu or by telephone (615) 494 8918.

17. **Confidentiality.** All efforts, within reason, will be made to keep the personal information in your child's research record private but total privacy cannot be promised. Your information may be shared with MTSU or the government, such as the Middle Tennessee State University Institutional Review Board, Federal Government Office for Human Research Protections, *if* you or someone else is in danger or if we are required to do so by law.

You do not have to do anything if you decide not to participate. If you wish to enroll, then enter your name and age in the attached Section B (next page). Please sign Section B and return it to the investigator. Please retain Section A (this document) for your future reference.

Consent obtained by:

_______________________ ____

Researcher's Signature Name and Title Date

B. Signature Section
(Researchers' Copy)

Primary Investigator(s)	Andrea Davis		**Student** ☒
Contact information	616-692-2303, ald5i@mtsu.edu		
Department Institution	Psychology		
Faculty Advisor	Dr. Kim Ujcich Ward	Department Psychology	
Study Title	An Investigation of Posterior Brain Function Across the Weight Spectrum		
IRB ID	**20-2081**	**Expiration: 12/31/2020**	**Approval 12/19/2019**

PARTICIPANT SECTION
(To be filled by the participant and returned to the researcher)

I have read this informed consent document	☐No ☐Yes
The research procedures to be conducted have been explained to me verbally	☐No ☐Yes
I understand all of the interventions and all my questions have been answered	☐No ☐Yes
I am aware of the potential risks of the study	☐No ☐Yes

By entering my name and signing below, I affirm that I freely and voluntarily choose to participate in this study. I understand I can withdraw from this study at any time without facing any consequences.

Name and Signature of the Participant   Date   Participant's Age

RESEARCHER SECTION
(To be filled by an investigator and the FA if applicable)

Informed Consent obtained by:	Faculty Verification (if administered by a student)
Name Signature Date	Name Signature Date

Appendix C

IRB Approval Page

IRB
INSTITUTIONAL REVIEW BOARD
Office of Research Compliance,
010A Sam Ingram Building,
2269 Middle Tennessee Blvd
Murfreesboro, TN 37129

MIDDLE TENNESSEE STATE UNIVERSITY

IRBN001 - EXPEDITED PROTOCOL APPROVAL NOTICE

Thursday, December 19, 2019

Principal Investigator	**Andrea Davis** (Student)
Faculty Advisor	Kimberly Ujcich Ward
Co-Investigators	NONE
Investigator Email(s)	*ald5i@mtmail.mtsu.edu; kimberly.ward@mtsu.edu*
Department	Psychology
Protocol Title	***An investigation of posterior brain function across the weight spectrum***
Protocol ID	**20-2081**

Dear Investigator(s),

The above identified research proposal has been reviewed by the MTSU Institutional Review Board (IRB) through the **EXPEDITED** mechanism under 45 CFR 46.110 and 21 CFR 56.110 within the category *(7) Research on individual or group characteristics or behavior*. A summary of the IRB action and other particulars in regard to this protocol application is tabulated below:

IRB Action	**APPROVED for ONE YEAR**		
Date of Expiration	**12/31/2020**	Date of Approval	12/19/20
Sample Size	100 (ONE HUNDRED)		
Participant Pool	Target Population 1: Primary Classification: **General Adults (18 or older)** Specific Classification: **MTSU Students** Target Population 2: Primary Classification: **General Adults (18 or older)** Specific Classification: **MTSU SONA**		
Exceptions	Retention of student information, including M number, is permitted for complying with MTSU SONA extra credit policies		
Restrictions	**1. Mandatory SIGNED adult informed consent.** **2. Direct interaction only; NOT approved for online data collection.** **3. Not approved to collect identifiable information, such as, audio/video data, photographs, handwriting samples, financial information, personal address, driving records, social security number, and etc.** **4. Mandatory final report (refer last page).**		
Approved Templates	MTSU templates: signature informed consent and SONA recruitment script. Non-MTSU template: Recruitment scriptl		
Comments	NONE		

Post-approval Actions

The investigator(s) indicated in this notification should read and abide by all of the post-approval conditions (https://www.mtsu.edu/irb/FAQ/PostApprovalResponsibilities.php) imposed with this approval. Any unanticipated harms to participants, adverse events or compliance breach must be reported to the Office of Compliance by calling 615-494-8918 within 48 hours of the incident. All amendments to this protocol, including adding/removing researchers, must be approved by the IRB before they can be implemented.

Continuing Review (**The PI has requested early termination**)

Although this protocol can be continued for up to THREE years, The PI has opted to end the study by **12/31/2020** **The PI must close-out this protocol by submitting a final report before 12/31/2020 Failure to close-out may result in penalties including cancellation of the data collected using this protocol.**

Post-approval Protocol Amendments:

Only two procedural amendment requests will be entertained per year. *In addition, the researchers can request amendments during continuing review. This amendment restriction does not apply to minor changes such as language usage and addition/removal of research personnel. .*

Date	Amendment(s)	IRB Comments
NONE	NONE.	NONE

Other Post-approval Actions:

Date	IRB Action(s)	IRB Comments
NONE	NONE.	NONE

Mandatory Data Storage Requirement: All research-related records (signed consent forms, investigator training and etc.) must be retained by the PI or the faculty advisor (if the PI is a student) at the secure location mentioned in the protocol application. The data must be stored for at least three (3) years after the study is closed. TN State data retention requirement may apply. The PI must consult with MTSU Office of Data Management. Subsequently, the data may be destroyed in a manner that maintains confidentiality and anonymity of the research subjects.

The MTSU IRB reserves the right to modify/update the approval criteria or change/cancel the terms listed in this letter without prior notice. Be advised that IRB also reserves the right to inspect or audit your records if needed.

Sincerely,

Institutional Review Board
Middle Tennessee State University

Quick Links:

- Post-approval Responsibilities: http://www.mtsu.edu/irb/FAQ/PostApprovalResponsibilities.php
- Expedited Procedures: https://mtsu.edu/irb/ExpeditedProcedures.php