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# Anti-Fat Bias and Attentional Capture

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Anti-Fat Bias and Attentional Capture

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## Abstract

Explicitly-rated anti-fat attitudes are correlated with weight-based discrimination, which is rampant in society today as many countries grapple with soaring rates of obesity. Early perceptual processes, such as conscious awareness and visual attention, may be biased based on the weight of the perceived or the perceiver, or any number of individual perceiver characteristics regarding weight-biased attitudes and experiences. The three experiments presented used continuous-flash suppression (CFS) to mask body stimuli, thereby hoping to gain insight into attentional capture of unseen images and its relation to anti-fat attitudes. The pattern of findings in the three experiments presented suggest that what makes a stimulus likely to capture spatial attention may be distinct from the characteristics that afford it conscious perceptual processing initially. Stimulus-level features interacted with participant characteristics to bias the effectiveness of CFS. All three studies demonstrated significant differences in stimulus breakthrough based on stimulus weight, where larger images broke through to conscious awareness more readily than smaller images. Study 2 controlled for size by including inverted bodies as primes. Analyses suggest that heavy bodies are more susceptible to suppression than their overall size would predict. This effect interacted with gender and BMI; overweight participants and female participants displayed the significant effect of stimulus weight on breakthrough rate. In contrast, findings regarding the relationship between explicit anti-fat bias and attentional capture were inconsistent across studies.

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## Introduction

Prejudice against individuals with excessive body weight, or anti-fat bias, is one of the last widely-acceptable forms of intolerance in society today (R. Puhl & Brownell, 2001). The latest statistics from the Centers for Disease Control and Prevention estimate that in the United States, 70.7% of adults over 20 years of age are overweight (Centers for Disease Control and Prevention [CDC], 2017). A 2014 analysis estimates that over one-third of the global population is overweight, representing an increase of almost ten percent from 1980 (Ng et al., 2014). As obesity rates rise worldwide, so too do anti-fat attitudes (R. M. Puhl et al., 2015). People who experience discrimination based on their weight are less likely to lose weight, and they are more likely to suffer from serious mental health consequences such as depression and anxiety when compared to those who do not experience such weight-based discrimination (Hunger, Major, Blodorn, & Miller, 2015). Given that so many individuals confront anti-fat bias and the dire consequences it carries, it comes as no surprise that this complex topic has gained widespread attention over the past decade.

One troubling characteristic of anti-fat attitudes is that regardless of whether or not a person is aware of them, they can still lead to potentially unintentional discriminatory behavior (Schupp & Renner, 2011). Medical professionals who specialize in obesity display implicit anti-fat attitudes, even as their jobs necessarily involve interaction with overweight patients (Schwartz, Chambliss, Brownell, Blair, & Billington, 2003). Even parents are less likely to provide college support for their overweight daughters than they are for their average-weight children (Crandall, 1995). A recent survey found that 40% of adults with a body mass index (BMI) of 35 or above had experienced weight-based discrimination (R. M. Puhl, Andreyeva, & Brownell, 2008). Discrimination can lead to differences in educational opportunities, hiring practices, housing allocation, among other domains (see R. Puhl & Brownell, 2001 for a review). Understanding the origins of these outcomes is thus crucial, particularly if they arise from unconscious processing.

**Attention and Prejudice**

Overt behavioral discrimination is certainly not the only form of bias; even processes that begin early in visual representation are subject to differences based on perceiver and target characteristics. Before a target's appearance can be deliberately scrutinized, the brain determines whether to orient attention in its direction. If a target fails to capture the processes of visual attention and selection, it may not earn a place in the viewer's visual representation of their world and, later, in their memory (e.g. Kawakami et al., 2014).

Differences in visual orienting and attention have been investigated extensively with respect to prejudice towards Black Americans. For example, Caucasian participants who were primed with crime-related words visually oriented to images of Black individuals more readily than those in a control condition (Eberhardt, Goff, Purdie, & Davies, 2004). The results of this study suggest that Caucasian Americans can be hyperaware of Black Americans, particularly when they are primed with threat-related concepts, but this hyperawareness does not hold in all contexts. Caucasian participants primed with interpersonal goals closer to the self, such as seeking a romantic relationship or friendship, were less likely to notice a Black actor in the background of a video task than were participants primed with interpersonal goals distant from the self, like looking for a coworker (Brown-Iannuzzi, Hoffman, Payne, & Trawalter, 2014). Taken together, these findings paint a reality where Black Americans are functionally invisible unless they are perceived by people who are vigilant towards threat or not focused on interpersonal goals, such as close friendship.

What does this mean for anti-fat bias? It is apparent that anti-fat discrimination happens, but it remains unclear how early perceptual processes, such as attention, play a role in its occurrence. Are overweight individuals attended to more than underweight and average-weight people (as though they are relevant to personal goals), or are they ignored (as though they are not relevant to interpersonal goals)? How might this pattern change if the perceiver happens to be overweight? I hope to begin to answer some of these outstanding questions in the present study by investigating how people differently and unconsciously attend to heavy individuals. Because implicit bias in attention is a central concept of my dissertation project, I include a brief review of relevant literature below.

**Unconscious Perception and Bias**

People generally have the sense that they perceive everything in their visual environment, a phenomenon termed the “Grand Illusion” (Noë, 2002). As suggested in its name, this sensation is a misconception – at any time, the visual system allocates resources to some inputs at the expense of others, and thus a complete representation of the entire visual world is metabolically impossible (or at least quite implausible). This allocation of resources can occur automatically and outside of visual awareness, even for complex social information such as race and age (e.g. Stein, End, & Sterzer, 2014). To the extent that such processing operates outside of awareness and influences attention, it may be especially likely to drive inadvertent discriminatory behavior.

My prior work included an investigation of how subliminally-presented images of heavy and thin bodies could yield automatic, emotional facial reactions. We discovered that people who reported higher levels of explicit anti-fat attitudes displayed more facial activity consistent with the expression of disgust to subliminally-presented heavy bodies compared to thin bodies. Importantly for the current investigation, our findings demonstrated that people can respond to images that are outside of their awareness in ways that correspond to how they explicitly state they feel about people of different weights.

Early biases, as in my study described above, have more potential to lead to anti-fat discrimination than late biases (Agerström & Rooth, 2011). For example, in a recent study, hiring managers were asked to complete surveys about their racial preferences in hiring employees. That they had time to consciously deliberate over their responses to the surveys suggests that biased responses on the questionnaires reflect a "late" bias. The same managers later completed a test of their implicit racial prejudice, which did not give participants time to consciously decide on the level of bias in their responses and is thought to reflect "early" bias (see Chaiken & Trope, 1999, for an overview of the distinction between early versus late biases). Managers' level of racial bias on the implicit tests predicted real hiring discrimination, whereas their survey responses did not (Agerström & Rooth, 2011). Early biases in perception thus influence how people feel and act and seem to be less within our control than many would like to believe.

**Attentional Capture**

The direction of a person's gaze is not random – it is strongly determined by what captures their attention. Many studies have focused on attentional capture of consciously-perceived stimuli, but I will here focus on those that investigate unconscious perception and attentional capture. I take this approach because most attention is directed outside of awareness, so that cognitive resources can be directed at more complex tasks (Hassin, 2013). In addition, as mentioned above, anti-fat bias can be expressed implicitly, suggesting that unconscious orienting of attention may play a role in its occurrence.

Individuals who endorse strong anti-fat attitudes also tend to prefer thin body types (e.g. Carels & Musher-Eizenman, 2010). The Implicit Relational Assessment Procedure (IRAP) was developed to allow researchers to independently evaluate the two constructs of interest, in this case, thin and heavy bodies (Barnes-Holmes, Barnes-Holmes, Stewart, & Boles, 2010). Using the IRAP and other similar techniques, researchers have been able to study whether anti-fat attitudes are different from pro-thin attitudes, and how each of these attitudinal stances contributes to discrimination against overweight individuals. One such experiment used electromyography (EMG) to measure facial reactions to images of average-weight and overweight bodies, along with implicit pro-thin and anti-fat bias during an IRAP procedure. Participants also completed explicit measures of their anti-fat bias and discriminatory behavior. Results from this work suggests that participants responded more positively to average-weight bodies than they responded negatively to overweight bodies. Crucially, their stimuli had been normed based on participant judgments; the average-weight bodies used in the study were rated as "thin," on average. This "pro-slim" rather than anti-fat bias was mirrored in the IRAP findings, and significantly predicted explicit discriminatory behavior against overweight individuals (Roddy, Stewart, & Barnes-Holmes, 2011).

Similarly, in another investigation using the IRAP where individual weight differences were considered, there emerged an implicit pro-thin bias across participants, regardless of their weight status (underweight, average-weight, overweight). An additional implicit anti-fat bias was only evident in underweight participants (Anselmi, Vianello, & Robusto, 2013). The hypotheses in the present study were developed with the understanding that explicit anti-fat attitudes may better predict implicit preference of thin bodies rather than an implicit derogation of heavy bodies. In the present study, an implicit pro-thin bias is reflected in attentional capture of thin bodies while an implicit anti-fat bias is conceptualized as attentional repulsion of heavy bodies.

Below, I briefly summarize literature describing characteristics (both of stimulus and perceiver) that modulate attentional capture across a variety of complex social features.

**Emotion.** It has long been demonstrated that emotion can capture attention, both when it is experienced and when it is seen. It makes sense that emotional images orient attention automatically and outside of awareness as part of a system that helps to distinguish survival-relevant information from extraneous perceptual noise. For example, images of spiders and snakes are found more quickly than fear-irrelevant images during visual search (Ohman, Flykt, & Esteves, 2001). Even when images of fearful faces are suppressed from consciousness using continuous-flash suppression (CFS), they gain access to awareness more quickly than neutral or happy faces (Yang, Zald, & Blake, 2007). Some emotional effects are even stronger when they occur without awareness. For example, neutrally-valenced surprise faces were rated as more positive when they were preceded by subliminally-presented happy faces. When the happy face was presented supraliminally, it did not impart its valence on the paired surprise face (Sweeny, Grabowecky, Suzuki, & Paller, 2009).

Individuals suffering from anxiety disorders tend to be even more attentionally drawn to threatening stimuli than people without anxiety disorders (see Cisler & Koster, 2010 for a review). Interestingly, the relationship between anxiety and sensitivity to threat is moderated by attentional control (Derryberry & Reed, 2002), an individual factor discussed in greater detail below.

Some work suggests that emotionally-relevant stimuli orient attention because they are more relevant for an individual's survival and, thereby, their success in propagating their genes (Fromberger, Jordan, & Herder, 2012). Another argument from evolutionary psychology suggests that automatic orienting is especially attuned to seek out potential mates (Maner, Gailliot, & Dewall, 2007).

**Sexual attraction.** Seeking suitable mates is a primary goal for all animals. This goal is so basic that orienting attention to attractive others often happens outside of awareness, at least for humans. In one study, heterosexual men automatically oriented their attention more to images of attractive women than to images of men and children, lending support to the idea that sexually-relevant stimuli orient attention (Fromberger et al., 2012). In another experiment using the dot probe task, participants displayed inhibited attentional disengagement from images of attractive women, while the complementary effect for attractive men was not significant. Surprisingly, this effect was strongest for sexually unrestricted male participants and for female participants who felt insecure in their current romantic relationships, suggesting the operation of a mate competition mechanism (Maner et al., 2007). Even when primes are suppressed from awareness using CFS, they can still orient attention: participants were most accurate at identifying the orientation of a Gabor patch (see Figure 1) presented at a location previously occupied by a subliminally-presented nude compared to a scrambled image. This attention orienting effect was strongest for nude male primes viewed by heterosexual female participants and homosexual male participants, whereas the reverse was true of nude female primes (Jiang, Costello, Fang, Huang, & He, 2006).

Subjective attractiveness of faces also orients attention. In another experiment using CFS, faces that participants had previously rated as most attractive broke suppression sooner than faces they had rated as less attractive, suggesting that they were processed more easily in the absence of visual awareness. This same study included another experiment where suppressed faces preceded Gabor patches for an orientation judgment at one of two locations. Participants displayed inhibition of return (IOR), where they were less accurate at determining Gabor orientation at the location of an attractive prime than an unattractive one. Presumably, participants' attention had already been captured at the location of the attractive prime first and then moved away when by the time the Gabor appeared at the first location (Hung, Nieh, & Hsieh, 2016). To summarize, Jiang et al. (2006) found attentional capture by attractive bodies, while Hung et al. (2016) found IOR. Although these findings seem contradictory, when one considers crucial timing differences in the study designs, their different results make sense. The Posner cueing paradigm used in these two studies can induce attentional capture and IOR, though at different interstimulus intervals (see Klein, 2000, for a review of IOR). Jiang et al. (2006) used an interstimulus interval (ISI) of 100ms between the prime and the Gabor and found exogenous attentional capture of the attractive primes whereas Hung et al. (2016) used a longer interval—200ms—associated with inhibition of return. In the present project, I used short ISI to evaluate attentional capture by bodies of different weights, rather than IOR, as attentional capture does not necessarily lead to IOR (Fuchs & Ansorge, 2012).

If sexual attraction is a factor that drives unconscious attentional bias, one would predict that hunger should drive attention to food-related cues, as adequate nourishment is relevant to an individual's survival. To investigate this possibility, Weng and colleagues (2019) subjected participants to a CFS study before and after a meal. Hunger biased perception of food-related stimuli only when the images were unsuppressed and visible. This surprising finding may point to one limitation of top-down modulation of visual perception.

**Self-relevance.** The degree to which information is relevant to the self is, unsurprisingly, another factor that guides attention. A well-known example of offline capture of attention due to self-relevance is the cocktail party effect. Even if you are not actively listening for your name, if you hear it across the room, your attention is more likely to be drawn to it than to another irrelevant word (Moray, 1959). The cocktail party effect has been studied in the visual domain, too; while other words that directly follow a target word in rapid serial presentation are often rendered invisible (attentional blink), if the word directly after the target happens to be your name, it is less often missed, similarly to emotional words (Shapiro, Caldwell, & Sorensen, 1997). More complex social characteristics, such as age and race, also direct attention preconsciously when they align with the features of the observer (Stein et al., 2014).

A recent investigation used a dot-probe task including masked images of the participant's face and of other individuals' faces. Their EEG findings indicated a clear attention shift (N2pc) to participants' own faces when they were presented, even when they were masked. Crucially, the presence of the neural attention marker was not correlated with subjective visibility of the stimuli, as assessed by the sensitivity measure *d'* (Wójcik, Nowicka, Bola, & Nowicka, 2019).

Many social psychology paradigms include between-subject factors that change the extent to which stimuli are relevant to observers. In one study, women who were primed to believe that they were devalued were more vigilant towards subliminal cues that threatened their social identity than were women who were primed to feel valued and respected (Kaiser, Vick, & Major, 2006). Critically for the present study on anti-fat attitudes, another experiment found that women with higher levels of body dissatisfaction displayed delayed attentional disengagement from images of thin bodies whereas women who were satisfied with their bodies did not (Moussally, Brosch, & Van der Linden, 2016). Keeping this information in mind, participants trying to lose weight may be attentionally drawn to images of individuals at their "goal" weight, if self-relevance is the predominant factor in attentional bias to images of bodies of different weights. Conversely, participants who report feeling afraid of gaining weight may be drawn to images of overweight individuals, if orienting to "threat" is the predominant factor.

**Attentional Control.** Not everyone is as susceptible to factors driving preconscious attention to the same degree. People who are more susceptible to experiencing the cocktail party phenomenon tend to have low working-memory capacity, suggesting that they struggle to ignore irrelevant stimuli (Conway, Cowan, & Bunting, 2001). Working-memory is one component of attentional control, also known as executive function, which includes the abilities to plan, organize, and shift attention effectively (see Hofmann, Schmeichel, & Baddeley, 2012). Recent research suggests that individual differences in attentional control moderate the relationship between implicit prejudice and behavioral discrimination (Payne, 2005).

Attentional control seems to be a characteristic with both state and trait components: while some people generally have more attentional control in their "banks" than others, the size of the vault can be increased temporarily. People who scored high on a measure of their motivation to control racially-prejudiced responses exhibited more attentional control during the weapon identification task than those who scored low on the same measure (Payne, 2005). Further supporting the notion that attentional control plays a critical role in prejudice, researchers found that White participants' attentional control (as measured by performance on a Stroop color-naming task) was depleted following interaction with a Black confederate, but not after they interacted with a White confederate (Richeson et al., 2003). Furthermore, during the presentation of unfamiliar Black faces, activity in a brain region broadly implicated in executive function (the dorsolateral prefrontal cortex) mediated the relationship between anti-Black bias and subsequent Stroop task performance (Richeson et al., 2003).

Investigating attentional control as an individual difference factor in the present study has the potential to shed light onto its utility in studies of attentional bias generally. Attentional control could prove to mediate the relationship between explicitly-rated anti-fat attitudes and unconscious visual orienting to heavy bodies.

## Present Project

The extant literature suggests that anti-fat bias is rampant, insidious, and can have detrimental physical and mental health consequences for a large proportion of the population. In this dissertation, I examine how weight bias interacts with attention at an unconscious level using images of bodies masked using continuous flash suppression (CFS). Participants judged the orientation of briefly-flashed tilted Gabor patches presented shortly after images of heavy, average-weight, or thin bodies, or scrambled images of bodies (control condition). The body primes and the scrambled control images were subjected to CFS masking to encourage suppression from conscious awareness.

### Hypotheses

1. Individuals explicitly endorsing higher levels of anti-fat attitudes will be more accurate at identifying the orientation of a tilted Gabor patch presented at a location previously occupied by a thin prime than a location previously occupied by a heavy prime.
2. Individuals will be more accurate at identifying the orientation of a tilted Gabor patch presented at a location previously occupied by an intact body prime than a location previously occupied by a scrambled body.
3. There will be stronger attentional attraction in the invisible condition (when participants report not to have seen the primes) compared to the visible condition.

4. This hypothesis is based on findings that emotional effects can sometimes be stronger when they occur without visual awareness (e.g. Sweeny et al., 2009) and a similar result in a study of unconscious attention to nude bodies (Jiang et al., 2006).

**Masking Technique**

During typical binocular vision, the visual system fuses slightly different visual inputs to (and outputs from) two eyes into one percept. Experiments using binocular rivalry capitalize on the visual system's natural tendency to fuse binocular inputs. In binocular rivalry, different images are presented on each side of a computer monitor that is separated by a divider that runs orthogonally from the screen to the participant's face (see Figure 1). A stereoscope mounted in front of the participant relays optical information via a series of mirrors so that one half of the screen is exclusively visible to each eye, with content from the other side occluded by the divider. Thus, each eye only has access to the image on its side of the screen. Yet because the eyes diverge their rotation in this setup and focus on two distinct points in space, each straight ahead (rather than at some shared point in front of the participant), the brain interprets the two images as occupying the same region of space near fixation, and naturally attempts to fuse the images into a single coherent percept, if possible. However, when different images are presented to each eye, this fusion becomes difficult and the visual system instead 'flips' between two alternate percepts.

Continuous Flash Suppression (CFS) is a masking technique used to prevent conscious perception of images in the context of binocular rivalry. CFS paradigms typically present visually complex, moving patterns to the participant's dominant eye and a static image (or images) of interest to the nondominant eye. In CFS, rather than experiencing binocular rivalry between image pairs, the participant tends to consciously perceive only the dynamic noise pattern, typically for several seconds. This makes CFS an exceptional technique for investigating unconscious processes in perception of the images presented to the nondominant eye without the necessity of presenting images for extremely brief durations. The present study explored unconscious attentional orienting to images, capitalizing on the extended stimulus presentation duration afforded by CFS.

While the distinction between exogenous (automatic and involuntary) attention, as compared to endogenous (volitional) attention is interesting and a fruitful area of research, it is not the focus of the current project. Indeed, successfully-masked exogenous cues have been shown to effectively bias spatial attention and subsequent visual processing (e.g. Mulckhuyse, Talsma, & Theeuwes, 2007), as well as masked centrally-presented endogenous cues (Palmer & Mattler, 2013). Thus, indexing change in spatial attention based on the stimuli presented using our methods could not answer the question of *how* participant attention is captured, just that it is.

A secondary outcome measure gathered was the proportion of trials of each stimulus type where participants indicated some stimulus breakthrough (or, as least, that they perceived a difference between the noise patches on either side of fixation). As mentioned previously, the visual system is bombarded with more information than can be consciously attended to and perceived. CFS capitalizes on the brain's evolutionary propensity to prioritize awareness of changes in the organism's environment by using visually interesting, dynamic masks that tend to override static stimuli. When perception of a static stimulus breaks through the mask, it can be proposed that it was determined to be relevant to the individual in some way. Stimuli that break CFS more quickly than others are prioritized by the visual system over those that take longer to break suppression. The mechanisms behind competition between stimuli under continuous flash suppression are beyond the scope of the present study. In the context of binocular rivalry, the breakthrough process likely emerges from a continuous neuronal process of rectifying the discrepant images supposedly occupying the same location in space. Another theorized parallel perceptual process is a stochastic fluctuation between dominance of the information received by one eye over the other (see Blake & Logothetis, 2002, for a review of binocular rivalry studies)

Other researchers have successfully used longer stimulus presentation durations and assessed differences in the amount of time, on average, it takes certain stimuli to break through the CFS mask, using study designs known as b-CFS (e.g. Almeida et al., 2014; Stein et al., 2014). More recently, Gayet and Stein published a meta-analysis including data from three b-CFS studies and determined that the differences between conditions in b-CFS tasks is problematically correlated with individual differences in suppression duration overall (2017). Based on their work, I determined that using the proportion of trials during which participants experienced breakthrough would effectively estimate stimulus dominance without the added task demand of quick responses and the individual variability of mask breakthrough duration.

The following experiments assessed differential awareness and attentional capture of bodies of different sizes. This spatial attention bias is often referred to simply as "bias" in the context of this project. To the extent that differential spatial attention to bodies of different sizes is related to explicit measures of prejudice, it could be proposed that spatial attention bias would lead to the same real-life consequence as explicit prejudice does – behavioral discrimination. Such downstream effects of are outside the scope of the current project but provide interesting avenues for future research.

## Experiment 1A

### Method

### Participants

70 undergraduate students at the University of Denver (16 men, 53 women, and 1 student who declined to state their gender) gave informed consent to participate in this study for optional course credit. Eight participants provided unusable data due to technical and experimenter errors. All included participants reported normal or corrected-to-normal visual acuity. All experimental procedures were approved by the University of Denver IRB.

### Design

All manipulations were within-subject, including stimulus weight and intact-body versus non-body stimulus type. Self-reported questionnaire data (outlined in greater detail below) was also collected from participants to examine the role of individual differences in the allocation of spatial attention.

### Stimuli

**Bodies.** Computer-generated photorealistic images of thin, average, and heavy female bodies were selected from a database designed to be used in weight research. The stimuli were created using the 3-D modeling software DAZ Studio 4.0 (DAZ Productions, 2011) and were normed to ensure that the weight manipulations on the stimuli were symmetrically distributed and similar to photos of real women on scales of attractiveness and "fatness" (Moussally, Rochat, Posada, & Van der Linden, 2017). Four thin, average, and heavy bodies were selected, in accordance with typical BMI ranges for underweight (< 18.5), average (18.5-24.9), and overweight (> 25) individuals in the United States, to maximize external validity ("Healthy Weight," 2017). Each body image was used to create its scrambled counterpart using a fast Fourier transform, generating a non-body image identical to the original in color and luminance (Figure 2). Scrambled images were used as probes in half of the experimental trials to control for the effect of low-level visual features on unconscious attention orienting.

**Targets.** Rotated Gabor patches (e.g. Figure 1) were used as targets in this set of experiments. While orientation, as a feature unto itself, is not the focus of the present investigation, it was determined to be adequately scalable in difficulty for our needs. Judging the orientation (e.g., tilted to the left or right) of Gabor patches was also a non-social evaluation on which to focus participant attention, so as to not interfere with body stimulus perception. Gabor characteristics were determined based on pilot testing to reliably yield orientation judgments between 70 and 90% accuracy, as in a similar study of unconscious attentional orienting (Hung et al., 2016). The Gabor generated for the present investigations had a Gaussian contrast envelope with a standard deviation of 10º that included a sinusoidal grating with a spatial frequency of 2 cycles per degree.

## Procedure

The present set of experiments featured the binocular rivalry and CFS techniques described above, using a mirror stereoscope mounted on a chinrest in front of a computer monitor separated by a divider (see Figure 3 for a schematic of the trial procedure). A black and white "checkerboard" frame was present on each trial to aid in fusion of the display regions for the two eyes. Each trial began with a fixation cross (0.8° x 0.8°) presented to each eye for a randomly selected duration between 100ms – 200ms. A body (4.1° x 6.2°) and its scrambled counterpart (see Stimuli, above) were presented on either side of the fixation cross to the participant's nondominant eye. The intact and scrambled bodies gradually faded in from 60% opacity to 100% over the first 300ms of each trial to reduce the likelihood that sudden onset transients from the bodies would capture awareness exogenously. Simultaneously, a pair of dynamic noise patches were presented to the participant's dominant eye to prevent the body images from reaching visual awareness. These noise patches, called Mondrians, were created using a composite image of high-contrast colored rectangles (Figure 4). Each Mondrian was rotated 180° every 200ms to create the illusion of motion and make it more visually attention-grabbing. If masking were successful, the percept during presentation of the bodies and the masks (the Mondrians) should have been only of the pair of Mondrians, one on either side of fixation.

The body and its scrambled counterpart were presented for 800ms (including the 300-ms fade-in) after which point the fixation cross reappeared for 100ms, following timing parameters reported by Jiang et al. (2006). Then, a Gabor patch rotated 1° (in Study 1A) or 5° (in Study 1B and Study 2) clockwise or counterclockwise was presented for 100ms either to the left or right of fixation, at one of the two previous stimulus Mondrian locations (one of which was previously occupied by the body or the scrambled body, although participants may not have seen it).

I chose not to include non-mask catch trials because the body images in non-mask (conscious) trials could have more readily biased the visibility of stimuli on subsequent masking trials, based on research demonstrating that the contents of visual working memory hasten the speed at which congruent images break CFS suppression (Pan, Lin, Zhao, & Soto, 2014). Amazingly, Pan et. al. showed that, when participants were told to "remember" masked images that they reported not seeing, the images still somewhat biased bCFS (2014). While it is possible that the procedure outlined here was still affected by this phenomenon (particularly following mask-fail trials), it was presumed that unmasked images would bias visual working memory more than images that were masked, especially because participants were not instructed to retain images in memory.

Participants first responded by indicating the orientation (L or R) of the target patch. Next, they indicated whether they had perceived a difference between the two Mondrians. If a participant responded in the affirmative, one could surmise that the mask was unsuccessful in eliminating conscious perception of the static stimuli (body and scramble) for that trial. Responses in this two-alternative forced-choice (2AFC) design were collected using a keyboard and trial order was completely randomized. Gabor-probe location (to the left or the right of fixation) was also randomized. In each experiment, there were an equal number of trials for each stimulus weight (thin, average, heavy) and the intact body prime was predictive of the Gabor-probe location on half of the trials. Before the main experiment of 240 trials, participants completed 50 practice trials under the supervision of the experimenter that contained only the target Gabor-patch (no bodies) to fine-tune the calibration of the stereoscope and familiarize participants with the task. The experimenter encouraged participants to respond as quickly as possible without sacrificing accuracy.

Participants were instructed to select that they noticed a difference between the Mondrian patches if they noticed an image or part of an image in the moving colors. Even on mask-fail trials, it is highly unlikely that the static, low-contrast noise image would break through to conscious awareness rather than the image of the body, as the visual noise image has no contours. Therefore, participants were not asked to indicate on which side of the screen they perceived breakthrough. Based on this logic, when participants reported a difference between the two sides of the screen, it was presumed they experienced "breakthrough" of the body stimulus.

In addition, pilot testing revealed that participants often became confused by the left/right judgment and had to be reminded during practice trials that it only referred to the tilt of the Gabor, and not its location on the screen. There was concern that participants would experience greater confusion and frustration if they were asked to make another directional judgment (i.e. "indicate which side the body image was on") in the response segment of trials.

**Breakthrough rate.** Although CFS often effectively limits subjective awareness of the suppressed images, it does not necessarily completely eliminate perception on every trial. As such, it was important to assess subjective awareness of the primes on a trial-by-trial basis (Yang, Brascamp, Kang, & Blake, 2014). Rather than asking if they were aware of the primes, participants indicated if they noticed any difference between noise patches on either side of fixation during the trial and responded with a keypress indicating either "yes" or "no" (as in Jiang et al., 2006). The proportion of each trial type during which participants indicated stimulus breakthrough was then computed.

**Gabor orientation accuracy.** Following prime and Gabor presentation and the question about subjective visibility, participants indicated whether the Gabor patch was tilted to the left or to the right. Each participant's accuracy was indexed using percent correct for each trial type.

**Reaction time.** Reaction time to make each judgment was collected for every trial. Trials yielding Gabor orientation reaction times longer than 2.5 standard deviations than that individual's mean reaction time across trials was excluded from analyses.

**Individual Difference Surveys.** Participants completed individual difference surveys following the main perception task. The order of survey completion was fixed to decrease the possibility that the salience of weight beliefs contributed to the demonstrated pattern of findings.

***Body Mass Index (BMI).*** Participants were asked to report their height and weight, which was then calculated into BMI scores during analysis, following guidelines from the Centers for Disease Control ("Healthy Weight," 2017).

***Body Shape Questionnaire – Short Form*** (Dowson & Henderson, 2001). This 14-item questionnaire assesses body dissatisfaction, particularly in the perceived-overweight domain. Its items are scored on a 6-point scale (1 = never, 6 = always) and summed to form a total score. Questions include "Has being with thin people made you feel self-conscious about your shape?" and "Have you felt ashamed of your body?"

***Antifat Attitudes Scale*** (AFAS; Morrison & O'Connor, 1999)**.** The AFAS is a unidimensional 5-item measure that assess explicit anti-fat attitudes. Items are rated on a 5-point scale (1= Strongly disagree, 5 = Strongly agree). Prompts include "I would never date a fat person" and "on average, fat people are lazier than thin people." Total scores are the summation of individual item responses, where higher scores reflect greater endorsement of anti-fat attitudes.

***Fat Phobia Scale - Short Form (FPS)*** (Bacon, Scheltema, & Robinson, 2001). The FPS is a 14-item measure that explicitly measures stereotypes of heavy people. Each item contains a pair of adjectives that participants are told are "sometimes used to describe fat or obese people." For each pair, participants indicate on a 5-point scale the adjective that most closely describes their feelings and beliefs, with higher scores reflecting greater endorsement of anti-fat stereotypes. For example, participants must choose from "obese or fat people are: lazy, somewhat lazy, neither lazy nor industrious, somewhat industrious, industrious." An overall fat phobia score is computed as the mean of all items.

***Penn State Worry Questionnaire (PSWQ;*** Meyer, Miller, Metzger, & Borkovec, 1990). The PSWQ was selected to measure trait anxiety in my sample because it is less susceptible to state anxiety and task vigilance effects than other similar self-report anxiety questionnaires (Davey, 1993). The PSWQ contains 16 items, including "I notice that I have been worrying about things" and "My worries overwhelm me." Participants selected responses ranging from 1 ("not at all typical of me") to 5 ("very typical of me"). A total score is the summation of all items.

***Attentional Control Scale*** (Derryberry & Reed, 2002) measures participant trait ability to focus and shift attention. As mentioned previously, this scale has been shown to reliably predict behavioral discrimination following implicit measures of racial bias. Many hypothesize that the scale measures an individual's ability to control a response after initial automatic bias has been activated (e.g. Payne, 2005). As such, this scale provides a useful insight into the automaticity of visual orienting to unconsciously presented stimuli. The Attentional Control Scale is comprised of 20 items, rated on a scale from 1 ("almost never") to 4 ("always"), and includes such items as "It is easy for me to read or write while I'm also talking on the phone" and "It's very hard for me to concentrate on a difficult task when there are noises around" (reverse scored). A total score is the sum of all item ratings.

***Relationship Status and Security.*** Participants were first asked to indicate their current romantic relationship status (single and looking, single and not looking, in an open relationship, in a closed relationship). If they indicated that they were in a relationship, they were prompted to answer the following question "indicate the extent to which you feel secure and stable in your relationship" on a scale from 1 = not at all to 9 = extremely, as in a previous investigation of relationship security and attention to attractive others (Maner et al., 2007).

## Results

### Data Inspection and Cleaning

Accuracy on the Gabor-orientation task ranged from 40.2% to 98.3% across participants. Mean accuracy was 67.2% (SD=14.8%) and participants, on average, detected a body stimulus on 33.4% of trials. Eight participants whose mean accuracy was less than 50% (chance performance) were excluded from further analysis. Average Gabor orientation accuracy for the remaining participants was 70.32% (SD=13.25%). Trials with reaction times (RTs) greater than twice the standard deviation above each participant's mean reaction time were removed (3.4% of trials). Scores on the individual difference survey measures and attentional effect scores greater than 2.5SD above the mean were winsorized to minimize their impact on inferential statistical analyses.

**Unconscious Attentional Effect (AE)**

The unconscious effect of spatial attention (AE) was computed as the difference in Gabor patch orientation discrimination accuracy between the two stimulus conditions (target appearing at the location of the intact body versus target appearing at the location of the scrambled control). A significant deviation from zero indicates that spatial attention was modified by the presence of the body. AE scores were averaged for each stimulus type (thin, average, heavy) for each experiment. A positive AE score suggests that the participant's spatial attention was preferentially drawn to the intact body image location on screen, improving orientation discrimination performance when the target appeared at the same location as the body. AE scores significantly less than zero represent attentional repulsion from the intact body location, thus impaired accuracy on prime-valid trials.

**Effect of Stimulus Weight on AE**

To test my primary hypothesis that accuracy would be highest when preceded by a thin body and lowest when preceded by a heavy body, I conducted a detection (detected image, undetected image) by stimulus weight (thin, average, heavy) analysis of variance (ANOVA) with participant gender included as a between-subjects factor. There was a significant main effect of detection, such that orientation accuracy was higher after trials when a stimulus body was detected (i.e., masking failed) compared to trials when the body was successfully masked; $F(1,43) = 5.667$, $p = .022$. There were no other significant main effects or interactions. Including attentional control as a covariate in an ANCOVA analysis with the same factors included resulted in no significant main effects or interactions (all $p > .283$).

**Exploratory Analyses**

**Unconscious Attentional Effect (AE)**

To examine on an exploratory basis whether self-reported anti-fat attitudes were predictive of spatial attention, I first performed a median split of participants based on scores on the Anti-Fat Attitudes Scale (AFAS). Next, I conducted a detection (detected body, undetected body) by stimulus weight (thin, average, heavy) analysis of variance (ANOVA) with participant gender and AFAS Group (Low, High) included as between-subjects factors. This analysis revealed a significant main effect of detection, $F(1,40) = 5.635$, $p = .022$ and a main effect of weight, $F(2, 40) = 4.641$, $p =.012$. The main effect of weight was further clarified in a significant weight by AFAS Group interaction, $F(2,40) = 7.368$, $p = .001$. Post-hoc pairwise comparisons were then conducted using the

Bonferroni correction for multiple comparisons. As shown in Figure 5, participants scoring low on anti-fat attitudes attended more to thin bodies than to average-weight ($p$ = .045) and heavy bodies ($p$ = .047). Participants who scored high in anti-fat attitudes attended significantly more to average and heavy weight stimuli than those low in AFAS scores did (average $p$ = .037; heavy $p$ = .005). The significant interaction between stimulus weight and AFAS Group persisted when attentional control was included as a covariate in the analysis, $F(2,40) = 7.126$, $p = .001$.

**Breakthrough Rate**

I computed the proportion of trials for each stimulus weight wherein CFS failed to completely mask the body image. To test whether the masking breakthrough rate varied by stimulus weight, I conducted a repeated-measures ANOVA including stimulus weight as the within-subjects factor and gender as the between-subjects factor. There was a significant main effect of weight $F(2,51) = 7.950$, $p = .002$, such that average and heavy stimuli were detected more readily than thin bodies. The main effect of weight did not significantly interact with gender.

Participant data was sorted into groups based on calculated BMI. As there were only five participants whose BMI placed them in the "underweight" range, they were combined with the "healthy weight" group. The remaining participants whose BMI fell in the "overweight" or "obese" categories were sorted into a second group for data analysis. A repeated-measures ANOVA on breakthrough rate data including BMI Group as the between-subjects factor revealed a significant interaction between stimulus weight and BMI group $F(2,48) = 3.958$, $p = .031$. Bonferroni-corrected post-hoc tests indicated that participants whose BMI placed them in the underweight or healthy categories detected significantly more heavy bodies compared to thin and average weight bodies, while overweight participants showed no difference in detection based on stimulus weight (shown in Figure 6). The significant interaction between BMI Group and stimulus weight persisted in an ANCOVA including attentional control as a covariate, $F(2,48) = 3.754$, $p = .027$.

**Discussion**

To my knowledge, this study was the first to demonstrates a potential link between individual differences based on weight and stimulus breakthrough rate. Breakthrough rate and stimulus size have not been studied often in relation to CFS, but one investigation found that elongated objects broke suppression sooner compared to rounded "blob-like" objects (Almeida et al., 2014). The result from Study 1A runs counter to what we would have predicted given this prior finding, but our stimuli were human bodies compared to the non-body objects used in the prior investigation. Human bodies may benefit from prioritized visual processing, as suggested by a specific cortical region that responds preferentially to visual presentation of body images (Downing, Jiang, Shuman, & Kanwisher, 2001). Therefore, this breakthrough rate effect may reflect a body-specific size bias in visual attention.

Because mean overall Gabor orientation accuracy was lower than anticipated in Study 1A (67.2%), I determined that a follow-up investigation was needed to better calibrate task difficulty, increase participant data retention for analysis and to reduce potential participant frustration.

## Experiment 1B

### Method

### Participants

30 undergraduate students at the University of Denver (8 men, 20 women, and 2 students who declined to state their gender) gave informed consent to participate in this study for optional course credit. Fewer participants were recruited than in Study 1A as the primary purpose of this investigation was to better calibrate task parameters. All participants reported normal or corrected-to-normal visual acuity. All experimental procedures were approved by the University of Denver IRB.

### Design

As in Study 1A, all manipulations were within-subject, including stimulus weight and intact-body versus non-body scrambled prime type. Self-reported questionnaire data was again collected from participants to examine the role of individual differences in the allocation of spatial attention and in stimulus breakthrough.

### Stimuli

Due to the aforementioned low average accuracy on the Gabor orientation judgment in Study 1A, I changed the Gabor rotation angles from 1° to 5° from vertical (clockwise and counterclockwise) in subsequent experiments. All other stimulus characteristics remained identical for Study 1B.

## Procedure

The experimenter emphasized the importance of practice trials and accurate calibration of the stereoscope for each participant. Otherwise, the procedure in Study 1B was identical to that of Study 1A.

## Results

### Data Inspection and Cleaning

Mean Gabor orientation accuracy was 81.43% (SD=12.08) and participants, on average, detected a body stimulus on 40.6% of trials. Five participants whose average accuracy was less than 50% were excluded from further analyses. As in Study 1A, trials with reaction times (RTs) greater than twice the standard deviation above each participant's mean reaction time were removed (3.8% of trials). Scores on the individual difference survey measures and the bias variables greater than 2.5SD above the mean were winsorized to minimize their impact on inferential statistical analyses.

### Attentional Effect

I first conducted a detection (detected prime, undetected prime) by stimulus weight (thin, average, heavy) analysis of covariance (ANCOVA) with gender included as the between-subjects factor and AE as the dependent variable. Attentional control was included as a covariate in this analysis. This analysis revealed a significant interaction between stimulus weight and gender, $F(2,17) = 3.929$, $p = .029$. Corrected post-hoc analyses yielded no significant pairwise comparisons.

An analysis of covariance attempting to replicate the significant finding in Study 1A included AFAS Group as a between-subjects factor. This analysis resulted in a significant interaction between stimulus weight and gender and an interaction between weight, gender, and stimulus detection at trend-level significance, $F(2,15) = 1.666$, $p = .058$. The significant interaction between stimulus weight and AFAS Group found in Study 1A was not replicated. To clarify the three-way interaction, separate ANCOVA were conducted on the detected and non-detected data. The ANCOVA including only data from trials where the stimulus was not detected (stimulus weight, gender, and AFAS Group included as factors) yielded no significant main effects or interactions, all $p > .115$. The ANCOVA including only data from trials where participants detected a stimulus yielded a significant interaction between stimulus weight and participant gender, $F(2,16) = 5.864$, $p = .006$, as depicted in Figure 7. Bonferroni-corrected post-hoc tests indicated no significant pairwise differences. An interaction with participant gender was particularly sensitive to spurious findings because only six male participants contributed to the AE analyses in this dataset.

An exploratory partial correlation analysis including AE variables and individual difference measures, controlling for the effect of attentional control, revealed a significant correlation between participant BMI and attention toward thin stimuli that broke suppression. The lower a participant's BMI, the stronger the attentional capture of a detected thin stimulus, $r(20) = -.465$, $p = .029$. There were no other significant correlations between AE variables and individual difference measures. A multiple regression model was conducted with attentional control and BMI entered in the first step and AFAS, FP, and BSQ entered in stepwise fashion in the second step of the analysis. None of the measures of body satisfaction or anti-fat bias significantly improved the ability of the linear model to predict attention to detected thin stimuli (all $p > .416$).

### Breakthrough Rate

As in Study 1A, I computed the proportion of trials for each stimulus weight where masking failed and the body image broke through (in whole or partly) to conscious awareness. I then conducted a repeated-measures ANOVA including stimulus weight (thin, average, heavy) as the within-subjects factor and gender and BMI Group as between-subjects factors. There was a significant main effect of stimulus weight, $F(2,19) = 10.152$, $p < .001$. Post-hoc analyses indicated that heavy body primes broke CFS suppression significantly more often than thin and average primes. When attentional control was included as a covariate, however, there were no significant main effects or interactions.

### Discussion

The significant attentional effects from Study 1A were not replicated in Study 1B, despite the task having been made easier. This could have resulted from insufficient power due to fewer participants, so Study 2 was planned to increase statistical power in attentional effect analyses by recruiting more participants. Stimulus weight did significantly interact with participant gender for mask-fail trials, although specific conclusions are difficult based on non-significant tests of pairwise comparisons. In Study 1B, heavy body images broke through to conscious awareness more often than thin and average bodies, as had been the case in Study 1A, although BMI did not significantly interact with the effect of stimulus weight.

The primary goal of Study 2 was to better understand the extent to which the size of an object or body influences its likelihood of breaking CFS and entering awareness. We used inverted body stimuli in an otherwise identical experimental procedure to Study 1B to determine whether the perception of the object as a body is necessary to yield differences in breakthrough rate due to stimulus size. A secondary goal was to investigate whether individual differences in BMI and anti-fat attitudes moderate weight bias in breakthrough rate.

# Experiment 2

## Method

### Participants

61 undergraduate students at the University of Denver (19 men, 41 women, and 1 student who declined to state their gender) gave informed consent to participate in this study for optional course credit. One observer provided unusable data due to technical error and one was not able to participate in the experimental task due to amblyopia. All included participants reported normal or corrected-to-normal visual acuity. As before, all experimental procedures were approved by the University of Denver IRB.

### Procedure

Participants completed two experimental blocks of 240 trials each separated by a voluntary break. The order of the two blocks was counterbalanced. The stereoscope was re-calibrated after the break and participants completed another 50 practice trials before beginning the second block. One of the two blocks was identical to Study 1B with upright bodies and the other block featured only inverted body stimuli. Other experimental parameters were identical to those used in Study 1B.

## Results

### Data inspection and cleaning

Mean Gabor orientation accuracy was 76.13% (SD=18.56) and participants detected a body stimulus on 52.78% of trials. Seven participants had an average Gabor orientation accuracy of less than 50% and were excluded from further analyses. After the exclusion of those seven participants, mean Gabor orientation accuracy was 80.44% (SD=14.25). Updated overall breakthrough rate was 56.33% (SD=27.49). A paired-samples t-test indicated no significant difference between the breakthrough rate on inverted prime trials compared to upright prime trials, $t(44) = -.958$, $p = .343$. As described previously, trials with reaction times (RTs) greater than twice the standard deviation above each participant's mean reaction time were removed. Scores on the individual difference survey measures and the bias variables greater than 2.5SD above the group mean were winsorized to minimize their impact on inferential statistical analyses.

### Attentional Effect

A paired-samples t-test indicated no significant overall difference in Gabor orientation accuracy between the upright and inverted blocks, $t(44) = -.206$, $p = .837$. A repeated-measures ANCOVA was conducted to test the hypothesis that people attend less to upright heavy bodies than they attend to upright bodies of other weights and that this difference is not present when the bodies are presented upside-down. The analysis included Detect (2) x Weight (3) x Orientation (2), where the orientation factor captures whether the body image was upright or inverted. Participant gender was included as a between-subjects factor and attentional control was included as a covariate. This ANCOVA revealed no significant main effects and no significant interactions.

**Differential Attentional Effect**

The inverted body condition was included in this experiment to act as a control for stimulus size and overall shape, as previous research has demonstrated that inversion significantly disrupts individuals' awareness of faces and headless human bodies during CFS, suggesting that they are processed differently (Stein, Sterzer, & Peelen, 2012). By computing difference scores for each stimulus size, I hoped to isolate the effect of *body* size from any effect of stimulus size. Specifically, the attentional effect (measured by Gabor orientation accuracy) on thin, inverted body trials was subtracted from the attentional effect on thin, upright body trials. Difference scores were calculated in the same way for average-weight and heavy body trials for each participant. If the effects found are specific to upright bodies, the difference scores should be significantly greater than zero.

A repeated-measures ANCOVA examining the effect of stimulus weight on attentional effect during detected prime trials (including attentional control as a covariate) did not result in any significant main effects or interactions (all $p > .089$). An ANCOVA using only data from successful masking trials (where the prime was not detected) similarly yielded no significant main effects or interactions (all $p > .212$).

**Attentional Control**

Self-reported attentional control (ACS) was examined as a potential mediator in the relationships between explicit anti-fat attitudes and differential attentional effect. A preliminary independent-samples t-test indicated no significant difference between male and female participants on ACS scores, $t(44) = -.346$, $p = .731$.

A hierarchical multiple regression analysis was conducted to explore the effect of anti-fat attitudes on unconscious attention to thin body primes (corrected for stimulus size) in male participants. Attentional control scores were included in step one of the model, which was not significant, $R^2 = .031$, $F(1,14) = .414$, $p = .531$. The addition of fat phobia and antifat attitudes scale scores in step 2 of the model significantly improved the model fit, accounting for 45.9% of the variance in unconscious bias to thin primes, $\Delta R^2 = .544$, $\Delta F(1, 14) = .011$, $p = .020$. A similar multiple regression analysis on undetected heavy body primes for male participants did not generate a significant regression equation.

For female participants, a hierarchical multiple regression analysis including attentional control scores in step one of the analysis and antifat attitude scores in step two did not generate a significant regression equation, nor did a regression analysis investigating the effect of anti-fat attitudes on attentional bias of undetected heavy primes.

**Breakthrough Rate**

First, a repeated-measures ANOVA was conducted to determine whether the significant effect of stimulus weight on the subjective visibility of body primes from Studies 1A and 1B was replicated in this dataset. Stimulus weight was included as a within-subject factor and participant gender was included as a between-subjects factor. There was a significant main effect of weight, $F(2,47) = 18.546$, $p < .001$. Bonferroni-corrected post-hoc analyses revealed significant differences in every possible pairwise comparison. Average-weight stimuli broke CFS masking more than thin stimuli, and heavy stimuli broke through to conscious awareness on a greater proportion of trials than average stimuli did.

To evaluate the impact of stimulus inversion on breakthrough rate, a repeated-measures ANCOVA was conducted with stimulus weight (3: thin, average, heavy) and orientation (2: upright, inverted) included as within-subject factors and gender included as a between-subjects factor. Attentional control scale was included as a covariate. This analysis revealed a significant main effect of orientation, $F(1,48) = 4.495$, $p = .039$; inverted bodies broke through to conscious awareness significantly more often than upright bodies did.

One interesting result from Study 1A had demonstrated a significant interaction between participant BMI Group and stimulus weight on breakthrough rates. An ANCOVA was conducted using the corrected breakthrough rates to determine whether this effect is specific to body weight rather than stimulus size generally. The analysis included attentional control as a covariate, as before, stimulus weight (thin, average, heavy) as the within-subjects factor, and gender and BMI Group included as between-subjects factors. There was a significant interaction between stimulus weight and participant gender, $F(2,37) = 3.358$, $p = .040$, as depicted in Figure 8. Post-hoc t-tests demonstrated no significant differences in breakthrough rate between male and female participants at each stimulus weight. Female participants' corrected breakthrough rate for heavy stimuli was significantly less than zero, $t(27) = -2.266$, $p = .032$. This suggests that heavy bodies were masked more effectively for female participants than the stimulus size alone would predict.

The breakthrough rate ANCOVA also yielded a significant interaction between stimulus weight and BMI Group, $F(2,37) = 3.153$, $p = .048$ (see Figure 9). Post-hoc tests demonstrated no significant differences in the breakthrough rate of each stimulus weight between participants with low-healthy BMI and participants whose BMI placed them in the overweight or obese range. High BMI participants' corrected breakthrough rate for heavy stimuli was significantly less than zero, $t(6) = -3.090$, $p = .021$. For participants with overweight or obese-range BMI scores, heavy bodies were suppressed from conscious awareness more than would be expected based on their overall size.

An exploratory analysis was then conducted to investigate the impact of body satisfaction (as measured by BSQ) on body-specific breakthrough rates. Corrected breakthrough rates were computed by subtracting the proportion of trials with inverted primes with breakthrough from the proportion of upright prime trials with stimulus breakthrough. The resulting repeated measures ANCOVA, controlling for attentional control, included BSQ Group (2: high, low) and gender as between-subject factors and stimulus weight (3: thin, average, heavy) as the within-subject factor. This ANCOVA revealed a significant interaction between weight and BSQ group [$F(2,45) = 3.543$, $p = .033$]. The interaction between weight and BSQ group differed based on participant gender, $F(2,45) = 3.667$, $p = .029$.

To clarify the significant three-way interaction between participant gender, stimulus weight, and BSQ group, separate analyses were conducted on data from female participants and male participants. The ANCOVA exploring corrected breakthrough rate data for female participants yielded no significant main effects or interactions (all $p > .523$). When male participant data was examined in a similar fashion, there was a significant interaction between stimulus weight and body satisfaction group [$F(2,13) = 3.607$, $p = .040$]. Post-hoc tests corrected for multiple comparisons on the breakthrough rate data for male participants showed that male participants scoring high on body dissatisfaction experienced significantly less breakthrough of heavy bodies than thin and average bodies, when those rates were corrected for stimulus size (see Figure 10). There were no significant differences between breakthrough rates for male participants in the low BSQ group.

**Discussion**

Study 2 included inverted body stimuli to account for potential stimulus size effects in the previous finding where heavier bodies broke CFS suppression more readily than thin bodies. This result was replicated and then clarified by the inclusion of correction factors for each stimulus size. Specifically, for female participants and for participants who reported BMI in the overweight or obese range, heavy stimuli were suppressed from conscious awareness more often than their size would predict. Otherwise, there were no significant differences in the breakthrough rate of upright body stimuli compared to their inverted counterparts. Regarding anti-fat attitudes, in male participants, fat phobia and AFAS scores significantly predicted unconscious attention to thin body primes, after the potential impact of attentional control had been accounted for. There were no such effects in female participants.

Overall, that Study 2 replicated and clarified the significant effect of stimulus weight on breakthrough rate supports its consideration as a stable pattern. In contrast, differential attentional capture based on stimulus weight and individual difference measures was inconsistent across studies.

## General Discussion

The focus of this project was to test whether explicit anti-fat bias is reflected in unconscious spatial attention to bodies of different weights. The three experiments within the project also incidentally added to literature on individual differences in explicit anti-fat bias. An ancillary area of study focused on the trials where complete stimulus suppression was not achieved, and on which stimulus and participant characteristics predicted stimulus breakthrough rate. The primary hypothesis was not supported by the current research; heavy stimuli did not reliably bias unconscious attention based on self-reported anti-fat attitudes. In an exploration into the impact of individual differences on stimulus breakthrough rate, I found that individuals higher than the median body dissatisfaction score experienced significantly more breakthrough of thin and average-weight bodies than heavy bodies. In contrast, there were no significant differences between breakthrough rates based on weight for participants in the low body dissatisfaction group. Heavy bodies broke CFS suppression less readily than their size would predict, specifically for female participants and individuals with high BMI. These early results contribute to evidence suggesting that individual factors modify stimulus breakthrough under CFS.

## Explicit Weight Bias

The two measures selected to index anti-fat attitudes in participants were the Fat Phobia Scale – Short Form (FP; Bacon, Scheltema, & Robinson, 2001) and the Antifat Attitudes Scale (Crandall, 1994), both of which have been used in similar studies to the present investigation (see Watts & Cranney, 2009, for a review). FP and AFAS scores were significantly positively correlated across all three experiments. Neither AFAS nor FP differed significantly based on participant gender, relationship status, self-reported anxiety, or BMI (calculated based on self-reported height and weight). As expected based on the literature regarding body image and cultural expectations regarding body size, female participants reported significantly greater body dissatisfaction scores than male participants did, across all three studies. These body satisfaction scores were significantly correlated with anti-fat attitudes (AFAS), such that the more dissatisfied a participant was with their body, the higher their anti-fat attitude rating. Surprisingly, BSQ was not significantly correlated with anti-fat attitudes as measured by the Fat Phobia Scale. In addition, participant BMI was significantly positively correlated with BSQ and anxiety ratings.

## Differential Attention to Bodies

Attention to body stimuli was assessed based on participant accuracy on Gabor patch orientation judgments when the patches quickly followed presentation of the body prime on either side of the screen. Differences in orientation judgments based on stimulus weight were found in study 1A and in study 2. In the first experiment, participants scoring higher than the median AFAS score were more attentionally drawn to average and heavy bodies than participants low in AFAS scores were. The results from study 1A suggest that individual differences in anti-fat bias ratings can modify attention to bodies of different sizes. However, this finding was not replicated in study 1B or study 2, wherein the analogous analyses yielded no significant effects.

Study 2 was designed to tease apart the effect of stimulus size on unconscious body weight perception. In previous work, stimulus elongation successfully biased the speed of stimulus breakthrough during CFS suppression (Almeida et al., 2014). Following this finding, the aforementioned differences in attentional effect based on stimulus "weight" could be attributed to the fact that the visual system prioritizes the low-level elongation features in the thin and average body stimuli. To correct for this possibility, inverted bodies were included as stimuli in Study 2 and the body-specific attentional effect was computed as the difference in Gabor orientation accuracy between trials including the upright body of each weight and its inverted counterpart. Inverted bodies were chosen as stimuli that contain the same low-level visual components as upright bodies while disrupting privileged "body" object processing (see Prkachin, 2003; and Stein, Sterzer, & Peelen, 2012 for similar uses of inversion). Study 2 in the current project demonstrated no significant main effects or interactions and failed to replicate the significant finding in study 1A.

The hypothesis that individual differences in explicit anti-fat bias would bias the unconscious attentional effect was not supported. An exploratory analysis found that AFAS and FP scores significantly predicted attention to thin primes in male participants; however, this finding is preliminary and was unique to study 2 data. Evidence for differential attentional bias to bodies based on individual differences thus far in the literature is mixed. One study of female college students using the dot-probe paradigm showed a general attentional bias toward thin bodies. Surprisingly, the less satisfied participants were with their bodies and the greater their BMI, the less of a thin bias they displayed (Glauert, Rhodes, Fink, & Grammer, 2010). Another study using a dot-probe task to investigate the effect of body satisfaction and BMI on attentional bias to bodies of different sizes found the opposite; after controlling for participant BMI, body dissatisfaction significantly predicted attentional bias toward thin stimuli (Joseph et al., 2016).

**Differences in Breakthrough Rate**

Recent work indicates that, while continuous flash suppression is a relatively potent form of masking, it is not without its weaknesses. In fact, some studies focus on participant-level and stimulus-level features that moderate how effectively stimuli are masked. In these breaking-CFS (bCFS) paradigms, the outcome variable of interest is typically the amount of time a masked stimulus takes to break through to conscious awareness (e.g. Hung et al., 2016; Stein et al., 2014). Because attentional capture was the variable of interest in the current project, time to stimulus breakthrough was not measured. In experiments like those in the current project, trials where the stimulus of interest was not fully suppressed are commonly discarded (e.g. Jiang et al., 2006). Interestingly, for the experiments described here, the proportion of trials where participants experienced stimulus breakthrough differed based on stimulus weight. Larger bodies broke through to conscious awareness more than thin and average-weight bodies across all three experiments. Crucially, some of this effect persisted when stimulus size was accounted for. Further, participant gender and BMI significantly interacted with differences in breakthrough rate by stimulus weight. This finding provides support for the notion that the strength of CFS can differ based on relatively complex stimulus features. Investigating this pattern using a bCFS design or more fine-tuned measures of participant awareness of stimuli may provide further evidence to this end.

**Pattern of Findings**

According to recent work where the subjective sensitivity to masking procedures was better measured than in previous studies, prior claims regarding the strength of attentional bias to emotional faces during masking may have been overzealous (Hedger, Garner, & Adams, 2019). These experiments demonstrated the expected pattern of preferential attentional cueing by emotional faces presented supraliminally, but this effect was best explained by low-level properties rather than emotional content. When the faces were effectively masked using CFS, there was no such cueing effect. Furthermore, sensitivity analyses using d’ revealed that prime visibility predicted cueing strength. This work effectively provides evidence to suggest that the emotional nature of images may not bias visual attention after all and that this pattern is especially unlikely to occur in the absence of viewer awareness.

The pattern of findings in the three experiments herein suggest that what makes a stimulus likely to capture spatial attention may be distinct from the characteristics that afford it conscious perceptual processing initially. Stimulus-level features interacted with participant characteristics to bias the effectiveness of CFS.

While some prior clinical psychology attention research suggests that trait anxiety decreases the effectiveness of a mask on feared stimuli and fearful faces (e.g. MacLeod, Rutherford, Campbell, Ebsworthty, & Holker (2002), there is nothing to suggest that anxious individuals might be less susceptible to the effects of masking overall. Indeed, there were no consistent findings across the current studies that suggest an effect of trait anxiety symptoms on stimulus breakthrough or attentional capture.

**Limitations**

There are many concerns regarding the validity of self-report measures of individual differences. Self-reported weight, in particular, is less valid than other measures, likely related to body self-esteem. One study found that female college students tended to underreport their weight in a psychological experiment; heavier women tended to give less accurate estimates of their weight (Cash, Counts, Hangen, & Huffine, 1989). This is especially true when participants do not know that their weight will be verified by a researcher at the end of the experiment (Larsen, Ouwens, Engels, Eisinga, & van Strien, 2008). The decision to use participant-reported weight rather than requiring a researcher-administered weight in the current set of studies was made to reduce participant discomfort. While a scale was available for participant use during the self-report portion of the experiment, the experimenter never checked to determine whether participants used it or accurately reported their weight on the survey.

The restricted weight range of participants was another potential limitation of the present set of studies. Participants were drawn from a sample of undergraduate students at the University of Denver. Across all three studies, only 18.3% of all participants reported weights that placed them in the overweight or obese BMI range. The limited BMI range of participants makes drawing conclusions from BMI data difficult from this dataset.

The categories of underweight, average-weight, overweight, and obese that are demarcated by the medical establishment based on BMI are inconsistently related to the risk factors they intend to predict, such as type 2 diabetes and heart disease. Even if these medical weight categories could perfectly predict risk of disease, the average layperson could not be expected to apply them with fidelity in their everyday life.

While the stimuli used had been chosen based on the medical categories for different weight classes, they do not necessarily represent the diversity of bodies undergraduates at the University of Denver are exposed to on a daily basis. Weight is not evenly distributed in the population; therefore, bodies at the extreme ends of the weight spectrum (underweight and obese) are necessarily encountered less-frequently than those in the average range.

Participants in the current study were not asked to categorize the images they saw based on weight status, but they nonetheless fit into each participant's understanding of weight categories. Based on these issues, it is recommended that future studies investigate individual perception of which BMI range maps onto different weight categories. Whether stimuli are perceived as thin, average, or heavy may contribute to implicit biases.

Gender is another important factor to consider when assessing anti-fat attitudes. Many of the studies related to weight attitudes reviewed included only female participants. Future research should include an adequate number of male participants in order to come to conclusions regarding weight attitudes and how men perceive individuals of different weights. Related to that concern is the factor of relationship status. Unfortunately, relationship status and satisfaction in current relationships did not sufficiently vary to justify inclusion in this project, although the data were collected.

Continuous flash suppression may not be the best masking method to investigate high-level bias in unconscious visual processing; in fact, there is debate as to whether high-level processing of suppressed stimuli even occurs. For example, Stein and Peelen determined that lower-level visual features were sufficient to replicate a finding demonstrating perceptual differences between dominant and non-dominant facial features (2018). Future experiments may seek to clarify the breakthrough rate effects reported here by including other types of stimuli that share different features with human bodies to rule out a low-level feature explanation for the pattern of results.

Similarly, it may be a fallacy to consider that stimuli that broke through to conscious awareness can be considered "detected" stimuli, especially given that participants were only asked to indicate whether they perceived any difference between the noise patches on either side of the screen (and did not explicitly report that they perceived a body as having broken through). There may be a consequential difference between how the brain perceives images that broke through CFS and images that were never “suppressed.” Stein and colleagues accommodated this possibility by investigatting "fully suppressed" images compared to "partially suppressed" and "visible" primes (2012). Their investigation including varying degrees of mask effectiveness demonstrated that inverting faces and headless bodies increased the effective mask duration before the stimuli broke through to conscious awareness, compared to their upright counterparts. The results found by Stein and colleagues (2012) are surprising given that study 2 in the current project found that inverted bodies tend to break through to conscious awareness more often than upright bodies, in general.

Grading levels of awareness rather than using a binary judgment would afford researchers improved understanding of how masking by CFS functions and whether there are differences in the effectiveness of a CFS mask based on high-level stimulus properties (such as weight). The Perceptual Awareness Scale uses ratings from “no visual experience at all” to “a clear and complete visual experience,” thus increasing the sensitivity of subjective awareness judgments (Ramsoy & Overgaard, 2004). Use of this scale, or one like it, could be useful in future iterations of this work.

Future studies might include an additional block of trials after the main experiment where participants also reported the location of the body on each trial. The question would be asked after each trial rather than only when participants reported breakthrough to account for individual differences in responses to ambiguous perceptual stimuli. Querying on every trial also eliminates any participant motivation to indicate no stimulus breakthrough to save time. The body location question would ensure that participants were not unclear in the instructions or not paying attention to the task. Another method for assessing whether participants were paying attention and understood the task would be to include catch trials; those where there was a low-contrast body superimposed on the Mondrian “mask” presented to both eyes, and trials where only scrambled body images were presented. In experiment 3, presentation of upright and inverted trials was blocked, to increase the validity in comparisons between results from the upright trials in experiment 3 and the results from experiments 1 and 2. Unfortunately, this methodological choice could have contributed to potential confounds; when participants experienced stimulus breakthrough or attentional capture, it could have been because they developed a perceptual sensitivity to features specific to inverted bodies over the course of that block. Interleaving the upright trials with the inverted trials would have disrupted this potential practice effect. As such, it is recommended that future studies interleave experimental and within-subject control trials when methodology allows.

## Conclusions

Anti-fat bias is prevalent and has concerning consequences in terms of the behavioral discrimination of heavy individuals. Preconscious allocation of visual attention is a powerful factor that may be moderated by anti-fat bias. The present series of experiments did not consistently demonstrate an effect of stimulus weight on visual attention when stimuli were effectively masked from conscious awareness using CFS. Although there may not be a spatial attention bias toward people of certain body weights, or at least not one as measured here, it appears that individual factors, such as body satisfaction, gender, and BMI may play a role in whether those stimuli reach conscious awareness at all. Future research should utilize more detailed methods of assessing the subjective awareness of suppressed primes to reduce the potential impact response bias differences may have on the data. Finally, it will be important to understand whether differences in suppression breakthrough lead to real-world discriminatory behavior. Such a link could lead to the development of more effective interventions to reduce anti-fat bias.

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**Appendix**

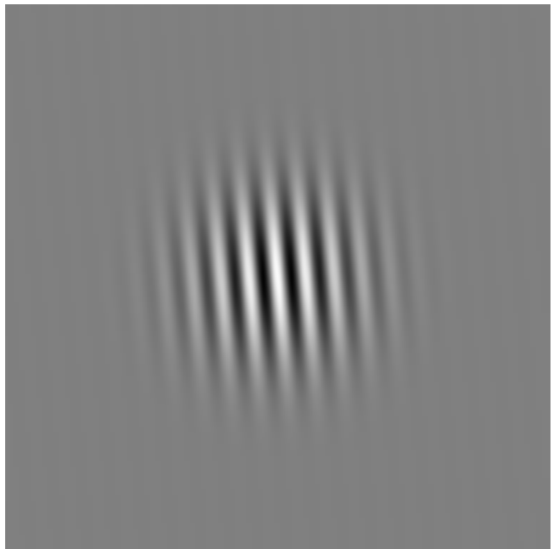

*Figure 1.* Example of a Gabor patch. In this stimulus, contrast is modulated along a Gaussian envelope, increasing and then decreasing from left to right so that the patch has no discernible edge. The spatial frequency is uniform across the image. The orientation of the lines is fixed; in this case, they are offset from vertical by 5°.

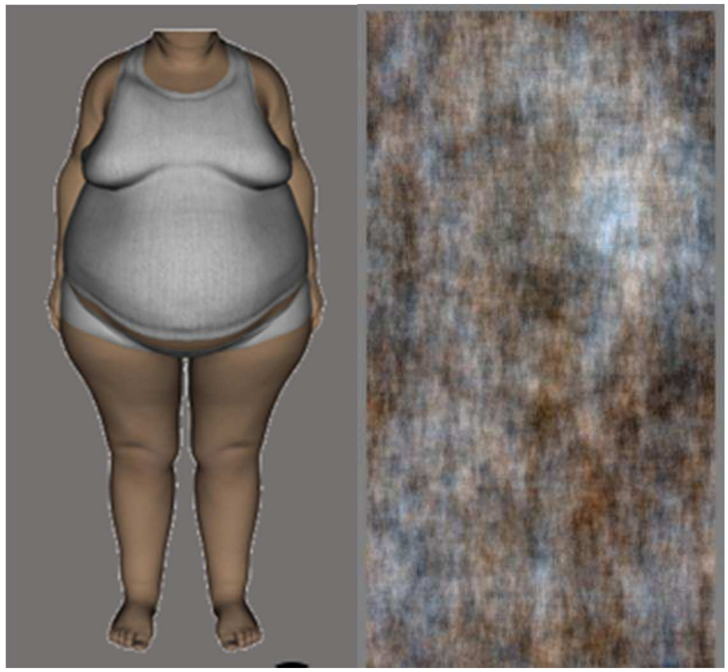

*Figure 2*. An example of a heavy, intact prime used in the current experiments and its scramble. The scrambled image was created as a control stimulus with equivalent low-level overall luminance as the intact prime but without a discernible form.

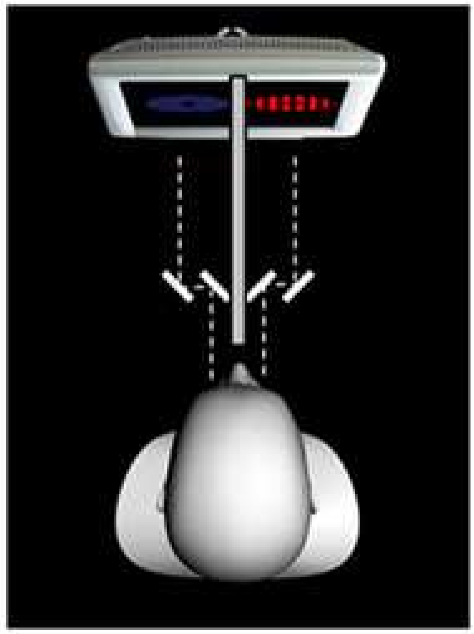

*Figure 3.* Typical binocular rivalry setup, with screen divider and mirror stereoscope. Adapted from "Reinforcement of perceptual inference: reward and punishment alter conscious visual perception during binocular rivalry," by G. Wilbertz, J. Slooten, and P. Sterzer 2014, *Frontiers in Psychology*, 5, p. 3. Copyright 2014 by Frontiers. Adapted with permission.

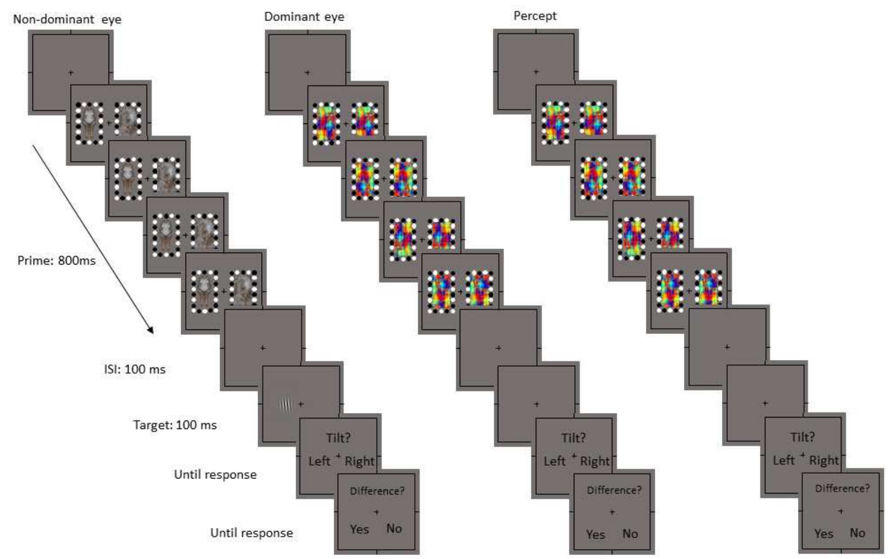


*Figure 4.* Trial procedure for prime-valid trials in Study 1A and Study 1B and an upright, prime-valid trial in Study 2.

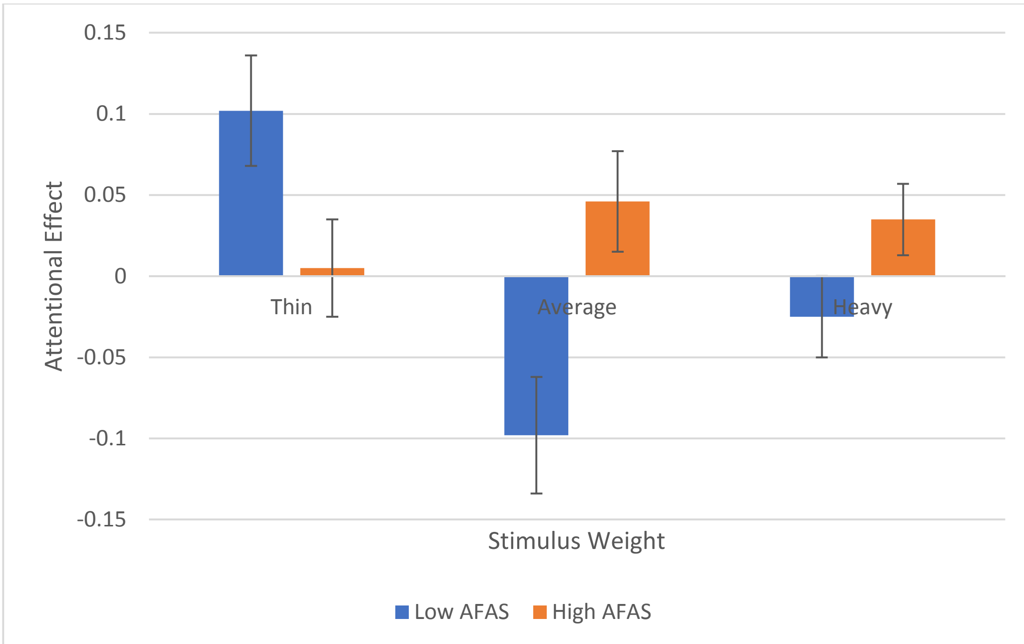


*Figure 5.* Study 1A: Stimulus weight x AFAS (antifat attitudes scale) Group interaction on attentional effect. Error bars represent 1SEM in either direction. This analysis revealed significant differences between attention to thin, average, and heavy bodies for those scoring low on AFAS. Attention to thin and average body primes differed significantly between participants low on AFAS and those reporting high anti-fat attitudes.

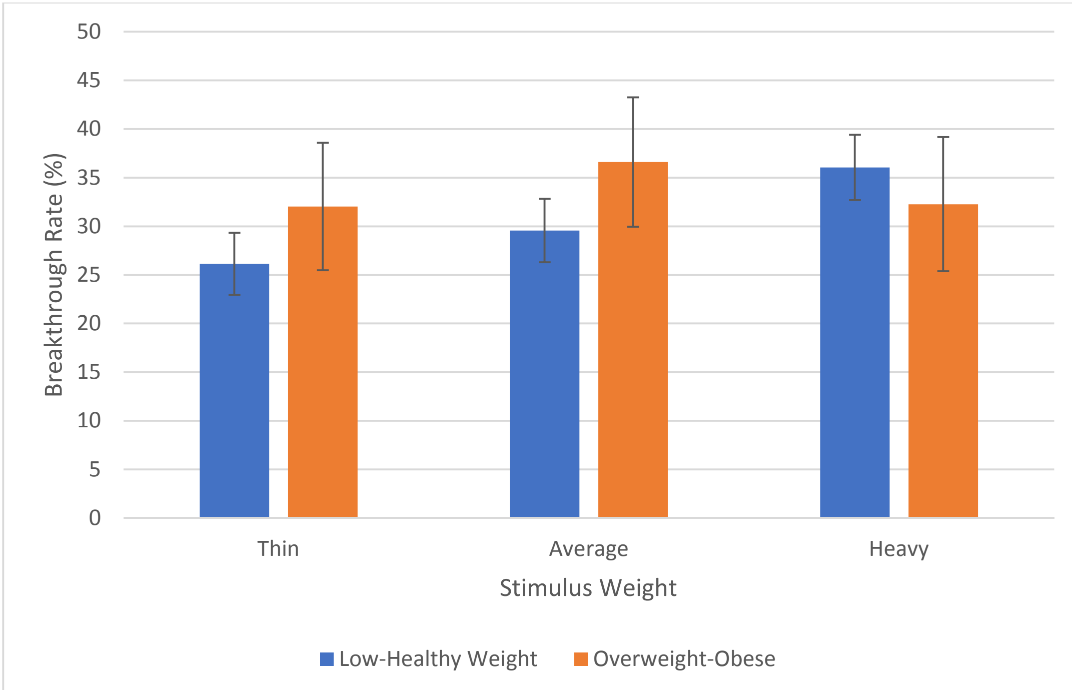


*Figure 6.* In Study 1A, stimulus weight x BMI Group Interaction on percentage of trials with stimulus breakthrough. Participants whose BMI placed them in the underweight or healthy categories detected significantly more heavy bodies than thin and average weight bodies. Participants with BMI in the overweight-obese range showed no significant difference in detection rate based on stimulus weight.

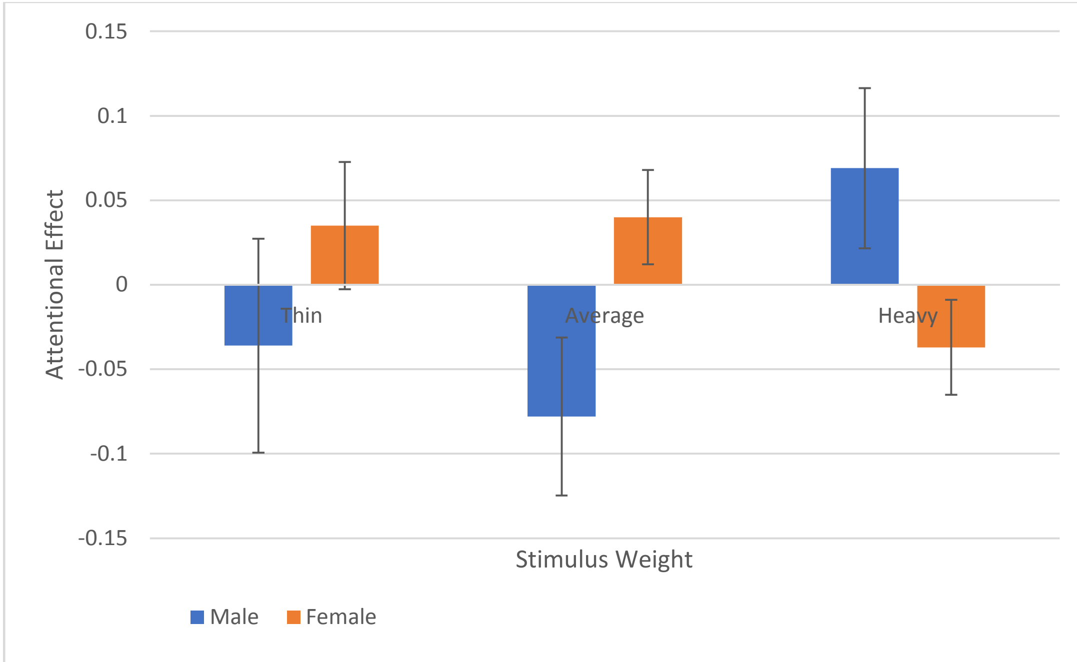


*Figure 7.* In Study 1B, stimulus weight significantly interacted with participant gender on attentional effect (AE) scores for trials where the stimuli were not successfully masked. Positive AE values indicate that attention was attracted to the stimulus, and negative AE values indicate attentional repulsion from the intact stimulus. Error bars represent 1SEM in either direction. Bonferroni-corrected post-hoc tests did not reveal any significant pairwise comparisons.

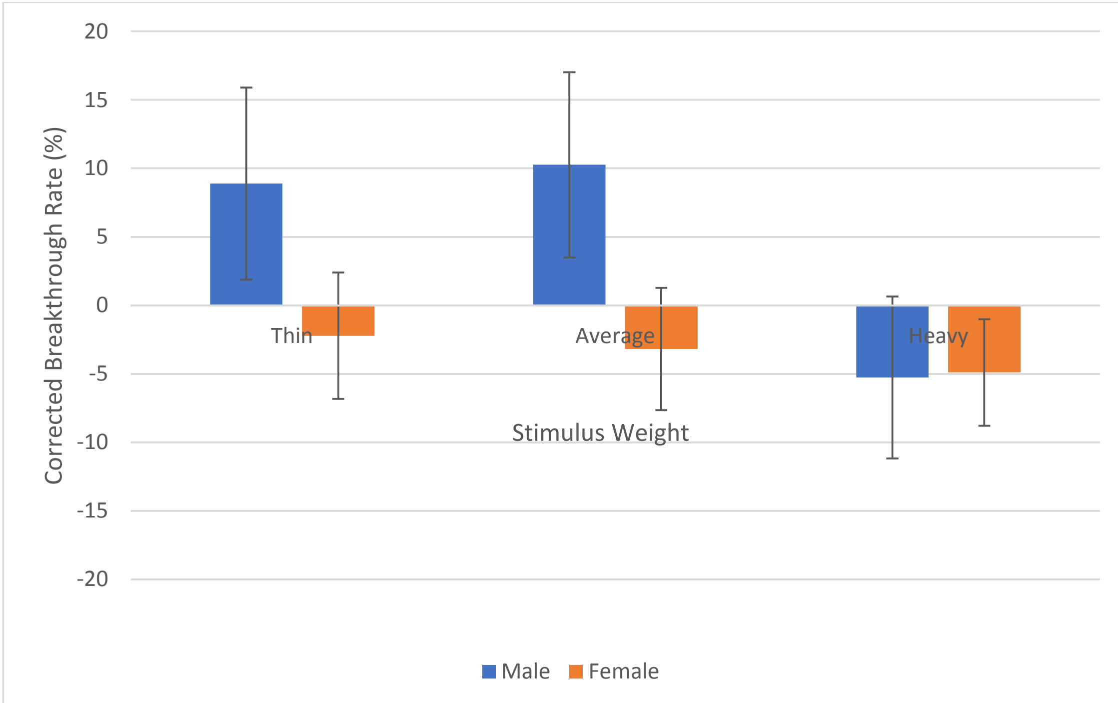


*Figure 8.* Study 2: Stimulus weight on breakthrough rate as a function of participant gender. Significantly positive values indicate more breakthrough of upright bodies than their inverted counterparts, and negative values indicate significantly less breakthrough than expected given the stimulus size. This analysis revealed significantly less breakthrough of upright heavy bodies compared to inverted heavy bodies in female participants.

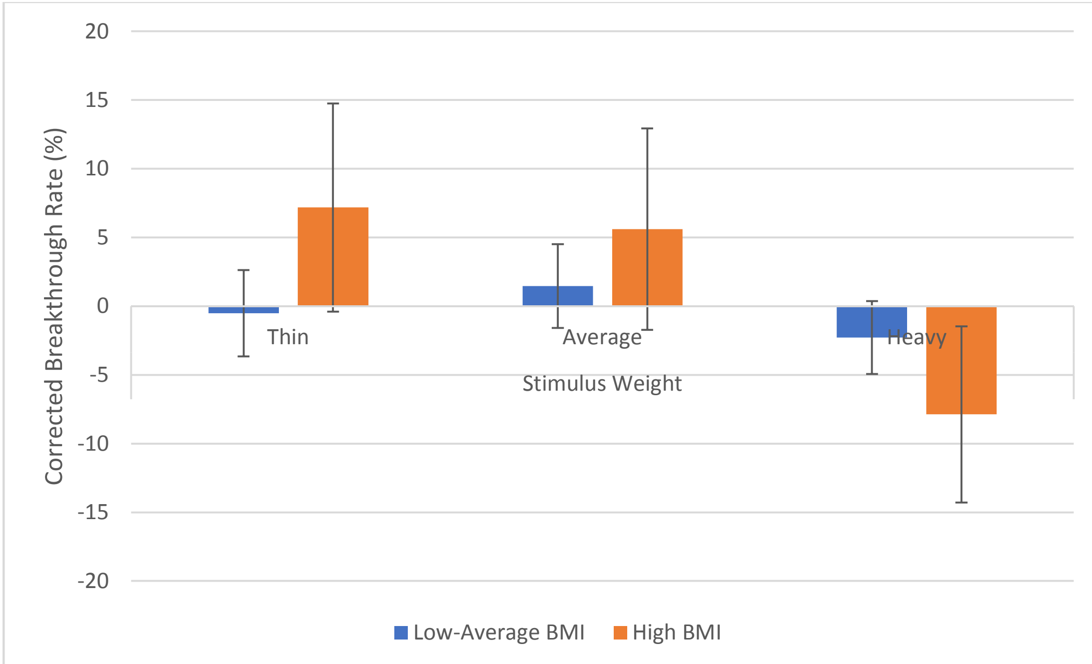


*Figure 9.* In Study 2, stimulus weight significantly interacted with BMI Group on breakthrough rates corrected for stimulus size. Error bars represent 1SEM in either direction. Post-hoc tests indicated that upright heavy stimuli were suppressed from conscious awareness more effectively for participants with overweight to obese-range BMI than the stimulus size would predict.

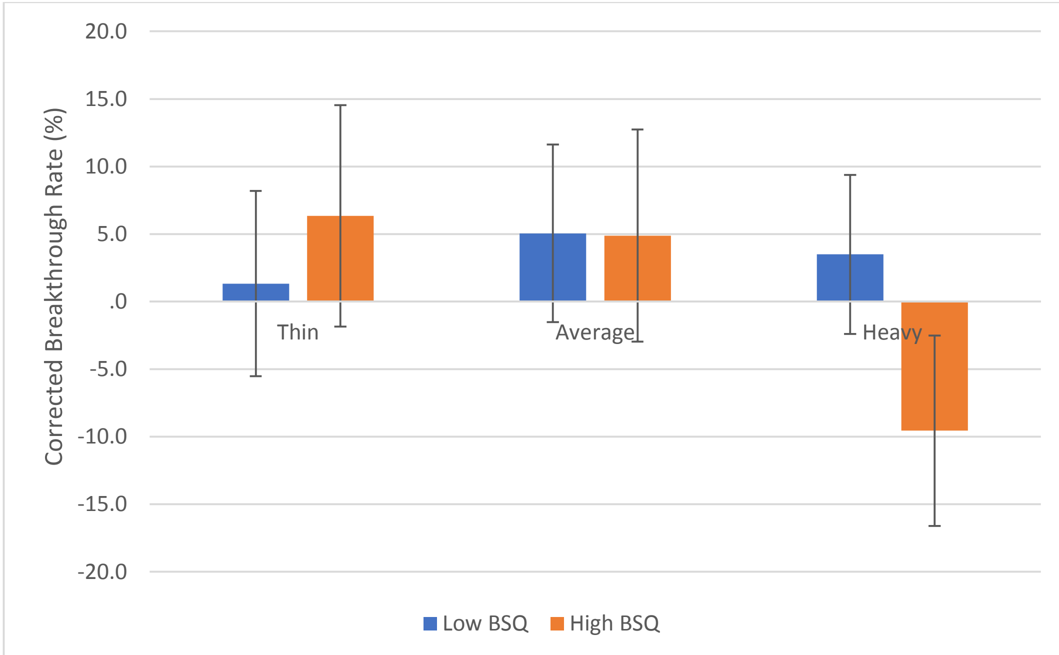


*Figure 10.* Study 2: Stimulus weight on breakthrough rate as a function of BSQ Group in male participants. Significantly positive values indicate more breakthrough of upright bodies than their inverted counterparts, and negative values indicate significantly less breakthrough than expected given the stimulus size. This analysis revealed significantly less breakthrough of upright heavy bodies compared to thin and average bodies in male participants reporting high body dissatisfaction.