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EXPLORING ILLUSIONS OF HEIGHT IN SUIT DESIGN

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EXPLORING ILLUSIONS OF HEIGHT IN SUIT DESIGN

DISSERTATION

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the College of Arts and Sciences at the University of Kentucky

By
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Lexington, Kentucky

Director: Dr. C. Melody Carswell, Professor of Psychology

Lexington, Kentucky

2018

ABSTRACT OF DISSERTATION

EXPLORING ILLUSIONS OF HEIGHT IN SUIT DESIGN

Objective: The goal of this research was to explore how the design of clothing, specifically the design of the suit, can create height illusions.
Background: Taller people enjoy many advantages, such as increased income and perceived attractiveness. These advantages motivate people to try to appear taller than they actually are, and clothing experts provide advice on how to accomplish this. However, there is little empirical evidence to validate the illusory effects clothing might have on overall height perception. The few studies that have explored illusions of body size created by clothing design have been limited in two important ways – the test stimuli have included unnatural body shapes and have failed to include naturalistic context (i.e., surrounding depth and size cues available in real scenes).
Method: In the first phase, participants (nonexperts in clothing design) provided suggestions for how to appear taller by changing clothes. In the second phase, participants 1) viewed photographs of a variety of targets wearing suit designs that are commonly believed to manipulate viewers' perceptions of height, 2) rated the targets on traits associated with height such as income and attractiveness, and 3) estimated the heights of these individuals. This study focused on the potential effects of suit color, specifically overall lightness (light vs. dark) and monochromaticity (monochromatic vs. lightness blocking). The effects of these designs were tested with and without contextual information by presenting targets within a natural streetscape or on a white background.
Results: In the first phase, we found that nonexperts provided similar suggestions as experts in clothing design, including those pertaining to monochromaticity and lightness. In the second phase, we found that estimates were more accurate with more contextual information, and that clothing *can* impact height estimations, where monochromatic outfits yielded taller height estimates, although other outfit comparisons did not have effects. Outfits overall did not impact ratings such as income and attractiveness, although estimated height did correlate with these same social attributes. In an exploration of the impact of contextual and target-specific cues other than clothing on height estimations, we found that height perception was potentially dependent on a variety of factors such as the target's race, location (indoors vs. outdoors), stance, and the presence of nearby people.

Scientific merit: This study increased our understanding of the conditions under which illusions of size in simple geometric stimuli generalize to the manipulation of size perception in real-world scenes.
Broader impact: A better understanding of biases in height perception is relevant to domains in which such estimates are used to identify individuals (e.g., criminal justice) as well as domains in which visual characteristics of individuals are associated with errors in judgments of performance-based merit. (e.g., personnel selection and promotion).

KEYWORDS: illusions, clothing design, height perception, psychophysical estimation, social perception

Michael Patrick Lee

4/16/2018
Date

EXPLORING ILLUSIONS OF HEIGHT IN SUIT DESIGN

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This dissertation is dedicated to Janet Faraci Lee, D.M.D.

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Exploring Illusions of Height in Suit Design

Chapter 1: Introduction

Taller people earn more money. Research suggests people who are 72 inches tall will earn $166,000 more over the course of a 30-year career than their peers who are seven inches shorter (Judge & Cable, 2004). Height has other associated benefits, such as increases in perceived attractiveness and leadership abilities. While altering physical height is easy, what if it were possible to create the *illusion* of greater height? With the suit being the historical epitome of formal businesswear (Reilly & Cosbey, 2008), it is not surprising that suit designers often suggest ways to create the illusion of increased height. These suggestions include manipulation of such features as the addition of vertical elements (e.g., adding pinstripes) and eliminating horizontal elements (e.g., avoiding clear color differentiation among suit components). Although people disseminate these "rules of thumb" widely, there is little evidence to support claims that they influence height perception. The purpose of this dissertation is to test the effects of such design manipulations on actual height perception.

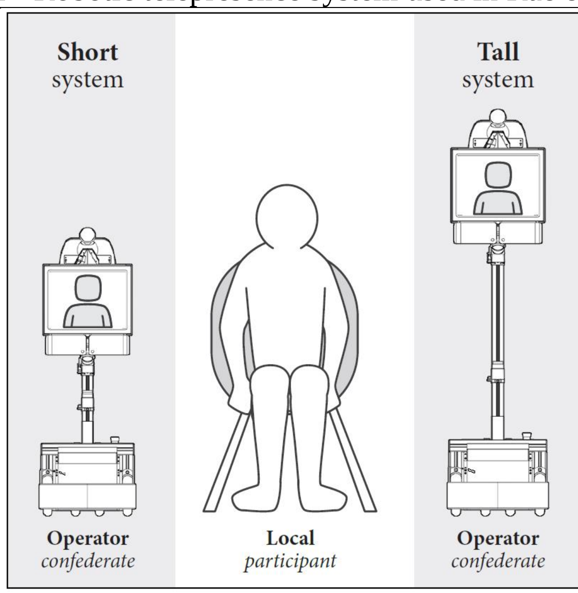
This dissertation is grounded in the multidisciplinary traditions of human factors psychology and user-centered design; it will draw from a variety of research approaches and application domains. After a review of some domains where height perception is particularly relevant, we will discuss common suggestions from suit experts whose intent is to help clients appear taller. We will then review common visual illusions that might plausibly explain purported height-enhancing effects. Although it has been tempting for designers to apply illusions from isolated research labs directly to size perception problems in domains as diverse as traffic safety, aviation safety, interior design, and fashion design, we will discuss the challenges involved in this translation of research from the lab to the field. For example, existing research applying well-known illusions to clothing design are limited in two important ways. First, there are important constraints in natural body shape variations that may provide inherent cues about height that may, in turn, constrain the impact superficial suit design elements can have on appearance of height. Second, people are usually viewed as part of complex scenes that provide many additional cues of distance and comparative size that can also constrain the apparent height of individuals. Based on this critical review of the literature, we will demonstrate methods for assessing the presence and magnitude of clothing-induced size illusions that can be used to explore not only the specific design heuristics tested here but should also prove useful in evaluating many other well-entrenched rules of clothing design.

Height in Social Domains

Social science researchers have often explored the implications of being tall. Domains such as business and politics frequently seem to be the focus of such research, and suits are often the normative attire in both domains. Increased height can lead to increases in income over time (Judge & Cable, 2004), perhaps because the rate at which someone receives promotions is positively correlated with height (Melamed & Bozionelos, 1992). These promotions, in turn, could stem from the fact that taller people are often attributed with positive traits such as better leadership abilities (Re et al., 2012) and increased attractiveness (Pierce, 1996). Such positive trait associations could also drive the findings that taller presidential candidates have received more popular votes, although they were not significantly more likely to win the actual election (Stulp, Buunk, Verhulst, & Pollet, 2013).

Factors other than actual physical height affect perceived height and associated social attributes. For example, nonverbal cues such as posture have been shown to influence perceptions of height along with perceptions of dominance (Marsh, Yu, Schechter, & Blair, 2009). Contrast illusions (i.e., comparisons to taller or shorter people) have also been found to influence perceptions of height and associated social perceptions such as attractiveness and dominance (Ludwig & Pollet, 2014). Perceived dominance can even be affected by the height of a robotic telepresence system, (Rae, Takayama, & Mutlu, 2013). For example, if the user controlling the robot is in a leadership position over the user viewing the robot, the leader will be perceived as less persuasive the shorter the robot (Figure 1.1).

Figure 1.1 - Robotic telepresence system used in Rae et al. (2013)



Height and clothing are also influential in the criminal justice system, particularly in eye-witness descriptions of perpetrators. However, the accuracy of physical descriptors is suspect (Meissner, Sporer, & Schooler, 2013). Even when eyewitnesses accurately recall height information, they are not more likely to accurately identify the perpetrator (Cutler, Penrod, & Martens, 1987). Clothing and size perception are also relevant in the court room. Offenders and suspects wearing black clothing are more likely to be perceived as guilty, and they are viewed as more aggressive than those wearing other colors (Vrij, 1997). However, black clothing is often said to create slimming illusions (Raes, 2008), which could motivate obese defendants to wear black clothing to combat weight biases associated with perceptions of guilt (Schvey, Puhl, Levandoski, & Brownell, 2013). Finally, Bodenhorn, Moehling, & Price (2012) argue that the finding that prisoners are on average shorter than the general population may be due to shorter individuals receiving fewer legitimate opportunities due to negative stereotypes.

Appearing Taller: Advice from Suit Experts

Given the benefits associated with increased height, it is no surprise that many people wish they were taller. Clothing serves as a way to transform an *actual* self into an *ideal* self, and there is an extensive body of academic research surrounding this complex relationship between clothing and the "self" in all its forms (Miller, 1997). A brief search online will yield many books or articles on "how to dress taller," many of which focus on suit or suit-like attire. For this review, we compiled advice and suggestions from four books and eight internet sources (Table 1.1). Note that the purpose here is not to review the academic research on how to create the illusion of height, but rather to identify the actual advice that clothing experts and fashion critics give to those in the general population who want to change their body shape and size. Portions of these sources are redundant; for example, one internet source includes an interview with the author of one of the books. Because the purpose of this study is to explore the effects of *illusions*, we omitted suggestions relating to drastic changes to the silhouette, such as wearing shoes with thicker soles or a jacket with built-up shoulders. Similarly, we also omitted suggestions in the vein of "get a suit that fits" or "have a good tailor" due to their lack of specificity.

We found two general heuristics for creating illusions of increased height: 1) reduce features, especially horizontal lines; 2) lengthen proportions, especially legs. Table 1.1 outlines some specific suggestions.

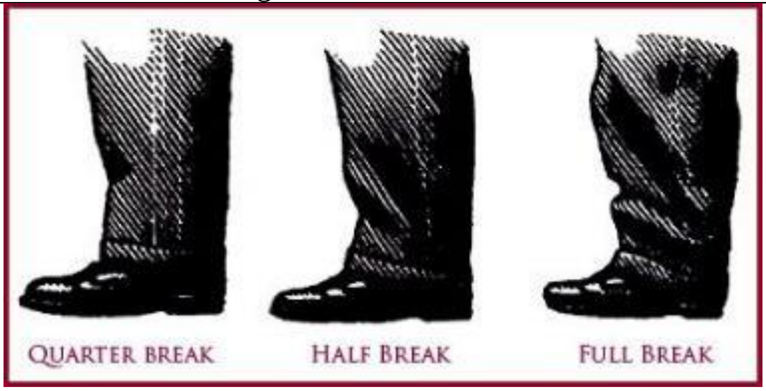
Table 1.1 - Examples of advice from suit experts

Reduce Features (especially horizontal lines)	Lengthen Proportions (especially legs)
• Monochromatic (especially if dark)	• Shorter jacket
• Avoid belts (or keep thin, low contrast)	• Raise pants waist
• Vertical patterns > horizontal patterns	• Button jacket at waist (just above navel)
• Minimize accessories	• High lapel notches and gorge
• No vests	• Long lapel rolls (deep V)
• No pocket flaps (or ticket pockets)	• If have accessories, place them high
• No jacket vents	• Shorter trouser rise
• No pant cuffs	
• Hide socks, have them match pants	

Sources
Books: Boyer, 1990; Esquire, 2009; Flusser, 2002; Raes, 2008
Internet: Centeno, 2011a, 2011b; Christian, 2015; Gerstein, 2015; Guy, 2011; Nicholson, 2013, 2015; Thorn, 2011

The "break" in the pant legs, or the way that pants lay on shoes (Figure 1.2), illustrates a potential dissociation between these two heuristics. Minimizing the break will reduce horizontal lines, much like avoiding pant cuffs. However, a fuller break requires more fabric, which inherently creates longer pant legs, and may help to ensure that the pants appear to be the appropriate size. Another interesting note is that two sources (Centeno, 2011b; Christian, 2015) suggested that if one does *not* wear monochromatic clothing then to wear a darker color on the bottom and a lighter color on top. This difference in lightness parallels a common heuristic used in interior design, which we will discuss in an upcoming section.

Figure 1.2 - Pant breaks



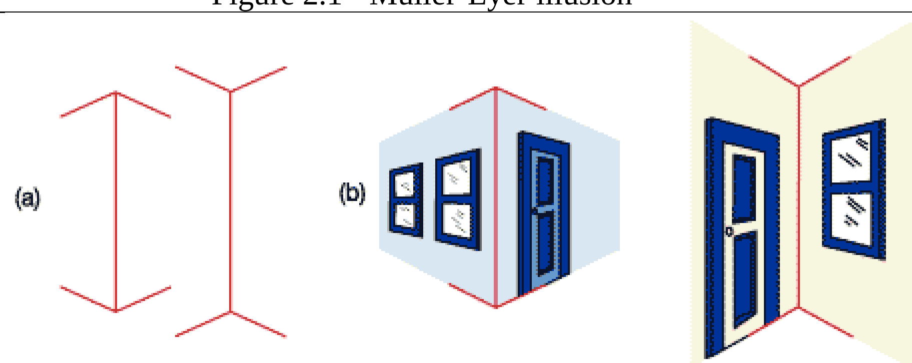
Chapter 2: Illusions

Although suit experts provide guidance on how suit designs can create illusions of increased height, they do not utilize the data-driven approaches of traditional perceptual illusion research. The study of the erroneous perception of visual stimuli has helped researchers understand how humans process size information since the 1800s (reviews: Gillam, 1980; Lindauer, 1973; Ninio, 2014). Although the majority of research surrounding metric illusions have focused on simple stimuli such as lines and shapes, some researchers have explored illusions in a variety of applied domains, including safety-critical applications such as driving and in applications where safety is less critical such as interior design and clothing design. Before turning to illusions manipulated in more realistic contexts, we will discuss the classic illusions of simple, geometric stimuli that are likely to be most relevant to the perception of human height.

Illusions with Simple Stimuli

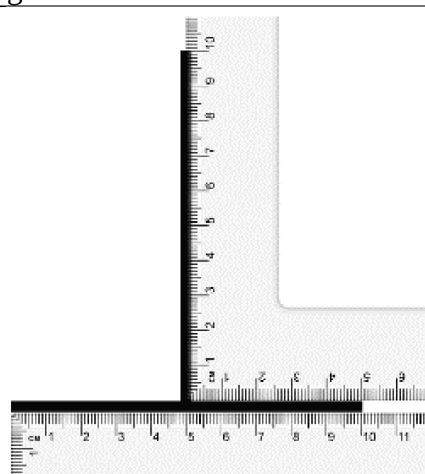
When looking at how suit design might create the illusion of greater height, the illusions that create shrinkage or expansion (i.e., metric illusions) are particularly relevant, even when using simple stimuli. The Müller-Lyer illusion (Figure 2.1a) is one of the most researched illusions in experimental psychology, having been found across cultures (Davis & Carlson, 1970) and even across species (Pepperberg, Vicinay, & Cavanagh, 2008). The Müller-Lyer illusion creates the appearance that a line with fins facing outward will appear longer than a line of equal length with fins facing inward. A common explanation for the Müller-Lyer illusion is that the two-dimensional stimulus is perceived in three dimensions, where the fins provide the only cues of depth (Gregory, 1968). As demonstrated in Figure 2.1b, the line with inward facing fins appears to be closer to the viewer than the line with outward facing fins. While the lines are the same length in two dimensions, the implied depth allows for the lines to be perceived as different distances from the viewer and thus interpreted as different sizes, due to "inappropriate size constancy" inferences. Researchers (e.g., Dragoi & Lockhead, 1999) describe geometric illusions of this sort as "context-induced," whereby limited contextual cues force inaccurate metric perceptions. However, a computational explanation of the Müller-Lyer illusion argues that it is the result of mis-locating the ends of each line (i.e., errors in centroid extraction), where outward facing fins cause the ends of the line to be estimated as farther from the center, rather than the fins being interpreted more globally as depth information (Bulatov, Bulatova, Surkys, & Mickienė, 2015; Morgan, Hole, & Glennerster, 1990).

Figure 2.1 - Müller-Lyer illusion



The “family” of illusions that are created by dividing a space into subsections parallels the “reduce features” advice provided by suit experts. The inverted-T illusion (a.k.a., vertical-horizontal illusion; Figure 2.2), is often discussed as the vertical segment appearing longer than the horizontal segment simply due to its orientation. However, research has shown that the inverted-T illusion is actually based in the fact that the vertical segment bisects the horizontal segment (Kunnapas, 1955). Attentional saccades are disrupted along the horizontal line, but they continue uninterrupted along the vertical line to create the illusion of length, a finding supported by eye-tracking studies (Chouinard, Peel, & Landry, 2017). Suits appear to reproduce bisection illusions by reducing subsections through monochromatic designs. That is, the designer increases the illusion of height by avoiding disruptions in the vertical dimension with designs such as a change of color or the addition of a salient belt.

Figure 2.2 – Inverted-T illusion



Although a single division of a space will decrease perceived length, multiple subdivisions will increase the perceived length as seen in the Helmholtz illusion (Figure 2.3) and the Oppel-Kundt illusion (Figure 2.4). In these “filled extent” illusions, expansion occurs in the direction of division. In the Helmholtz illusion, horizontal lines divide the vertical dimension to make the perimeter box appear taller, and in the Oppel-Kundt illusion, the side with multiple divisions in the horizontal dimension appears longer than the side without any divisions at all. Noguchi, Hilz, & Rentschler (1990) explored variations on the Oppel-Kundt illusion that seem to parallel some of the advice provided by suit experts. While the illusion is typically presented with equally spaced items, Noguchi et al. (1990) found that unequal spacing will still yield overestimations, though not as large in magnitude. In clothing design, homogenously spaced patterns are practically impossible to create, given the contours of the body especially in motion. However, the advice to favor vertically-orientated patterns (e.g., pinstripes) contradicts these simple shape illusions by creating multiple subsections that should increase perceived width, not perceived height. We will discuss research regarding the illusory effects of stripe direction in clothing design in a later section.

Figure 2.3 – Helmholtz illusion

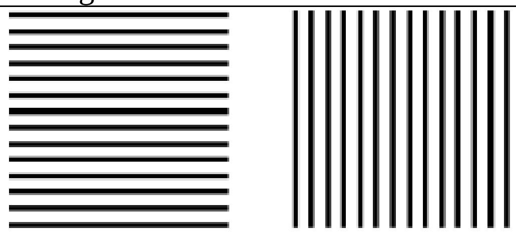


Figure 2.4 - Oppel-Kundt illusion

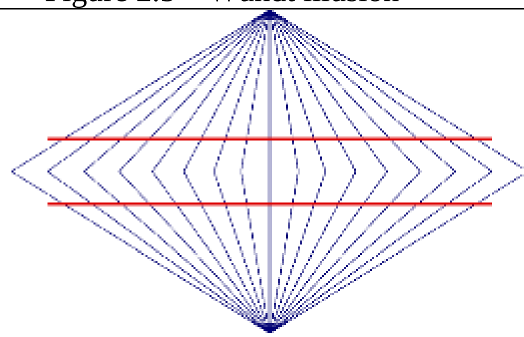
Color in Illusions

In the review of common suggestions by clothing experts regarding how to look taller, the most common suggestion was that a solid, monochromatic appearance will create the illusion of increased height, especially with darker colors. However, research from the information processing tradition suggests that size and lightness are processed as separable dimensions (Handel & Imai, 1972), meaning that an object will appear the same size, regardless its lightness. Nevertheless, research surrounding the irradiation illusion suggests that light, white objects appear larger than equally-sized dark, black objects (Westheimer, 2008). A neurophysiological explanation for the irradiation illusion is in the asymmetrical nature of neural pathways for contrasting light objects against a dark background compared to the reversed polarity (dark on a light background; Kremkow et al., 2014). Another explanation of the irradiation illusion derives from depth perception, where lighter objects are perceived as being farther away (Coules, 1955), which creates inappropriate size-depth constancy. We will discuss the link between size and depth more thoroughly when we discuss the importance of contextual cues in helping observers more accurately estimate the distance of objects.

Illusions in Applied Settings

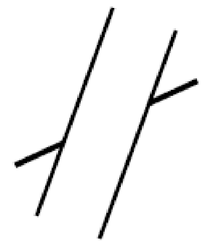
While metric illusions exist in simple stimuli, human factors researchers have explored how visual illusions might also affect perception and performance in application. Depending on the specific domain, illusions can lead to errors with dire consequences, such as the illusions of size or distance that pilots can encounter when making a night landing (Gibb, Ercoline, & Scharff, 2011). Researchers have also discovered that some illusions that occur when driving can have serious consequences. For example, a car's design can make drivers overestimate intervehicular distances. A smaller-than-average car will appear farther away (Eberts & MacMillan, 1985), as will cars with taillights that are closer together (Cavallo, Colomb, & Dore, 2001) or higher on the car than average (Buchner, Brandt, Bell, & Weise, 2006). These studies call attention to misinterpretations that have severely negative outcomes (i.e., car crashes), but designers may also intentionally create illusions to yield positive results. For example, a pattern designed on the road to resemble the Wundt illusion where parallel lines appear to bend inward (Figure 2.5) will make drivers drive slower, supposedly because the road appears narrower (Shinar, Rockwell, & Malecki, 1980).

Figure 2.5 – Wundt illusion



Given the high stakes in flying and driving, understanding illusions in those cases is certainly important. However, illusions also exist in designs where safety is less critical. For example, illusions affect the interpretation of data visualization graphs (Kosslyn, 2006). Specifically, the Poggendorf illusion (Figure 2.6), where oblique lines appear to be offset, creates the illusion of a flatter line graph (Poulton, 1985). Relatedly, the Müller-Lyer illusion can make the user of a computer overestimate the distance between a cursor and a target on a display (Phillips, Triggs, & Meehan, 2003) and overestimate the distance between two points on a map (Gillan, Schmidt, & Hanowski, 1999).

Figure 2.6 – Poggendorf illusion



Examples from graph and interaction design demonstrate how illusions can negatively affect performance, but there are also cases where people design illusions to have positive effects in non-safety-critical contexts. An example of an intentional illusion can be seen in interior design (Oberfeld & Hecht, 2011; Oberfeld, Hecht, & Gamer, 2010; von Castell, Hecht, & Oberfeld, 2017), where a common design heuristic is that a room will appear larger depending on the combinations of ceiling color, wall color, and floor color. Specifically, a room will appear taller if the ceiling is lighter than the walls (i.e., a contrast effect). Both experts and nonexperts endorse this contrast heuristic. However, the assumed relation between lightness contrast and room height is erroneous. Perceptual studies showed that contrasting shades do *not* influence perceived room height. Rather, there is an overall lightness effect. A room will appear taller if both the ceiling and walls are a light shade. These results are similar to findings from a small study conducted by Ramkumar & Bennett (1979), where they built small-scale models to test size perceptions. In their model, they placed a human figurine in a room and manipulated the color of the wall behind the figure. When the wall was lighter, observers overestimated the distance between the figure and the wall, and they overestimated the height of the figure as well. Both interior design and clothing design experts tout the contrast heuristic that higher portions should be lighter.

Illusions in Clothing Design

A few studies have explored the application of simple metric illusions to clothing design. Horn & Gurel (1981) and Sethumadhavan (2012) discussed simple illusions in relation to clothing, but they did not support their assertions with data. Additionally, Ridgway, Parsons, & Sohn (2016) explored clothing illusions as they relate to body image, although they only utilized qualitative semi-structured interviews, which provide no information about the actual magnitude of potential illusions.

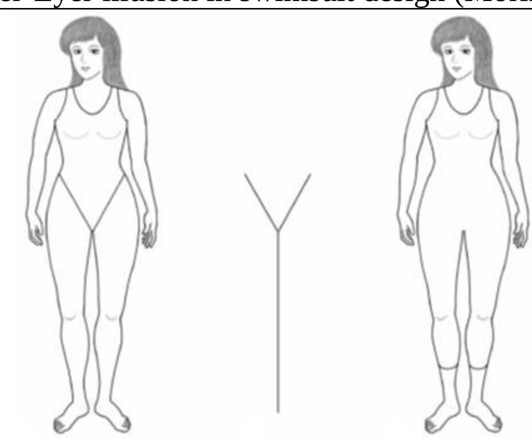
Other researchers *have* collected data to support their conclusions about the direction and magnitude of clothing illusions. For example, Bian et al. (2013) found that people in lighter clothing appeared larger overall (i.e., in height and width) than those in darker clothing. Two specific simple illusions in clothing have been explored independent of color: the Helmholtz illusion and the Müller-Lyer illusion. The Helmholtz illusion, if found in clothing, would contradict the common design guidance that vertical stripes will make the body appear taller and thinner than horizontal stripes. Thompson & Mikellidou (2011) found evidence of the Helmholtz illusion – horizontal lines on a dress created the illusion of increased height while vertical lines increased perceived width. However, Ashida, Kuraguchi, & Miyoshi (2013) found that the illusory effect in the horizontal dimension varies depending on the thinness of the figure, in that horizontal lines only created a thinning illusion when the person is already thin (Figure 2.7). While Ashida et al. (2013) did not collect height judgments, Chen & Peng (2013) did, finding that horizontal stripes made tall targets appear shorter while vertical stripes made short targets appear taller.

We would like to note that Chen & Peng (2013) used photographs of people wearing loose-fitting clothing, while the other studies used drawings or computer renderings to show figures in tight-fitting outfits. Similarly, Bennett, Lee, Peterson, & Yoon (1978) conducted a small study where students sitting in lecture halls viewed two confederates in different outfits. They found similar height illusions – vertical stripes made a target person appear taller and horizontal stripes made the target appear shorter – although overall accuracy was so high that the researchers deemed the small effect size "inappreciable." In these studies applying the Helmholtz illusion to clothing design, the overall trend in the results seems to be in opposition to the predictions derived from the Helmholtz illusion as studied in the context of simple geometric stimuli. While the Helmholtz illusion suggests that horizontal stripes will make a person appear taller, the results from clothing studies suggest that vertical stripes will instead increase apparent height. In relation to suit design, vertical striping is common in the form of pinstripes, and experts recommend pinstripe patterns over a horizontally oriented pattern, although a monochromatic appearance may be recommended over the use of any pattern at all.

Figure 2.7 - Helmholtz illusion in clothing patterns (Ashida et al., 2013)

It is not surprising given the amount of research devoted to the Müller-Lyer illusion in the basic psychophysical literature, that there have been attempts to exploit the illusion in clothing design. In one such study, Morikawa (2003) explored how the lines on some swimsuit designs create a fin-like pattern when the leg of the swimsuit goes up and over the hips (Figure 2.8). Participants perceived leg length (i.e., crotch-to-floor length) to be longer with the hip-cut design than when the swimsuit extended down the leg and ended at the lower calf, thus removing the outward fins over the hips. Rather than it actually being the upward fin that causes the elongation, however, it might be that the other condition shortens the legs with the hems adding horizontal segmentations to the swimsuit. The latter explanation is similar to the argument used by designers when arguing against the use of cuffs on pants. A limitation of this study is that the researchers did not test for an effect on overall height. While one design created the illusion of longer legs, the design may have also created the illusion of a shorter torso, negating any illusion of overall height. As we will discuss in the following section, people are very sensitive to changes in relative sizes of different body parts. Perhaps an apparent lengthening of one portion, such as the legs, leads to a perception of an overall body "shape" that is consistent with the shapes of those with overall taller stature.

Figure 2.8 - Müller-Lyer illusion in swimsuit design (Morikawa, 2003)



The Advice of Experts vs. The Data of Previous Research

Before moving on to methodological considerations, we will compare the advice of suit experts relative to the data from previous research, both focusing on illusions in clothing and in abstract geometric illusions. For lightness, experts suggest wearing darker colors to appear taller, but this contradicts the research. Using abstract stimuli, lighter objects appear larger, and someone is wearing lighter colors produces a similar effect. The story is not so clear when focusing on dividing subsections, or reducing interruptions for attentional saccades. For example, suit experts suggest wearing vertical stripes and avoiding horizontal stripes to appear taller, while the Helmholtz illusion shows that a box of horizontal stripes appears taller than one of vertical stripes, and the data from studies exploring this phenomenon provides mixed findings. However, the general trend appears to be that vertical stripes make someone appear taller. At a more macro level, experts suggest reducing features and dressing monochromatically in the name of reducing saccadic interruption, which aligns with abstract geometric illusions such as the inverted-T illusion. Unfortunately, there does not appear to be any data on the illusory effects this type of visual division has on perceived height of individuals due to the clothing they wear.

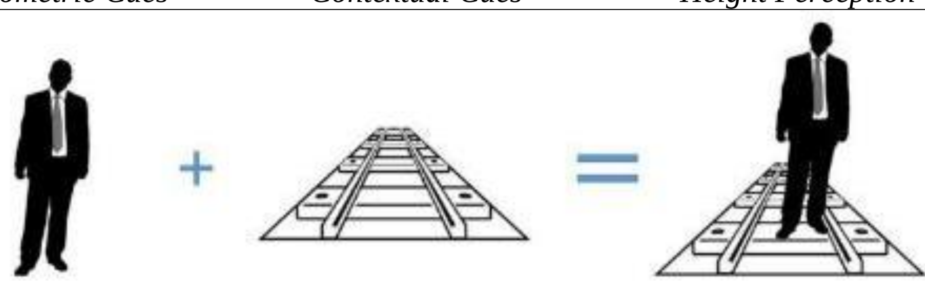
The discrepancies among these three categories (expert advice, abstract illusions data, and clothing illusions data) may highlight interesting comparisons in this type of research. For example, drawing an analogy from classic information processing models, we can describe the advice from experts as “top-down,” while the data from studies on abstract illusions are more “bottom-up.” Unfortunately, there is great variability among the studies focusing on clothing illusions, all of which have some degree of methodological issues that may contribute to the inconsistencies among their results, but also restrict their generalizability beyond the scope of the study to real world applications to explore real world effects. The following chapter will discuss these limitations.

Chapter 3: Limitations of Previous Research

In considering previous research exploring clothing illusions, concerns arise from the lack of explicit control of cues other than clothing design that may guide peoples' estimations of height. These perceptual cues can divide into two categories: 1) anthropometric cues and 2) contextual cues. Anthropometric cues relate to how we process and perceive the metric properties and proportions of the human form (i.e., complex properties that define "body shape") and may influence perceptions of height independent of the surroundings. On the other hand, contextual cues relate to how we perceive size and distance of a target in an environment rich with cues of size and distance of nearby objects, cues that may influence perceptions of height independent of a person's body shape or clothes. In Figure 3.1, anthropometric cues would relate to anything within the human's silhouette such as head size relative to overall body size, and the contextual cues would be anything outside of the silhouette such as the railroad tracks. As we will discuss in the subsequent sections, anthropometric cues are often erroneously manipulated leading to distorted or unrealistic bodies in experiments on clothing-induced illusions, while researchers often attempt to remove contextual cues altogether.

Figure 3.1 – Anthropometric cues and contextual cues

Anthropometric Cues + *Contextual Cues* = *Height Perception*



Anthropometric Cues

Anthropometry is the field of research pertaining to the metric properties of the human body (Dreyfuss, 1955; Tilley & Associates, 2001). Humans, even as infants, are sensitive to variations in these metric properties because differences in metric properties help to differentiate one person from another (Linkenauger et al., 2015; in infants: Zieber, Kangas, Hock, & Bhatt, 2015). Because of this sensitivity to body structure dimensions, research that manipulates body size and shape must be careful not to create stimulus bodies that fall outside the range of normal relationships between the dimensions of different body parts. At an extreme, the use of stimuli that fall outside the bounds of "normal" shapes may cause observers to treat the stimuli as abstract objects and fail to utilize inherent correlations between height and body shape in making their height estimates. Unfortunately, previous research into clothing illusions have not always been particularly careful to maintain natural body shapes in their stimulus manipulations. For example, Ashida et al. (2013) manipulated body size by stretching the image when exploring the Helmholtz illusion in clothing (Figure 2.7). Given the configural nature with which humans perceive body structure, this stretching affects the perceptions of the body as a whole, not just on the dimension intended.

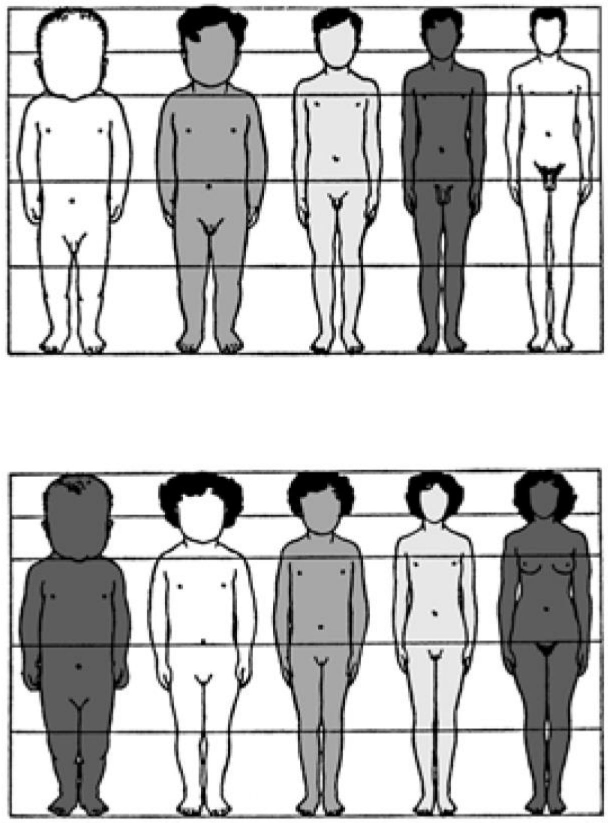
The importance of carefully controlling the metric properties, proportions, and ratios of a body and its parts is highlighted by how differences in these elements provide information. Attractiveness judgments are affected by variations in metric properties, such as waist-hip ratio (Singh, Dixson, Jessop, Morgan, & Dixson, 2010), leg-body ratio (Kiire, 2016), and waist-chest ratio (Maisey, Vale, Cornelissen, & Tovee, 1999). Variations in metric properties also serve as cues of an individual's sex (waist-hip ratio:

Johnson & Tassinary, 2005), race (femur-body ratio: Feldesman & Fountain, 1996), health (leg-body ratio: Bogin & Varela-Silva, 2010), or age (head-body ratio: Alley, 1983).

Metric properties that correlate with overall height are particularly relevant to this dissertation. In artistic and animation domains, head height serves as a standard "rule of thumb" for a character's designed height, where an adult should be about eight heads tall (Sloan, 2015). However, this rule of thumb fails in certain important situations, such as creating people of different ages. Indeed, both leg length and head size are metric proportions that change relative to body size with age (Figure 3.2). For example, as reviewed by Bogin & Varela-Silva (2010), older people have proportionally smaller heads and proportionally longer legs. Leg-body ratio has been shown to vary depending on height, such that taller people have proportionally longer tibia (Duyar & Pelin, 2003). Head-body ratio might also serve as a cue of overall height, such that bodies with proportionally larger heads could be perceived as less mature and, thusly, shorter. Still, these proportions can serve as cues of an individual's age and height independent of their surroundings.

Figure 3.2 - Body structure proportions through development

From Bogin & Varela-Silva (2010): "Changes in body proportion during human growth after birth. Ages for each profile are, from left to right, newborn, 2 years, 6 years, 12 years, 25 years. The hair style and shading of the cartoon silhouettes are for artistic purposes and is not meant to imply any ethnic, eco-geographical, or "racial" phenotypic characteristics of the human species"



However, as demonstrated by the changes in head and leg size with age, an increase in one metric property does not mean that the rest of the body increases isomorphically. In researching contrast effects, Ludwig & Pollet (2014) manipulated body size by proportionally increasing the body in all directions Figure 3.6. They cite these uniform size increases as a limitation as such proportions are not always realistic. In fact, a uniform increase in body proportions may be interpreted as a person being closer to the observer rather than inherently larger. However, similar assumptions of proportional increases of size in body parts have been the driving force in standardized clothing-size practices dating back to military uniforms in the 1800s (Boyer, 1990; Gupta

& Zakaria, 2014). To simplify manufacturing, clothing may be designed to correlate to different body proportions, such as an arm length being predicted based on a specific chest circumference. While such predictions may be relatively accurate in a very homogeneous population (e.g., all healthy males of a specific age range, often within a limited height range), after-purchase clothing alterations in the broader community demonstrate the variability inherent in comparisons of one metric property to others. Human factors researchers have explored and discussed the inaccuracies of such correlational approaches and have made suggestions about how to more effectively measure and model the metric properties of users (Peacock, 2003; Robinette & Veitch, 2016).

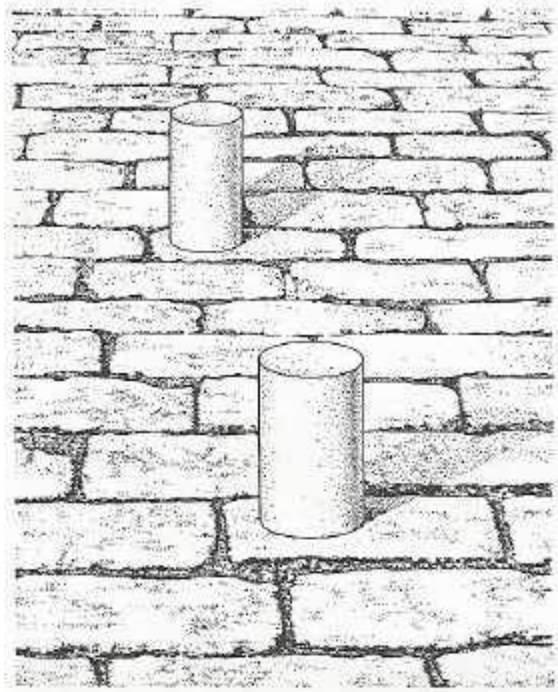
The abstract parts, or "geons" (Biederman, 1987), of a body parallel those of a suit in their spatial configuration and proportions. However, we should note that there are discrepancies. For example, the suit covers and drapes the body to create an abstracted size and shape, or silhouette, which differs from the body underneath. The body's actual waist and the suit's presented waist may be quite different in size and location. A suit may have added features such as cuffs that appear to influence metric properties of the body such as leg length. While leg length, alone or in proportion to the rest of the body, may serve as a cue of height, the leg-body ratio may also influence judgments of attractiveness and other social attributes independent of height perceptions.

In the current study, we maintained those natural configural properties of bodies that may be used by observers as cues to overall height, even in the absence of environmental context. For targets (i.e., to-be-judged stimuli), we digitally manipulated the clothing on photographs of a sample of men who represent a range of actual heights.

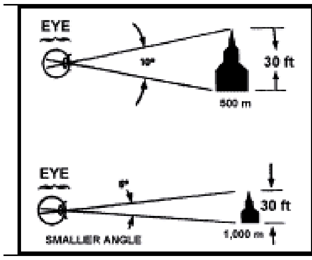
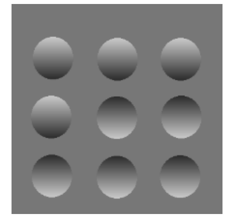
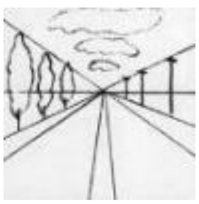
Contextual Cues

Although the metric properties of a body other than height may influence how tall a person looks, there is additional perceptual information surrounding the body that can also influence perceived size. This additional contextual information is often limited in research on visual illusions to force participants to attend to the dimensions of interest to the researcher and induce illusory effects. On the other hand, targets surrounded by rich contextual information may make size easily and directly perceptible, with no need to compute estimated height based on perceived distance. The "ecological" approach to perception of J.J. Gibson argues that the use of simplified, static stimuli in research is misguided; it will fail to provide a widely applicable understanding of the most important types of perceptual errors (review chapter: Bruce, Green, & Georgeson, 2000). Gibson's ecological approach stresses the optical array of the textures surrounding an object (e.g., texture of the cylinders and the surrounding bricks in Figure 3.3), so much so that he has claimed that illusion research in lab settings tells us little about how human perception truly operates. We should note that Gibson also discusses the importance of motion in perception, as movement creates changes in surrounding textures. While the current study will not include the important perceptual cue of motion, we will explore the effects of a more ecologically valid stimulus than those typically used in illusion studies.

Figure 3.3 - Demonstration of textures in ecological perception

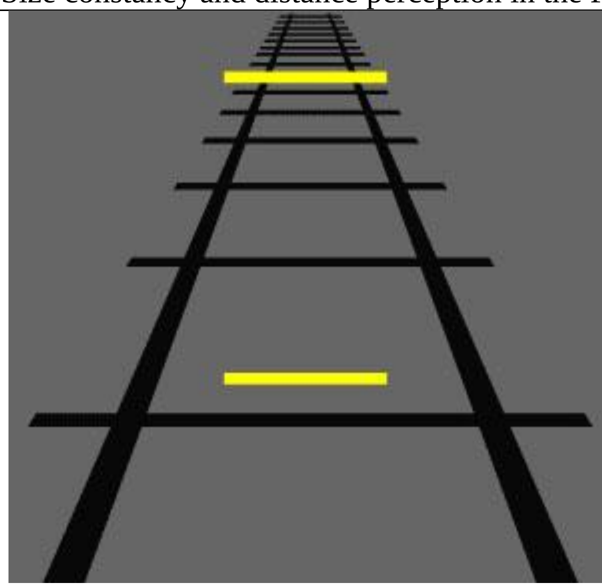


Gibson's ecological approach developed as a response to the traditional approach psychologists have used for describing the perceptions of size and distance in terms of the integration of separate cues. Monocular pictorial depth cues, some of which are shown in Table 3.1, are widely believed to be critical in the processing of size and depth information (reviews: Proctor & Proctor, 2012; Wickens & Carswell, 2012). Using combinations of various cues, we disambiguate depth and size, as modeled by researchers such as Bruno & Cutting (1988) and Landy, Maloney, Johnston, & Young (1995). Specific to color, a gradient change of saturation serves as a depth cue (Fry, Bridgman, & Ellerbrock, 1949), but a hue gradient serves as a cue of depth only when combined with other cues (Guibal & Dresp, 2004; Troscianko, Montagnon, Clerc, Malbert, & Chanteau, 1991).

Table 3.1 - Examples of monocular pictorial depth cues			
Retinal Size: Visual angle size on retina	Familiar Size: Knowledge of what size should be	Interposition: Occlusion, foreground covers background	Shading: Shadows, assume light source is above
			
Linear Perspective: Parallel lines converge at horizon	Height in Plane: Closer to horizon means farther away	Texture Gradient: Linear perspective + familiar size	Color Gradient: Color is less saturated at farther distances
			

Our perception of the length of the yellow lines in the Ponzo illusion in Figure 3.4 illustrates the key process suggested by those researchers favoring the cue integration approach. The retinal image of the line segment will subtend a particular visual angle. To know the true size of the distal stimulus projecting this retinal image, we must estimate the distance of the distal stimulus. If there are no other cues in the environment, and if we have no knowledge of the true size of the object or similar objects (familiar size), it will be impossible to determine the distance and true size. The principle of size constancy refers to our ability to perceive an object as fixed in size as it moves further away from us, even though the retinal image becomes smaller and smaller. Knowing the actual distance of the object, however, usually depends on the interpretation of other cues. For example, if two suit-wearing people of equal size are standing the same distance from an observer, they may still appear different sizes if additional cues make one of the two appear further away. If the color of the suit of one of the two people is interpreted as meaning that person is closer, then size constancy will be inaccurately applied by the observer and he or she will assume that the closer person must be smaller (put another way, the other person is farther away yet casts the same size retinal image and, thus, must be larger). If, however, there are additional cues to demonstrate that these two people are actually the same distance away, then the illusory effects may diminish.

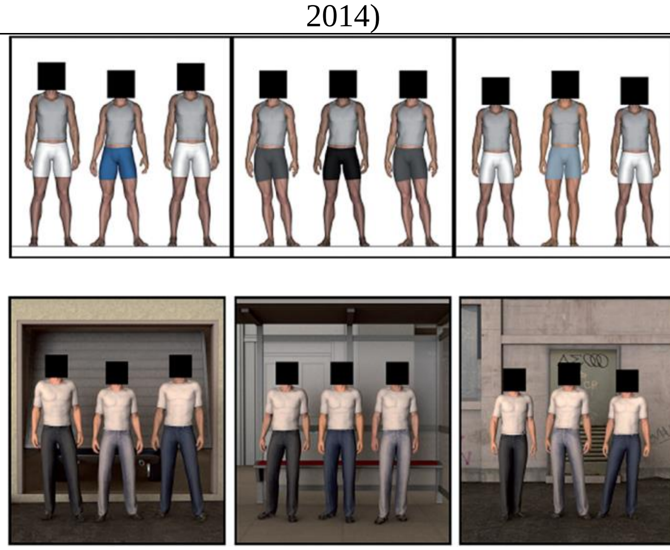
Figure 3.4 - Size constancy and distance perception in the Ponzo illusion



When encountering a clothed person, there are typically numerous visual cues to provide information regarding their height such as nearby cars, doorways, and other people. However, studies exploring clothing illusions often use stimuli stripped of such cues, forcing people to rely on more idiosyncratic points of reference, such as their own height as anchors (Twedt, Crawford, & Proffitt, 2015), or making judgments based on the correlation between height and other anthropometric cues. The absence of contextual information may artificially inflate the effect clothing has on perceived height. A richer environment may constrain illusions by reducing the contribution of clothing-based cues in favor of more reliable context cues. Past social research found context manipulations affected perceived height and height-associated attributes, such as varying the height of wall outlets to influence perceived height and dominance (Figure 3.5; Marsh et al., 2009). Similarly, Ludwig & Pollet (2014) influenced perceived height, attractiveness, and dominance by surrounding a target individual with distractor individuals of different sizes (Figure 3.6). This contrast-illusion effect was demonstrated when presenting the individuals against a white background and against a more realistic background full of contextual depth cues.

Figure 3.5 - Visual cues influencing height and status perception (Marsh et al., 2009)

Figure 3.6 – Background manipulation in height-contrast illusions (Ludwig & Pollet, 2014)



In the current study, we maintained the rich, real-world contextual information (i.e., backgrounds) that existed in the original photograph of the target for one of the experimental conditions. The backgrounds of the stimuli varied in multiple ways, some of which we categorized for within-subject comparison as we will discuss later. For the other experimental condition, we removed the background so that the target appeared against a white background, although still in the same position in the frame.

Chapter 4: Research Methods

This dissertation used an exploratory sequential mixed-methods design in two phases (Creswell & Plano Clark, 2011). Phase 1 consisted of a survey of non-experts to see how their advice and suggestions parallel the advice and suggestions of suit experts as covered in Chapter 1. The purpose of the exploratory Phase 1 was to see what suit design manipulations should be included in the stimuli for Phase 2. The advice of experts, along with the history of perceptual research in illusions, gave us the idea to manipulate monochromaticity and overall lightness, but these conditions needed validation with a more general population. Phase 2 utilized a height estimation task to examine whether our selected manipulations of clothing design can make the wearer appear taller. We also investigated the impact of naturalistic context on the magnitude of any obtained size illusions. Because the height of individuals correlates with social judgments about a variety of attributes such as attractiveness and status, we also determined whether variations in suit design, which theoretically impact perceived height, also created corresponding changes in observers' judgments about these characteristics.

Height Estimation Task

The key data from this dissertation are the height estimations. There are concerns around utilizing estimation methodologies for collecting psychophysical data (Gescheider, 1988; Poulton, 1979). However, estimation methods using responses linked to well-known rules such as familiar physical units (e.g., feet and meters) are less susceptible to methodological biases (e.g., centering bias and stimulus spacing bias) than estimation methods using arbitrary units (Poulton, 1979). For the height of people, an estimation task using familiar physical units ensures that participants understand that they are to estimate the presumed size of the target person rather than estimate the size of the image rendered on their screens. Furthermore, an estimation task using familiar units has application in the criminal justice domain, despite the inaccuracies described earlier. One contributing factor to these inaccuracies could be how people will bias height estimations of others towards their own height (Twedt et al., 2015).

Other psychophysical methods we could have potentially used, such as those outlined by Gescheider (1985), have their own limitations. For example, some researchers (e.g., Oberfeld & Hecht, 2011; Oberfeld et al., 2010) fear that direct comparisons such as those in a forced-choice task could emphasize irrelevant differences, decreasing the possible impact of an illusion. When Coren & Girgus (1972a) compared five different methods for testing the Müller-Lyer illusion, they found that magnitude estimation yielded a reliably larger effect size (ω^2=0.07) compared to a rating scale task or a graded series task, and magnitude estimation had the same effect size as a reproduction task. Pilot testing for this dissertation revealed that a reproduction task was slow and difficult, making fatigue and attrition potential problems. Furthermore, reproduction tasks might encourage participants to use ad hoc reference strategies (e.g., using their own hand length to measure), which could be a problem when conducting online research.

Anticipated Results

Non-experts Suggestions

We predicted that many of the suggestions of non-experts would parallel those of experts. Non-experts have heard the many of the "rules" experts have proliferated, which likely drive what non-experts know about how clothing design impacts perceived height. More specifically, we predicted that non-experts will suggest monochromatic outfits over lightness-blocked outfits, and that overall dark outfits will be suggested more than overall lighter outfits. These generally echo the advice of experts, and also validate that monochromaticity and lightness-blocking are valid suit design manipulations to explore the illusory effects of clothing design on perceived height. With this in mind, four outfits will be used in Phase 2 (Table 4.1).

Table 4.1: Clothing Color Combinations

	Dark Jacket	Light Jacket
Dark Pants	Monochromatic Dark ("DD")	Light jacket blocking ("LD")
Light Pants	Light pants blocking ("DL")	Monochromatic Light ("LL")

Monochromaticity

We predicted that monochromatic designs (DD and LL) would appear taller than non-monochromatic designs (DL and LD). As seen in the saccadic disruption of bisection illusions, a monochromatic design will create an uninterrupted path for one's eye to travel, leading to a greater perceived height (Chouinard et al., 2017; Kunnapas, 1955). The social attribute ratings will likely parallel height perceptions – individuals wearing monochromatic designs will be rated higher on income, attractiveness, leadership skills, status, and stylishness. The interaction of monochromaticity with the context manipulation will likely be minimal as the illusory effects are not derived from false size constancies induced by the absence of depth cues. Generally speaking, height estimations in the C- condition will be more erroneous, but monochromaticity is not expected to interact with these cues in any reliable way.

Lightness

We predicted that the lighter condition (LL) would appear taller than the darker condition (DD). Lighter objects appear larger, or farther away which leads to the perception of greater size at the same visual angle, which suggests that lighter suits should create the illusion of increased height, despite the standard advice from stylists to select darker colors to increase the perception of height. The social attribute ratings may diverge from the height estimations. The darker suit may have higher ratings because of the traditionally ubiquitous nature of the dark suit, along with experts suggesting darker colors. Unlike monochromaticity, the context manipulation will likely interact with lightness. If the lightness illusion occurs because lighter objects appear farther away, then the lightness manipulations may create greater illusions in the C- condition because there is not additional information to correct inaccuracies in distance estimates caused by lightness.

Lightness blocking

We predicted that the lighter pants condition (DL) will appear taller than the lighter jacket condition (LD). As discussed above, lighter objects appear larger, and based on the anthropometric proportions of leg length to overall height, the appearance of longer legs should create the appearance of greater overall height. The social attribute ratings will likely parallel the height estimations, where the lighter pants condition will be rated higher, especially as this lightness blocking is likely more familiar due to similarities to the traditional, preppy, "Ivy League" style of a dark blazer with khaki pants. However, experts suggest a lighter jacket to increase height because dark pants will purportedly grab attention first, forcing the viewer to scan up the full length of the body to create the illusion of height (Centeno, 2011b). The context manipulation will likely interact with the lightness blocking manipulation for the same reasons discussed regarding overall lightness effects.

Chapter 5: Phase 1 – Survey of non-experts

Our literature review revealed suggestions from experts about how to create the illusion that someone is taller than they really are through different clothing design choices, with two general heuristics arising: 1) reduce features, especially horizontal lines; 2) lengthen proportions, especially legs. However, rather than assume nonexperts shared these views, we conducted a survey to see if individuals who worked outside of the clothing design industry used the similar heuristics, including reducing features by wearing monochromatic outfits.

Methods

Phase 1 was an online qualitative survey used to investigate heuristics employed by non-experts to choose clothing that would create the illusion of increased height.

Participants

Two hundred thirty-two participants (F=146, M=86) completed the survey, with a mean age of 34 years. We recruited participants from Amazon Mechanical Turk with the limitation that they must be in the United States to complete the survey. Participants received $1.50 compensation, with an average completion time of four minutes.

Participants reported owning 2 suits (on average), and 56% of the participants reported wearing a suit at least once a year, with 7% reporting wearing a suit at least once a week. The most commonly reported professions/educational backgrounds were business (25%) and education (13%), with no participants reporting being designers or working in the fashion industry. Male participants' reported heights ranged from 63 inches to 79 (median=71) while female participants' reported heights ranged from 58 to 70 inches (median=65). During exploration into the data, analyses included the participants' heights as a covariate, and the results paralleled those presented below (without controlling for the participants' heights). Table 5.1 includes the sample sizes among the demographic groups, but we excluded participants of median height in their respective gender group from a follow-up gender x height chi-squared analysis of suggestion frequencies (19 M excluded, 23 F excluded).

Table 5.1 - Demographic groups (gender and height), with their height ranges and sample sizes.

	Short	Tall
Male	n=38	n=29
Female	n=63	n=60

Materials and Procedure

Participants completed the survey on Qualtrics using their own computers. This survey had three parts: open-ended advice, forced-choice advice, and demographic questionnaire. First, participants provided one suggestion after reading a scenario about a friend who wanted to buy clothes to appear taller (Table 5.2). Following this open-ended portion of the survey, participants were asked to choose a jacket and pants, each of which could be either dark or light, that would make the friend look tallest (Table 5.2). They then were asked to explain their choice. Part 3 of the survey collected typical demographic information including gender, age, height, background (education or profession), and suit ownership and exposure.

Table 5.2 - Qualitative survey questions for Phase 1

Imagine that your friend is looking to buy some formal clothes, including (but not limited to) a new jacket and some pants. Your friend is a little on the short side, and wants to get some clothes that will make him appear taller. What advice would you give your friend to make him look taller? This suggestion can be positive ("wear this") or negative ("avoid that"). Please be specific and detailed in your responses, but don't be restrained - imagine that your friend can customize every aspect of these clothes (sizes, styles, colors, materials, accessories, etc.). ____
[page break]
More specifically, what color jacket and what color pants would you suggest to your short friend? Jacket Color: ○ Light color (example: tan or light grey) ○ Dark color (example: navy or dark grey) Pants Color: ○ Light color (example: tan or light grey) ○ Dark color (example: navy or dark grey) Why do you suggest that jackets/pants color combination? ____

Results

Participants' suggestions were coded according to six categories, largely based on the suggestions provided from suit experts (Table 5.3). The primary researcher and a second researcher coded the individual suggestions offered by each participant. Agreement among the scorers was high, as reflected in a kappa of 0.83.

Table 5.3: The six coding categories (with examples) of non-experts' suggestions for increasing perceived height

Reduce Features	Global Changes	Lengthen Proportions
• Monochromatic • Avoid belts (or keep thin, low contrast) • Minimize accessories • No vests • No pocket flaps (or extra pockets, such as ticket pockets) • No jacket vents • No pant cuffs • Hide socks, have them match pants	• Overall colors suggestions (dark vs. light) • Add vertical patterns • Avoid horizontal patterns • Specific textures and/or materials	• Shorter jacket • Raise pants waist • Button jacket at waist (just above navel) • High lapel notches and gorge • Long lapel rolls (deep V) • If have accessories, place them high • Shorter trouser rise
Silhouette Change	**Physiological**	**Other**
• Good tailoring • Fit (tighter or bigger) • Hat • Taller hair • Taller shoes • Bigger shoulders	• Work out / lose weight • Better posture • Do stretches	• Smile • Be comfortable in your own skin • Anything else that does not fit into one of the other categories

What do non-experts suggest? (open-ended)

According to the frequency percentages of each category presented in Table 5.4, the two most common design suggestions were *global changes* (38.84%) and *silhouette changes* (35.71%). Because participants were not told to avoid changing the silhouette, it is no surprise that they suggested changes such as wearing taller shoes and avoiding baggy clothes. *Global change* suggestions most frequently referenced stripes, either wearing vertical (18.02%) or avoiding horizontal (5.41%). This reflects the proliferation of heuristics regarding stripes in clothing design discussed in Chapter 1. However, participants also suggested wearing dark colors (6.76%). The third most common category of suggestions was *reduce features* (10.71%). Most of these suggestions mentioned monochromaticity, independent of brightness or hue (7.66%). Interestingly, six participants (2.70%) made suggestions regarding the length of pants (i.e., pants break), however there was no consensus in the appropriate length.

In comparing different groups of participants, an interesting trend emerges. Women provide suggestions that more closely align with the illusion suggestions of the experts (Table 5.4). We conducted a chi-squared analysis to explore these interactions (Table 5.5), and found this effect of gender to be reliable, where female participants provided more "illusion" suggestions while male participants provided more suggestions to change the silhouette. The interaction of gender with height was also statistically reliable, wherein male participants who were short provided disproportionately more suggestions for changing the silhouette than taller male participants, a directional effect also seen in female participants, but not as large.

Table 5.4: Open-ended suggestion responses

	Total	Male		Female	
		Tall	Short	Tall	Short
Global Changes	38.84%	34.48%	21.05%	45.00%	36.51%
Silhouette Change	35.71%	51.72%	63.16%	23.33%	26.98%
Reduce Features	10.71%	3.45%	0.00%	15.00%	20.63%
Lengthen Proportions	9.82%	3.45%	10.53%	13.33%	12.70%
Other	2.23%	0.00%	5.26%	3.33%	3.17%
Physiological	1.79%	0.00%	0.00%	0.00%	0.00%
Combined illusion	*63.39%*	*48.28%*	*36.84%*	*76.67%*	*73.02%*

Table 5.5 - Chi-square test for open-ended suggestions for gender (M vs. F), height (tall vs. Short), and suggestion (change silhouette vs. illusion)

	df	χ^2	p
Gender x Height x Suggestion	4	23.36	<0.001
Gender x Height	2	0.46	0.79
Gender x Suggestion	2	21.42	<0.001
Height x Suggestion	2	0.60	0.74

__Which color combination of jackets and pants do non-experts recommend?__

In the forced-choice response, most participants selected monochromatic color combinations, and participants selected a fully dark outfit most frequently overall (Figure 5.1). The reasons participants gave for selecting monochromatic dark outfits varied, but the most common explanation referenced the slimming effects of dark clothing (26% of the monochromatic dark selection explanations). When looking at different demographic groups, the effects of gender were not statistically reliable according to chi-squared analysis (Table 5.7) as we saw above, but the percentage data was in the same direction (i.e., the advice of women more closely paralleled advice of experts).

Figure 5.1: Forced-choice responses

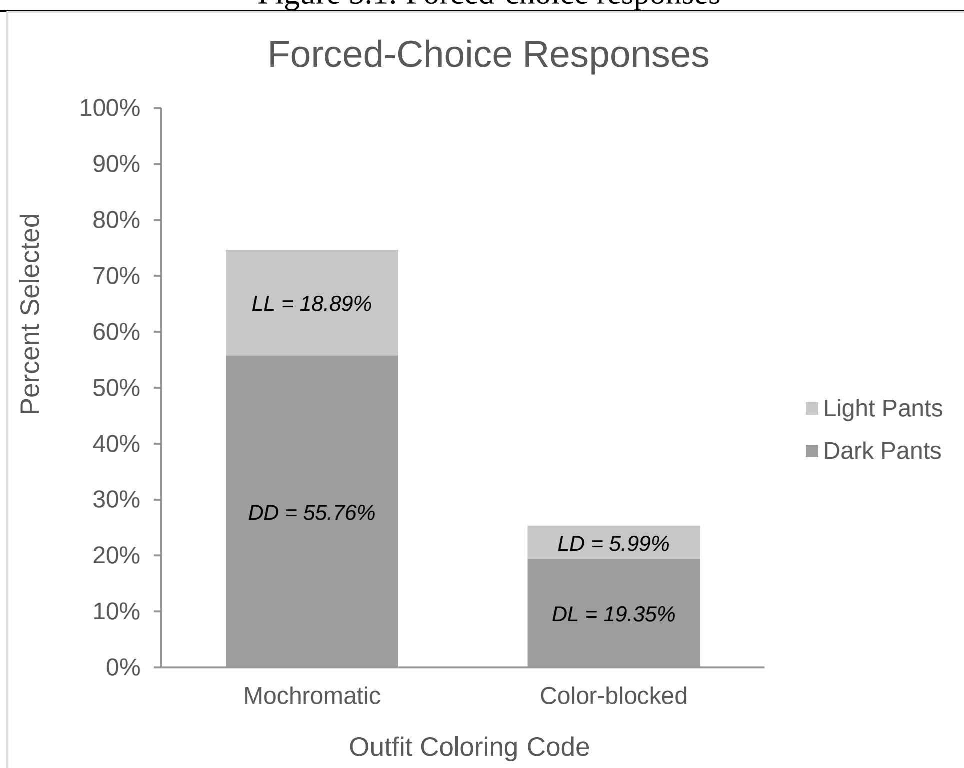


Table 5.6 - Percentages of forced-choice responses

	Total	Male		Female	
		Tall	Short	Tall	Short
Monochromatic	74.65%	65.52%	71.05%	75.00%	84.13%
DD	55.76%	44.83%	57.89%	55.00%	63.49%
LL	18.89%	20.69%	13.16%	20.00%	20.63%
Color-blocked	25.34%	34.48%	28.95%	25.00%	15.87%
DL	19.35%	3.45%	7.89%	3.33%	11.11%
LD	5.99%	31.03%	21.05%	21.67%	4.76%

Table 5.7 - Chi-square test for forced-choice responses for gender (M vs. F), height (tall vs. Short), and suggestion (change silhouette vs. illusion)

	df	χ^2	p
Gender x Height x Suggestion	4	5.14	0.27
Gender x Height	2	0.98	0.61
Gender x Suggestion	2	3.26	0.20
Height x Suggestion	2	1.82	0.40

Phase 1 Discussion

In general, the results of this survey parallel the findings of our review of advice from the experts, especially if we had included expert advice about the impact of changing the silhouette. We believe that some of the non-expert advice is either the most obvious or intuitive, such as changes to the silhouette (e.g., wear taller shoes), or the most “popular,” such as advice regarding stripes. Rules regarding stripes and their orientation are common among experts and non-experts alike. Regardless, the themes of non-experts’ advice echo the themes from experts’ advice such as global changes (e.g., overall lightness) and reducing features (e.g., monochromaticity). While lightness and monochromaticity may not have been as common as other suggestions such as those relating to stripes, they were still present. Furthermore, the results of the forced-choice question echoed advice of experts, which directs people toward darker colors. Note that this contradicts wisdom derived from the perceptual literature, specifically that lighter objects appear larger.

In exploring effects among different demographics groups, we found that women provided more open-ended suggestions which aligned with the illusion suggestions of experts. One explanation is that women have sought these types of suggestions, or they make more of an effort to retain those suggestions, to combat the nature of generally being shorter in the overall population. It is also interesting to note the interaction of height with this gender effect, wherein shorter male participants provided the most suggestions pertaining to changes in the silhouette. One explanation could be that shorter men have tried creating illusions but have not felt any meaningful effects. For example, if a shorter man is wearing a monochromatic outfit, he will still be physically looking up to see taller counterparts, but taller shoes will reduce the amount of "looking up" he will have to do. These key findings – the focus by experts and nonexperts alike on monochromaticity and overall darkness – provide additional justification for our choice of suit manipulations in the remainder of this dissertation.

Chapter 6: Phase 2 – Effects of Outfit Design and Context on Height Estimation and Social Ratings

In Phase 1 and the literature review in Chapter 1, we found that experts and nonexperts believe some general heuristics to create the illusion of increased height. However, the validity of these claims is suspect, as data-driven research to investigate these claims is sparse. In Phase 2, we will discuss a data-driven research approach to investigate the illusory effects clothing may have on height perception.

Phase 2 Research Design

Phase 2 utilized a 2 (context) x 4 (outfit) x 50 (target) mixed-factor design, with context and outfit designs manipulated between subjects and targets manipulated within subjects. Dependent variables included height estimation and ratings of income, attractiveness, status, leadership skills, and stylishness. We collected the same demographics as in Phase 1.

Participants

We recruited 349 participants through Amazon Mechanical Turk (MTurk), and they received $1.50 for compensation. They took 24 minutes to complete the survey on average for a mean pay rate of $3.75 per hour. Qualtrics randomly assigned participants to each condition, resulting in unequal group sizes (Table 6.1). Although unequal sample sizes can be a concern for factorial analyses (Brown & Forsythe, 1974; Shaw & Mitchell-Olds, 1993), we tested for homogeneity of variance and did not find it violated for any of our analyses (Levene's test: $F \leq 1.56$, $p \geq 0.20$).

According to the demographic information participants provided, the mean age of the participants was 33 years, ranging from 18 years old to 73 years old, and more men (n=191) completed the study than women (n=153). Although geometric illusions have been found to be the same across sexes (Porac, Coren, Girgus, & Verde, 1979), the traditionally male-gendered suit may influence familiarity with, and sensitivity to, design manipulations.

Participants reported owning two suits on average, and 56% of participants reported wearing a suit once a year, with 7% reporting wearing a suit at least once a week. The most commonly reported professions/educational backgrounds were business (33%) and engineering (12%), with no participants reporting being designers or working in the fashion industry. The self-reported heights of participants ranged from 59 inches to 78 inches, with a median of 68 inches.

Table 6.1: Sample size distribution across conditions					
	DD	LL	DL	LD	Total
C+	44	43	30	45	162
C-	40	50	54	43	187
Total	84	93	84	88	349

Stimuli

Fifty source photographs served as the templates from which we generated the stimuli, which we edited in Adobe Photoshop CC 2017 for each condition. For inclusion in the stimuli set, photos met the following criteria. (1) All stimuli included a person of known height ranging from 65 inches to 75 inches, with a median of 69 inches. This height distribution is similar to the population distribution for men in the US (Tilley & Associates, 2001). (2) The entire body was visible (head to toe), but we digitally obscured their faces during stimulus preparation as many targets were celebrities. (3) Each person was wearing a solid-colored suit with a light-colored shirt and a necktie. (4) The backgrounds of the images were rich with perceptual cues, such as an urban streetscape or an interior room. The height of each image was controlled for, but the horizontal dimensions, the targets' position in the frame, and the targets' rendered size all varied from target to target. Marsh et al. (2009) similarly used a standard set of individuals as their targets, although they used sixteen actors from a local theater company and did not obscure the targets' faces.

To create the different outfits, we manipulated the fifty source stimuli by changing the darkness of the suit jacket and pants to match each of our four conditions, (i.e., DD, LL, DL, and LD). For the context manipulation, the background was either unedited (pictorial context, "C+"), or completely replaced with a solid white background (reduced context, "C-"). Examples of the stimuli are in Table 6.2 and Table 6.3, and all of the stimuli are located here: https://1drv.ms/f/s!Ah3gjsxS9l3ju1zDExWBYLJaw0R0.

Table 6.2 - Example of stimuli (tall, white, walking, alone, outside)

	DD	LL	LD	DL
C+				
C-				

Table 6.3 - Example of stimuli (short, nonwhite, standing, others present, indoors)

	DD	LL	LD	DL
C+				
C-				

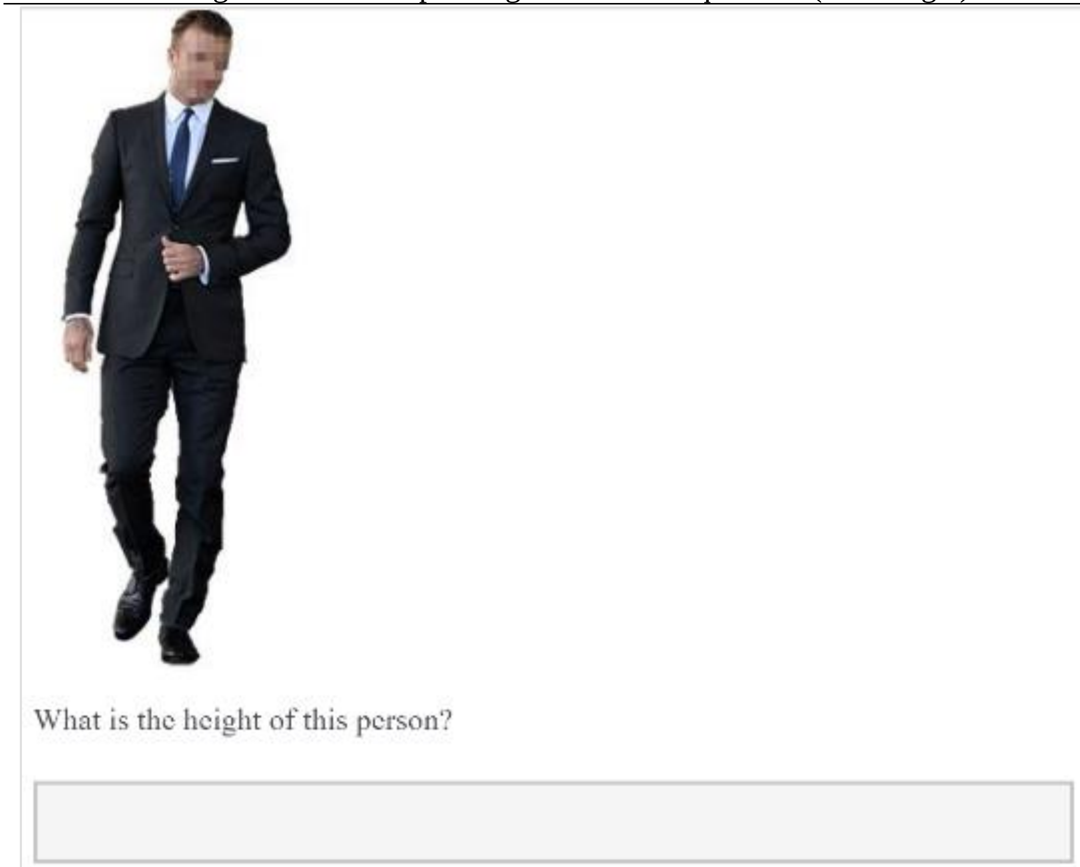
Materials

We created all three survey parts– social attributes, height estimation, and demographics – using Qualtrics software. Participants completed the entire study on their personal laptop or desktop computer. The order of the social attributes survey and the height estimation survey was randomized, with the demographics survey always presented last. The social attributes survey collected participants' perceptions of income, leadership skills, attractiveness, status, and stylishness using 7-point Likert scales instructing participants to compare the person presented in the stimulus to the person's hypothetical peers (Figure 6.1). The height estimation survey required participants to input their numerical height estimates into a text box, using the units of their choice (imperial: feet and inches; metric: centimeters). The third and final survey portion collected demographic information, using the same survey as in Study 1.

Figure 6.1 - Scales for social attribute ratings for Phase 2

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
This person has higher income than his peers.							
This person is a better leader than his peers.							
This person is more attractive than his peers.							
This person is a higher status than his peers.							
This person is more stylish than his peers.							

Figure 6.2 - Example height estimation question (with target)



Procedure

Participants found the study on Amazon Mechanical Turk, which directed them to the Qualtrics page. They then began either the social attribute rating portion or the height estimation portion in one of the Outfit x Context conditions. Qualtrics randomized the order of the surveys and the condition assignment, but participants only saw stimuli for that condition throughout the study. In both surveys, participants viewed fifty stimuli, all fifty targets in their respective condition. After participants completed both surveys, they completed the demographics survey and then returned to MTurk to conclude the study.

Analysis

We transformed all estimates into inches for our analyses (two participants responded in centimeters, while the rest responded in feet and inches). We calculated error by taking the absolute value of the estimates' difference from the targets' *actual height* (as reported by online sources). Additionally, we categorized existing characteristics of the images into non-outfit attributes, specifically coding based on two person-oriented attributes and two environment-oriented attributes (Table 6.4). We did not manipulate these non-outfit attributes in Photoshop as we did for the outfits. Rather, using the images we selected based on the constraints for the primary analyses, we sorted and categorized those existing images based on specific attributes for additional exploratory analyses.

The person-oriented attributes were race (white & nonwhite) and stance (walking and standing). We created an additional category of height stratification dividing thirds by height, but we did not include data from the analysis of this factor in the present dissertation because the findings parallel those presented in the sections referencing the relations among dependent variables. However, we included the height stratification categorization in the "Disadvantaged Groups" section to focus on the effects of our suit manipulations on shorter individuals.

There were two categories for variations among environment-oriented attributes: presence of other people (alone, man present, woman present), and location (indoors and outdoors). The presence of other people categorization includes some overlap between genders, as some targets' backgrounds had both men and women present. The only full body visible in the stimuli was the targets', but portions of other people were visible in 30 of the images.

Table 6.4 - Categorization of Non-Outfit, Non-Manipulated Photo Characteristics		
	Number of Targets	Mean Actual Height
Race		
White	41	69.76
Nonwhite	9	69.44
Stance		
Walking	24	69.21
Standing	26	70.15
Other People		
Alone	20	70.05
Man Present	27	69.48
Woman Present	15	69.20
Location		
Inside	12	70.67
Outside	38	69.39

We ran 2 (context) x 4 (outfit) x 50 (target) mixed-factor ANOVAs for most of the analyses, using partial-eta squared (η_p^2) as the measure of effect size. We have included a table summarizing the results of each analysis below.

Phase 2 Results and Discussion

In this results and discussion section, we begin by focusing on the primary dependent variable: height estimates. First, we explore the relation between the estimates of participants and the actual heights of the targets. We then compare height estimations as a function of our primary independent variables: context and outfit. We followed a similar procedure when we moved focus to absolute estimation error. Then, we focused on the social attribute ratings. We began by exploring the relations between these ratings and the estimated and actual heights. We also explored the relations among the ratings themselves by conducting a factor analysis to create reduced ratings factors. We used these composite ratings factors to test for effects and interactions of context and outfit. As a final, exploratory analysis, we looked at the potential impact of non-outfit image attributes on both height perception and social attribute ratings. These non-outfit attributes included whether the target is walking or standing, is inside or outside, is white or nonwhite, and is alone or with others (Table 6.4). Lastly we explored the impact of suit design specifically on those subgroups who stand to gain the most social capital from being perceived as taller. We identified two groups as a focus: shorter individuals (the shorter third of targets) and nonwhite targets.

Height Estimates

As we discussed in Chapter 4, the primary dependent measure in this study is participants' height. We predicted, based on research on perceptual illusions, that monochromatic outfits appear taller than lightness-blocked outfits, and that lighter outfits would appear taller than darker outfits.

Is there a relationship between the actual heights and the estimated heights of targets?

We conducted a bivariate linear regression to explore the relations between the targets' actual heights and the means of the targets' estimated heights, averaging participants' estimates across outfit and context conditions for each of the fifty targets. Thirty-six percent of the variance was explained (R^2=0.36), suggesting that participants were not incredibly accurate in their estimates, but they were on the right track. More importantly, 64% of the variance in height estimates was due to something *other* than the actual height of the target. The same approximate amount of variance is explained for each outfit (DD: R^2=0.34, DL: R^2=0.32, LD: R^2=0.33, LL: R^2=0.36), but some more of the variance was explained when focusing on targets with full context (C+: R^2=0.42) than targets without (C-: R^2=0.26). We will discuss the differences in C+ and C- when we discuss the height estimate errors in a later section.

Yes, there is a positive relationship between the actual heights and the estimated heights of targets.

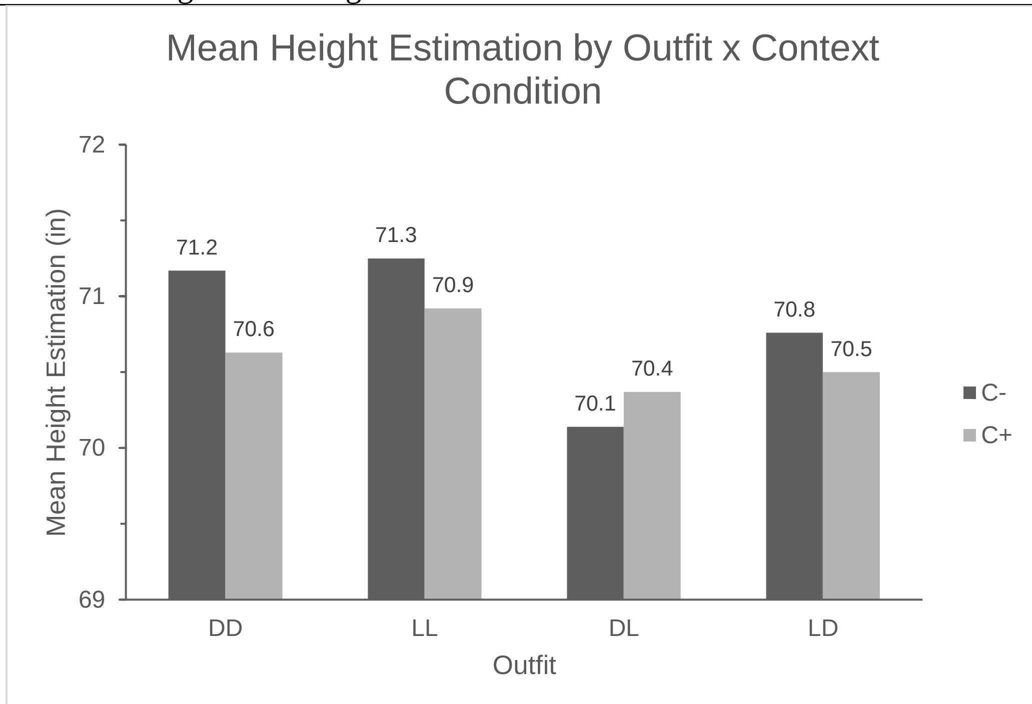
Do outfits and context affect height estimation?

ANOVAs did not reveal a reliable difference between the context conditions, nor an interaction of context with outfit (Table 6.5). However, there was a main effect of outfit. Collapsing the outfit conditions in order to compare monochrome and blocked designs (DD+LL vs. LD+DL) yielded a similar main effect of monochromaticity. Estimates for monochrome outfits (mean=71.00 inches) were taller than non-monochrome outfits (mean=70.42 inches). These results aligned with our anticipated results, where participants perceived people in monochromatic outfits as taller. However, our anticipated results for an outfit's overall lightness (DD vs. LL) were not found, nor did overall lightness interact with context.

Table 6.5: Context and outfit effects on height estimation

	df	F	η_p^2	p
Context	1,337	1.79	0.04	0.001
Outfit	3,337	4.58	0.04	<0.001
Monochromaticity	1,341	11.64	0.03	0.001
Lightness	1,171	0.53	<0.01	0.47
Outfit x Context	3,337	0.89	0.01	0.45
Monochromaticity x Context	1,341	2.01	<0.01	0.16
Lightness x Context	1,171	0.17	<0.01	0.68

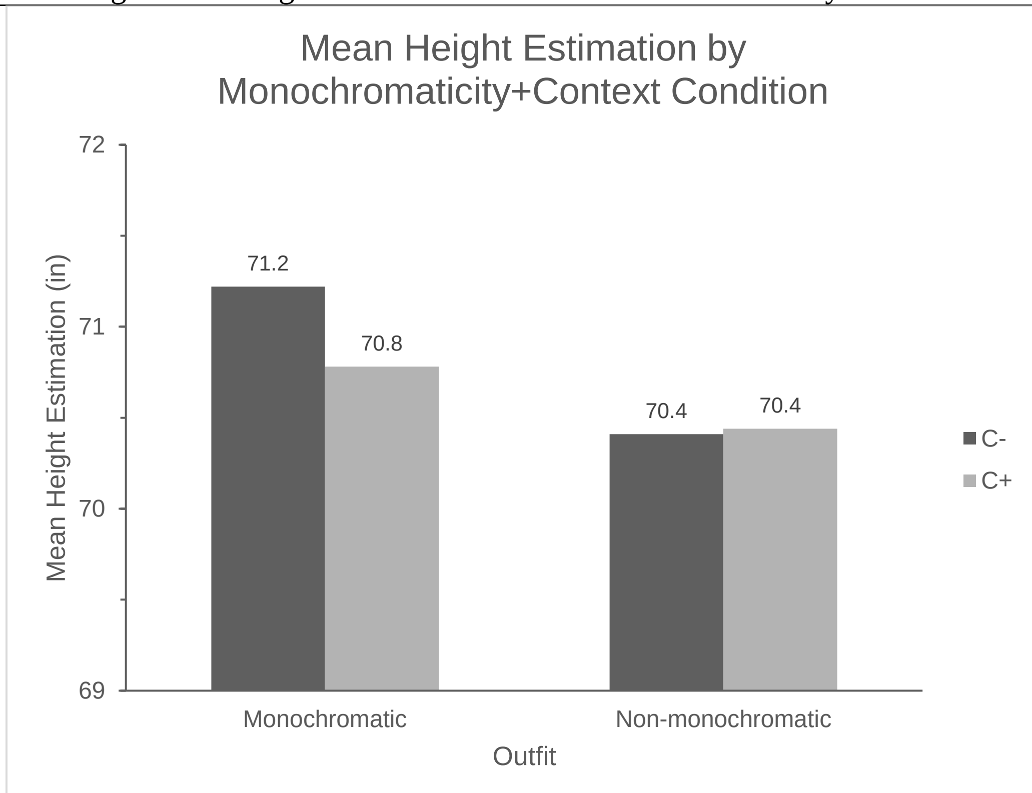
Figure 6.3: Height estimation results for context and outfit



Mean (SE)	**DD**	**LL**	**DL**	**LD**	**Total**
C-	71.17 (0.25)	71.25 (0.22)	70.14 (0.21)	70.76 (0.24)	70.83 (0.12)
C+	70.63 (0.22)	70.92 (0.24)	70.37 (0.28)	70.50 (0.23)	70.60 (0.12)
Total	70.90 (0.17)	71.09 (0.16)	70.25 (0.17)	70.63 (0.17)	

Overall, the data show that estimates were taller for targets wearing monochromatic outfits (Table 6.5 and Figure 6.4). This supports our prediction that monochromatic designs (DD and LL) will appear taller than non-monochromatic designs (DL and LD). These findings are consistent with the saccadic disruption hypothesis. This hypothesis explains size distortions in bisection illusions, (e.g., the inverted-T illusion: Chouinard et al., 2017; Kunnapas, 1955) based on the premise that visual scan patterns affect distance judgments. Another possible explanation could be that participants made social associations with the monochromatic outfits, such as perceiving monochromatic outfits as more formal. Although it is often thought that being taller leads to perceptions of greater status, the reverse might be true. Greater status may lead to taller height perception. A more formal outfit (i.e., monochromatic) may make the wearer seem higher in status, leading to an association with higher stature.

Figure 6.4: Height estimation results for monochromaticity of outfits



Mean (SE)	**Monochrome**	**Non-monochrome**	**Total**
C-	71.22 (0.17)	70.41 (0.16)	70.81 (0.12)
C+	70.78 (0.17)	70.44 (0.18)	70.61 (0.12)
Total	71.00 (0.12)	70.42 (0.12)	

The data did not support our prediction regarding overall lightness in an outfit. This suggests that the illusions relating to depth, such as lightness, may not be as influential on body height perception as illusions relating to segmentation along the dimension being estimated (vertical extent). For the perceptual studies which the "lightness" hypothesis was based on, light (or dark) stimuli were traditionally presented against a simple, solid background, often of the opposite color (Coules, 1955; Kremkow et al., 2014; Westheimer, 2008). Perhaps these lightness effects are rather small, and the many pictorial depth cues presented in our stimuli may have corrected for any erroneous processing and estimates that the lightness effect may have caused. Given that every C+ stimulus had a darker background than the C- counterpart and we did not find an interaction of outfit lightness and context, this suggests that even the limited cues in the C- condition (e.g., anthropometric proportions) corrected for lightness-illusion effects.

Context did not exert a reliable effect on overall height estimation, nor did it reliably attenuate the effects found for outfits. However, outfit did affect perceived height, specifically that monochromatic outfits made targets appear taller.

Do outfits and context affect how accurate people are at estimating height?

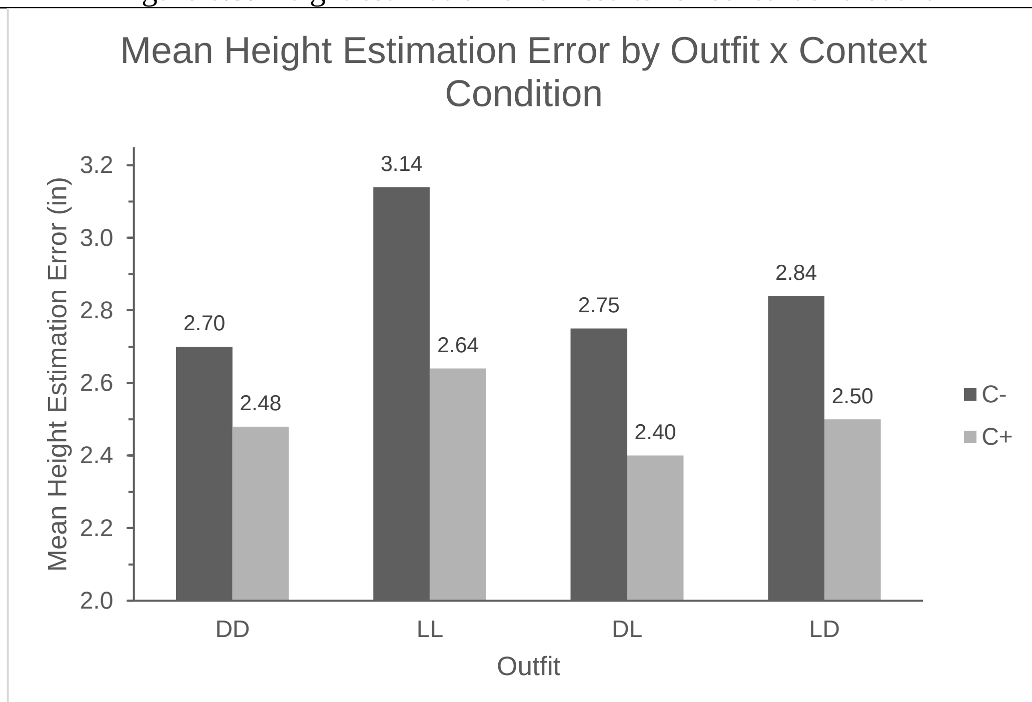
We were surprised to find that there was no main effect of context on height estimates because research typically indicates that the greater the number of depth cues, the more accurate size estimation becomes. However, it is important to remember that we were looking at directional error, or bias (i.e., overestimation of height) in the previous section. It might still be the case that overall accuracy (i.e., the size of the combined over and underestimates) may vary with the presence and absence of contextual information. The earlier regression analysis seemed to support this conclusion.

Overall, there was no interaction of context and outfit for the error of participants' estimates, and the main effect of outfit was not statistically reliable (Table 6.6). However, there was a main effect of context, where estimates were more erroneous for the "limited context" condition (C- mean=2.86) than the "full context" condition (C+ mean=2.50; Figure 6.5). We found similar results when focusing on monochromaticity and when focusing on overall suit lightness: there was a main effect of context, but no interaction of outfit and context, and no main effect of outfit. These results align with our predictions, that additional contextual information yields more accurate estimates. The C- condition relied on a few, potentially unreliable size cues, and the rich background information in the C+ condition provided many pictorial cues to assist in more accurate estimates.

Table 6.6: Context and outfit effects on height estimation error

	df	F	η_p^2	*p*
Context	1,333	11.39	0.03	<0.001
Outfit	3,333	2.01	0.02	0.12
Outfit x Context	3,333	0.32	<0.01	0.81

Figure 6.5: Height estimation error results for context and outfit



Mean (SE)	**DD**	**LL**	**DL**	**LD**	**Total**
C-	2.70 (0.15)	3.14 (0.14)	2.75 (0.13)	2.84 (0.15)	2.86 (0.07)
C+	2.48 (0.15)	2.64 (0.15)	2.40 (0.18)	2.50 (0.15)	2.50 (0.08)
Total	2.59 (0.11)	2.89 (0.10)	2.57 (0.11)	2.67 (0.10)	

More contextual information yielded more accurate height estimates. However, outfits did not affect estimates, nor did outfits interact with context.

Social Attribute Ratings

As we discussed in Chapter 1, being taller has many benefits, many of which relate to social perceptions. These social benefits may motivate individuals to want to appear taller than they are in reality. However, although we have found that outfit design can influence height perception, does this translate to changes in social perceptions? We focus on four social attributes pertaining to height based on previous literature (income, attractiveness, status, and leadership ability), with an additional fifth attribute (style) for its relation to clothing design.

Is there a relationship between the social attribute ratings and height estimation?

While the relationship between height estimations and actual height was moderately strong, the relationships were weak between the social ratings and the actual heights (Table 6.7). This discrepancy appears at first to contradict previous research showing that height is predictive of various social attributes. However, perceived (estimated) height showed a stronger relationship with social attributes. So, if an outfit can create the illusion of increased height, then social attribute perceptions should increase accordingly. This also indicates that it is critical that those interested in studying social biases that may be associated with height should measure perceived height rather than objective height.

Table 6.7 - Bivariate Fit (R^2) of Actual Height and Mean Estimated Heights Against Dependent Variables

	Actual Height	Mean Estimated Height
Mean Height Est.	0.36*	
Mean Attractiveness	0.07	0.45*
Mean Income	0.07	0.27*
Mean Leadership	0.06	0.27*
Mean Status	0.07	0.29*
Mean Style	0.07	0.42*

* *p* values less than 0.05 according to *F* values (*df* =1,49).

Is there a relationship among the social attribute ratings?

The results of the bivariate regressions presented above appear to demonstrate some relations among the social attribute ratings, specifically that Attractiveness and Style appeared to behave similarly, while Income, Leadership, and Status appeared to behave in a different manner. To confirm these suspicions, we ran a factor analysis (Figure 6.6, Table 6.8, and Table 6.9).

Table 6.8 - Table of Correlations (r) for Social Attribute Ratings

	Income	Leadership	Status	Attractiveness	Style
Income	1				
Leadership	0.68	1			
Status	0.79	0.70	1		
Attractiveness	0.55	0.53	0.77	1	
Style	0.60	0.70	0.63	0.77	1

Visual exploration of the scree suggested that there were two factors that accounted for most of the variation. Specifically, these factors accounted for 97.91% of the total variance (Figure 6.6 and Table 6.9). Factor 1, labeled "Dominance," included the ratings of income, leadership, and status, and accounted for 55.11% of the variance. Factor 2, labeled "Aesthetics," included ratings of attractiveness and style, and accounted for 42.80% of the variance. These results suggest that we can reduce participants' ratings from the five requested to two.

Figure 6.6: Factor analysis plots

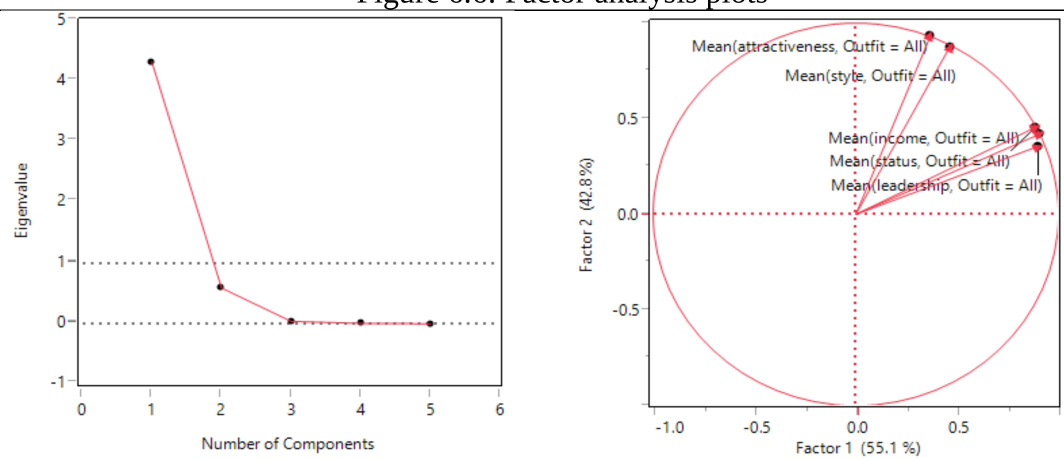


Table 6.9 - Rotated Factor Loading		
	Factor 1: "Dominance"	Factor 2: "Aesthetics"
Income	**0.90**	0.42
Leadership	**0.90**	0.35
Status	**0.89**	0.46
Attractiveness	0.37	**0.93**
Style	0.46	**0.88**
Variance % Explained by Factor	55.11	42.80

For the following social attribute perceptions analyses, we averaged the ratings in accordance to the factor analysis: "Aesthetics Rating" = average of attractiveness and style; "Dominance Rating" = average of leadership, income, and status. We then analyzed the bivariate fit of these two new variables in relation to the actual and estimated heights of targets (Table 6.10).

Table 6.10 - Bivariate Fit (R^2) of Actual Height and Estimated Heights Against Dependent Variables		
	Actual Height	Mean Estimated Height
Mean Aesthetics Ratings	0.07	0.44*
Mean Dominance Ratings	0.07	0.29*

* *p* values less than 0.05 according to *F* values (*df* =1,49)
Aesthetic=Attractiveness, Style
Dominance=Income, Status, Leadership

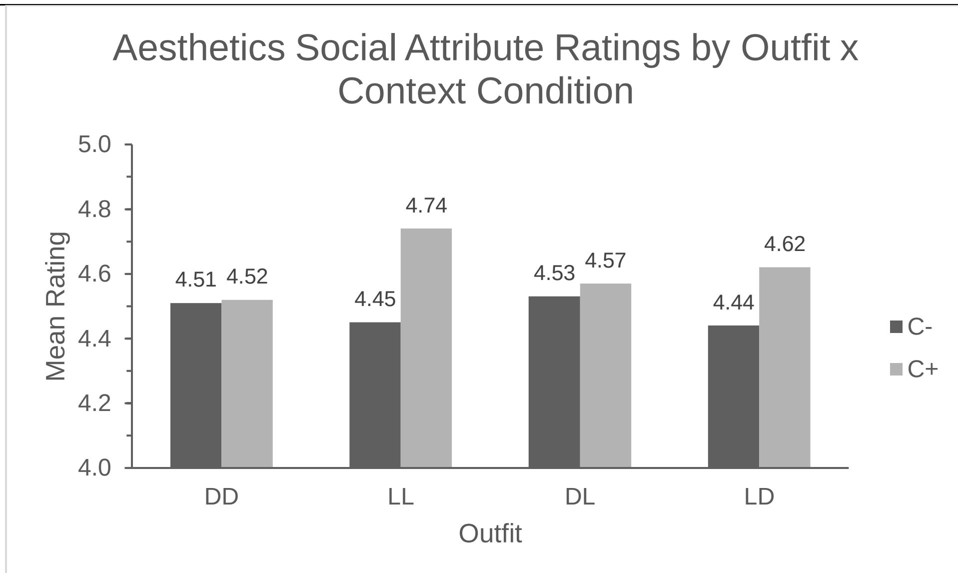
Do outfits or context affect social attribute perceptions?

Although outfit had reliable effects on height estimation, the data did not show the same effects in the social attribute ratings (Table 6.11). There was no reliable main effect of context or outfit, nor an interaction between context and outfit, for the Aesthetics Ratings or the Dominance Ratings, including the comparisons of monochromaticity and overall lightness. Given participants' estimates of height were affected by outfits (specifically monochromaticity), and the fact that attribute ratings were, in fact, related to participants' estimates of height (i.e., ratings increased with increased perceived height), the lack of differences found among the outfit manipulations suggests that perhaps the half-inch effect of monochromaticity was too small to yield meaningful differences in social attribute ratings. However, it could be that the results were more heavily influenced by the fact that the targets were wearing relatively formal outfits, overriding other potential influencing variables. The suit (or suit separates) carries associations with the social attributes we explored, and, despite prompting participants to consider the targets relative to their peers, a ceiling effect may have occurred. Future studies should compare suits to non-suit outfits, or explore the new study designs, such as a forced-choice paradigm to elicit relative social attribute levels between clothing conditions.

Table 6.11 - Statistics for Context and Outfit Effects on Social Attribute Ratings

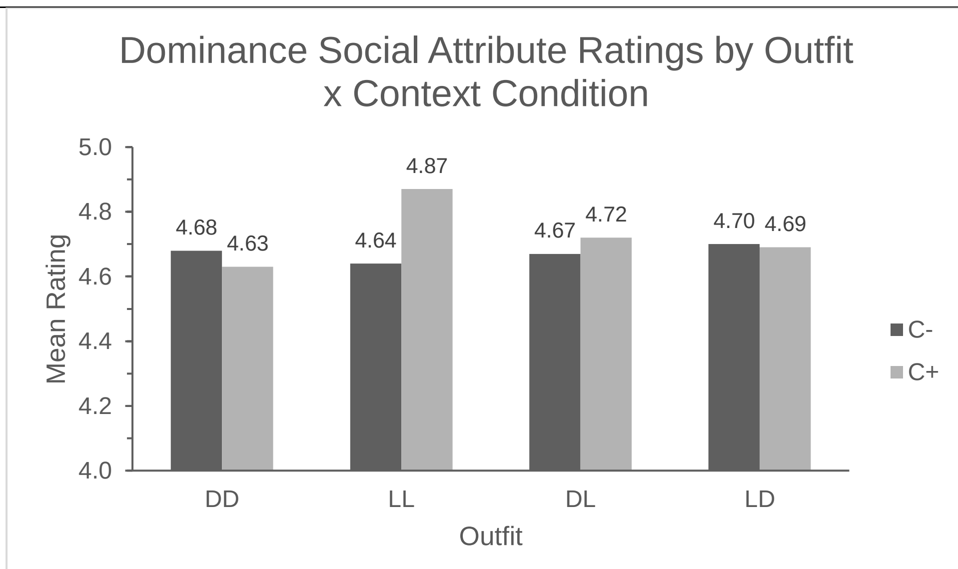
	df	F	η_p^2	*p*
Aesthetic Ratings (Attractiveness, Style)				
Context	1,340	2.68	0.01	0.12
Outfit	1,340	0.18	<0.01	0.91
Context x Outfit	3,340	0.66	<0.01	0.58
Dominance Ratings (Income, Status, Leadership)				
Context	1,340	0.88	<0.01	0.35
Outfit	1,340	0.44	<0.01	0.73
Context x Outfit	3,340	0.51	0.01	0.67

Figure 6.7 - Aesthetics social attribute ratings (attractiveness and style) by outfit and condition



Mean (SE)	**DD**	**LL**	**DL**	**LD**	**Total**
C-	4.51 (0.12)	4.45 (0.10)	4.53 (0.10)	4.44 (0.11)	4.48 (0.05)
C+	4.52 (0.11)	4.74 (0.13)	4.57 (0.11)	4.62 (0.11)	4.61 (0.06)
Total	4.52 (0.08)	4.59 (0.08)	4.55 (0.08)	4.53 (0.08)	

Figure 6.8 - Dominance social attribute ratings (income, leadership, and status) by outfit and condition



Mean (SE)	**DD**	**LL**	**DL**	**LD**	**Total**
C-	4.68 (0.12)	4.64 (0.11)	4.67 (0.10)	4.70 (0.11)	4.65 (0.06)
C+	4.63 (0.11)	4.87 (0.11)	4.72 (0.13)	4.69 (0.11)	4.72 (0.06)
Total	4.65 (0.08)	4.76 (0.08)	4.70 (0.09)	4.64 (0.08)	

Non-outfit Image Attributes

We have found that variations in the monochromaticity of outfit design can affect the perceived height of a target, and that the presence or absence of rich contextual information can affect the accuracy of height estimations, but that neither the outfit nor context manipulations affect social attribute ratings. However, there are image attributes among the fifty stimuli that we can also explore for other sources of variability. Person-oriented attributes (i.e., such as the targets' race/ethnicity and stance), or environment-oriented attributes (i.e., location and other people) may affect height perception, estimation accuracy, and social attribute ratings.

To explore the potential effects of these non-outfit image attributes on height estimation and social attribute ratings, we used repeated measures analysis of covariance, controlling for the actual height of the targets. We have included the raw descriptive statistics (mean and standard error) along with the adjusted parameters.

Does race/ethnicity affect height or social perceptions?

Controlling for actual target height, the estimates for white targets were reliably taller, and more accurate, than estimates for nonwhite targets, and the social attribute ratings, for both aesthetics and dominance, were higher for white targets than for nonwhite targets (Table 6.12 and Table 6.13).

Height estimates were more erroneous for non-white targets, leading to more under-estimates, and the cultural associations with white targets prevailed in the social attribute ratings. The more erroneous estimates for non-white targets may have been due to some "other-race" effects. Other-race effects have found that sensitivity to relative spatial features in faces (Kelly et al., 2007) or in bodies (Humphreys, Hodsoll, & Campbell, 2005) vary depending on whether there is a match between the race of the viewer and that of the target. Although we did not collect the race/ethnicity of the participants, the demographics of MTurk users skew white (Chandler & Shapiro, 2016). This means that many participants may have been less familiar with the anthropometric proportions of nonwhite targets, yielding more erroneous estimates. However, exploring this phenomenon requires additional research.

Table 6.12 - Height Estimation and Social Attribute Ratings by Race/Ethnicity

	Nonwhite		White	
	M (*SE*)	*Adj. M* (*SE*)	*M* (*SE*)	*Adj. M* (*SE*)
Height Estimation	70.04 (0.05)	70.09 (0.09)	70.85 (0.02)	70.83 (0.08)
Height Estimation Error	2.82 (0.02)	2.82 (0.06)	2.67 (0.02)	2.68 (0.05)
Aesthetic Ratings	4.17 (0.03)	4.19 (0.04)	4.63 (0.01)	4.62 (0.04)
Dominance Ratings	4.42 (0.02)	4.44 (0.04)	4.74 (0.01)	4.74 (0.04)

Aesthetic=Attractiveness, Style
Dominance=Income, Status, Leadership

Table 6.13 – Effect of Race/Ethnicity on Height Estimation and Social Attribute Ratings

	df	F	η_p^2	*p*
Height Estimation	1,381	305.48	0.52	<0.001
Height Estimation Error	1,383	12.05	0.05	<0.001
Aesthetic Ratings (Attractiveness, Style)	1,383	268.36	0.46	<0.001
Dominance Ratings (Income, Status, Leadership)	1,364	135.92	0.31	<0.001

Does stance affect height and social perception?

We found reliable main effects between standing targets and walking targets when controlling for targets' actual heights (Table 6.14 and Table 6.15). Specifically, estimates were taller, but less accurate, when the target was walking, and the ratings were higher for walking targets as well.

An interesting finding here is how *implied* motion, in the form of a static image of a walking target, did not yield more accurate height estimates, even though *actual* motion is an important cue for size and distance as we discussed in Chapter 2. Previous research has found similar neural activations when processing actual motion and implied motion

(Kourtzi & Kanwisher, 2000). This suggests that actual motion information, such as optical flow (Gibson, 2014), is key to accurately perceiving size and depth, not just the interpretation of motion.

Table 6.14 - Height Estimation and Social Attribute Ratings by Stance

	Standing		Walking	
	M (*SE*)	*Adj. M* (*SE*)	*M* (*SE*)	*Adj. M* (*SE*)
Height Estimation	70.57 (0.03)	70.44 (0.09)	70.86 (0.03)	71.05 (0.08)
Height Estimation Error	2.56 (0.02)	2.58 (0.05)	2.85 (0.02)	2.78 (0.05)
Aesthetic Ratings	4.51 (0.02)	4.49 (0.04)	4.58 (0.02)	4.63 (0.04)
Dominance Ratings	4.65 (0.01)	4.63 (0.04)	4.71 (0.01)	4.73 (0.04)

Aesthetic=Attractiveness, Style
Dominance=Income, Status, Leadership

Table 6.15 – Effect of Stance on Height Estimation and Social Attribute Ratings

	df	F	η_p^2	*p*
Height Estimation	1,362	262.32	0.40	<0.001
Height Estimation Error	1,349	49.17	0.03	<0.001
Aesthetic Ratings (Attractiveness, Style)	1,382	359.67	0.11	<0.001
Dominance Ratings (Income, Status, Leadership)	1,373	41.24	0.06	<0.001

Does location affect height and social perception?

Focusing on the C+ condition, we found reliable main effects between targets inside and outside when controlling for targets' actual heights (Table 6.16 and Table 6.17). Height estimations were taller for targets outside, but more erroneous, and ratings were higher for targets outside as well.

A possible explanation for erroneous estimates can be that the objects of familiar size outside were more ambiguous than objects of familiar size inside. For example, a bush may have a greater amount of variability in its size than a chair. This ambiguity may have led to more over-estimations in height, accompanied with higher social attribute ratings.

Table 6.16 - Height Estimations and Social Attribute Ratings by Location				
	Inside		Outside	
	M (*SE*)	*Adj. M* (*SE*)	*M* (*SE*)	*Adj. M* (*SE*)
Height Estimation	70.47 (0.07)	70.02 (0.12)	70.66 (0.03)	70.78 (0.11)
Height Estimation Error	2.28 (0.04)	2.31 (0.07)	2.58 (0.03)	2.54 (0.06)
Aesthetic Ratings	4.53 (0.03)	4.49 (0.06)	4.64 (0.02)	4.67 (0.06)
Dominance Ratings	4.68 (0.03)	4.69 (0.07)	4.87 (0.02)	4.93 (0.06)

Aesthetic=Attractiveness, Style
Dominance=Income, Status, Leadership

Table 6.17 – Effect of Location on Height Estimation and Social Attribute Ratings				
	df	F	η_p^2	*p*
Height Estimation	1,253	232.05	0.11	<0.001
Height Estimation Error	1,233	21.62	0.20	<0.001
Aesthetic Ratings (Attractiveness, Style)	1,233	26.12	0.06	<0.001
Dominance Ratings (Income, Status, Leadership)	1,205	50.08	0.22	<0.001

Does the presence of other people affect height and social perception?

Focusing on the C+ condition and controlling for targets' actual heights, we found that height estimations were taller for targets that were alone than targets that were with others, and targets alone were also rated higher on dominance and aesthetics (Table 6.18 and Table 6.19). However, there was no reliable difference in absolute error. We collapsed the targets with men and women for the analyses because there was little difference in the dependent variables as a function of the gender of "others" in the photos: For height estimation [95%CI: man=70.38-70.84; woman=70.35-70.80], for error [95%CI: man=2.44-2.68; woman=2.39-2.64], and for social attribute ratings [95%CI aesthetics: man=4.23-4.69; woman=4.33-4.76; 95%CI dominance: man=4.41-4.93; woman=4.49-5.02].

Our findings appear to contradict the “cheerleader effect” found in previous research (Walker & Vul, 2014), wherein a face is perceived as more attractive when presented in a group than when presented alone. Although the validity of the cheerleader effect is suspect (replication study: Ojiro, Gobara, Nam, Sasaki, & Kishimoto, 2015), it is interesting to note that our study found the *inverse* effect – a “lonely at the top” stereotype. It is also interesting to note that the presence of others did not yield more accurate height estimates. This suggests that other people are not particularly reliable cues of familiar height, an interesting consideration as a person often serves as a reference point to convey scale of large objects or surroundings. It may be the case that a person serves as an accessible cue of size relative to something like a whale, but not a reliable cue when scaled down to other people.

Table 6.18 - Height Estimation and Social Attribute Ratings by Presence of Others

	Alone		With Others	
	M (*SE*)	*Adj. M* (*SE*)	*M* (*SE*)	*Adj. M* (*SE*)
Height Estimation	70.82 (0.05)	70.68 (0.11)	70.48 (0.04)	70.56 (0.11)
Height Estimation Error	2.46 (0.03)	2.50 (0.06)	2.54(0.03)	2.51 (0.06)
Aesthetic Ratings	4.74 (0.03)	4.71 (0.06)	4.53 (0.02)	4.55 (0.06)
Dominance Ratings	4.83 (0.02)	4.82 (0.06)	4.66 (0.02)	4.67 (0.06)

Aesthetic=Attractiveness, Style
Dominance=Income, Status, Leadership

Table 6.19 – Effect of Presence of Others on Height Estimation and Social Attribute Ratings

	df	F	η_p^2	*p*
Height Estimation	1,166	8.95	0.24	0.003
Height Estimation Error	1,164	0.01	0.02	0.90
Aesthetic Ratings (Attractiveness, Style)	1,166	47.58	0.30	<0.001
Dominance Ratings (Income, Status, Leadership)	1,165	52.23	0.29	<0.001

Disadvantaged Groups

Some groups may benefit more than others by appearing taller. Based on previous research, as well as the current work, it is clear that there are costs in ratings of social attributes associated with being shorter and with being nonwhite (at least in the U.S.). In this section, we focus on the effects of outfits specifically on perception of targets that fall into one of these "disadvantaged" groups. We used mixed-model analysis of variance to analyze height estimates and social attribute ratings for just the nonwhite targets and just the shorter targets. To classify a target as "short," we created three stratifications of height: shorter targets (68 inches and below, n=18), targets of medium height (69 inches to 71 inches, n=17), and taller targets (72 inches and above, n=15).

Can clothing help nonwhite individuals?

The effect of outfit on height estimation held when focusing on just the nonwhite targets (Table 6.20 and Table 6.21), wherein monochromatic outfits were perceived taller. We did not find a reliable effect of outfit on social attribute ratings when focusing on nonwhite targets (Table 6.20 and Table 6.21), paralleling the findings discussed earlier. However, it is interesting to note the trending interaction of outfit with race/ethnicity for aesthetics ratings [F(3,380)=2.41, p=0.07, η_p^2=0.02] and dominance ratings [F(3,361)=2.69, p=0.05, η_p^2=0.02]. Relative to other outfits, the DL outfit yielded especially poor ratings for nonwhite targets. Participants may view the DL outfit as more "preppy," and thus more associated with white people, which may have created some dissonance when viewing nonwhite targets. We discuss this possibility further in the general discussion, but the effect we found is weak and may be an outcome of performing many analyses in the exploratory portion of this dissertation.

Table 6.20 – Effect of Outfit Height Estimation and Social Attribute Ratings for Nonwhite targets

	df	F	η_p^2	p
Height Estimation	3,344	3.62	0.05	0.01
Aesthetic Ratings (Attractiveness, Style)	3,344	0.25	<0.01	0.85
Dominance Ratings (Income, Status, Leadership)	3,344	0.52	<0.01	0.67

Table 6.21 – Descriptive statistics (Mean and Standard Error) for Nonwhite targets by Outfit

	Height Estimation	Aesthetic Ratings	Dominance Ratings
Monochrome	70.28 (0.08)	4.19 (0.04)	4.48 (0.03)
DD	70.21 (0.08)	4.24 (0.05)	4.49 (0.04)
LL	70.35 (0.12)	4.15 (0.05)	4.47 (0.04)
Lightness-blocked	69.79 (0.08)	4.15 (0.04)	4.37 (0.04)
DL	69.55 (0.11)	4.13 (0.06)	4.37 (0.05)
LD	70.02 (0.11)	4.16 (0.05)	4.37 (0.05)

Nonwhite individuals can see the illusory effects of taller height estimates for monochromatic outfits, but it does not translate to higher social attribute ratings.

Can clothing help shorter individuals?

The benefit of monochromaticity held when focusing on just shorter targets (Table 6.22 and Table 6.23). Similar to the effects of monochromaticity on social attribute ratings discussed earlier, there was not a reliable effect of monochromaticity on social attribute ratings when focusing on short targets (Table 6.22 and Table 6.23).

Table 6.22 – Effect of Outfit on Height Estimation and Social Attribute Ratings for Shorter targets

	df	F	η_p^2	p
Height Estimation	3,337	8.37	0.06	0.004
Aesthetic Ratings (Attractiveness, Style)	3,337	0.18	<0.01	0.67
Dominance Ratings (Income, Status, Leadership)	3,337	0.33	<0.01	0.57

Table 6.23 – Descriptive statistics (Mean and Standard Error) for Shorter targets by Outfit

	Height Est.	Aesthetic Ratings	Dominance Ratings
Monochrome	70.03 (0.05)	4.27 (0.03)	4.56 (0.02)
DD	69.95 (0.06)	4.23 (0.04)	4.54 (0.03)
LL	70.10 (0.08)	4.30 (0.04)	4.59 (0.03)
Lightness-blocked	69.52 (0.05)	4.23 (0.03)	4.52 (0.02)
DL	69.32 (0.07)	4.22 (0.04)	4.56 (0.03)
LD	69.71 (0.07)	4.24 (0.04)	4.48 (0.03)

Shorter individuals can see the illusory effects of taller height estimates for monochromatic outfits, but it does not translate to higher social attribute ratings.

Chapter 7: General Discussion

Outfits *can* impact the perceived height of an individual, specifically, monochromatic outfits lead to estimates that individuals are taller than when they are wearing non-monochrome outfits. Traditional suits with matching jackets and pants make their wearers appear taller than would be the case with unmatched "separates." This aligns with our prediction regarding monochromatic outfits based on the idea that fewer edges in a stimulus may lead to fewer fixations (uninterrupted scan). Monochromatic suits allow for uninterrupted attentional saccades similar to those discussed in the inverted-T illusion (Chouinard et al., 2017; Kunnapas, 1955).

However, we found no evidence supporting our prediction regarding overall lightness in an outfit. This suggests that the illusions relating to size-depth ambiguity, such as size-lightness illusions, may not be as influential on body height perception as illusions relating to segmentation along the dimension being estimated (vertical extent). For the perceptual studies which were the basis of the “lightness” hypothesis, light (or dark) stimuli were traditionally presented against a simple, solid background, often of the opposite color (Coules, 1955; Kremkow et al., 2014; Westheimer, 2008). Given that every C+ stimulus had a darker background than the C- counterpart and we did not find an interaction of outfit lightness and context, it seems unlikely that we can attribute our failure to replicate the earlier studies to lack of background contrast.

We did not find a main effect of context on height estimation, nor did context interact with outfits for height estimations. However, context did affect the accuracy of the estimates. As we hypothesized, the rich background information in the full context

(C+) condition provided many pictorial cues to assist in more accurate estimates than the C- condition.

The social attribute ratings told a similar story to the height estimation results, but with a few interesting differences. Overall, the relationship between the ratings and estimated heights was moderate, and in the positive direction. This relationship between dependent measures is replicated in most main effects we found within the non-outfit image attributes of race/ethnicity, stance, location, and the presence of others. That is, when these non-outfit factors caused an increase in social attribute ratings we also saw an increase in the target's estimated height.

However, race/ethnicity told an interesting story. Height estimates were more erroneous for non-white targets, but the cultural associations with white status prevailed with white targets seen as taller, more dominant, and more aesthetically pleasing. The more erroneous estimates for non-white targets may have been due to some “other-race” effects. Other-race effects have found that sensitivity to relative spatial features in faces (Kelly et al., 2007) or in bodies (Humphreys et al., 2005) vary depending on the match between the viewer's and target's race. Although we did not collect the race/ethnicity of the participants, the demographics of MTurk users skews white (Chandler & Shapiro, 2016). This means that many participants may have been less familiar with the anthropometric proportions of nonwhite targets, yielding more erroneous estimates.

Furthermore, we found a marginal interaction of race/ethnicity and outfit. The discrepancy in social ratings between white and non-white targets was greatest when the target was wearing a dark jacket with light pants, which may convey a more “preppy” aesthetic. Given the traditional English, “white” associations with “prep” attire dating back to the late 1800s (Flusser, 2002), the higher ratings for white targets are even higher when aligning with the prep uniform, while the lower ratings for nonwhite targets may result from a mismatch between attire and racial stereotypes.

These "appropriateness" or "incongruence" explanations of these interactions of outfit and race/ethnicity may be compatible with other clothing and social psychological theories. Symbolic interaction theory, which largely stems from the philosopher George Herbert Mead (reviews: Reilly, 2014, pgs: 47-49; Roach-Higgins & Eicher, 1992), posits that viewers learn to associate meanings with objects, including clothing. "Context," which here includes anything from the social situation and the culture (review: Reilly, 2014, pgs: 38-39), helps to decipher ambiguous meanings from objects' messages. However, *ambivalence* occurs when there is conflict in messaging (Kaiser, Nagawasa, & Hutton, 1997). In the results described above, there are conflicts in messaging: "white" clothing on nonwhite people. Using the exemplar-based model of social judgment (Smith & Zarate, 1992) suggests that this type of conflict is a conflict of stereotypicality which can impact prejudice (Ramasubramanian, 2011), and prejudice in this dissertation comes in the form of lower social attribute ratings.

Advice Revisited

This dissertation stemmed from observations that people, especially suit experts, discuss aspects of clothing design in ways directly tied to basic, perceptual psychological principles. We reviewed these illusion-inducing suggestions in Chapter 1. Our data appear to support expert claims regarding monochromaticity, wherein monochromatic suits yielded taller estimates than lightness-blocked suits by about half an inch on average. Based on prior modeling of height-income relationships (Judge & Cable, 2004), this half-inch difference translates to approximately $11,857.14 over the course of a 30-year career. This effect of monochromaticity worked for all heights, including shorter individuals. To that end, if someone wishes to appear shorter, then we would suggest *avoiding* monochromatic outfits.

The current data seem to contradict other suggestions by experts. Specifically, the overall lightness of a suit did not have an effect on estimates of height. Based on the psychophysical literature, we would predict that people wearing lighter suits would appear taller. Experts, on the other hand, suggest that wearing darker suits will provide the illusion of greater height. Although there was no reliable difference in perceived height as a function of suit lightness in our research, the trend was opposite that predicted by the experts. There appears to be no reason for shorter individuals to favor darker suits.

It is important to note that, although we found an effect of monochromaticity on height estimation, this did not translate into improvements in social attribute ratings. So, while an individual may appear half an inch taller when wearing a monochromatic suit, the benefits associated with increased height may not apply (e.g., will not appear more attractive). Monochromaticity by itself may not create enough of a change in apparent height to make others view the target more favorably during a limited exposure, but there may be other benefits to a slight change in apparent height. For example, it might change self-perception and self-confidence in the wearer. There might also be other design features that might further amplify the illusion. In the present case, we simply find that wearing a uniform color gives a person approximately an extra half inch in perceived stature. Likewise, a taller person who wants to appear shorter may opt for a "separates" look rather than a traditional monochromatic suit.

Limitations and Future Research

Experimental control is one of the apparent limitations in this study. One control issue arises from utilizing a survey with the MTurk population. The unmoderated, unsupervised nature of this methodology exposes the data collection to a great deal of variability, such as variations in display size and resolution, environmental distractions, and participant motivation. However, MTurk has been shown to be valid for graphical perception research (Heer & Bostock, 2010), and, relative to traditional methods of sampling and recruiting such as introductory psychology students, MTurk provides additional benefits such as a more diverse population (Shapiro, Chandler, & Mueller, 2013).

Another example of a control limitation stems from how we did not manipulate the contexts surrounding targets (other than the overall removal for the C- condition). Future research should include actual manipulations of the background context. The current study used Photoshop to manipulate the outfit of the target, and Photoshop can similarly manipulate the background contextual information for the same interesting comparisons, although some will be easier than others (e.g., removing a person in the background vs. moving the target from outside to inside).

Future research should also explore other outfit manipulations. For a start, there are other suit designs we discuss as potential advice or suggestions from experts and non-experts alike (e.g., pinstripes with different orientations). Furthermore, researchers should explore outfits beyond suits, especially since the formality of the suit has decreased its popularity as a daily outfit in recent years (Guy, 2016). Researchers should also explore dimensions other than height, such as weight or horizontal size.

Additionally, research should explore illusory effects of outfits on other types of stimuli. Firstly, we compiled the targets in this study using existing images of men of known heights, or at least assumed to be known based on internet sources for celebrities' heights. This is a limitation in that participants may have recognized some targets despite the obscured faces, and this knowledge might have biased there estimates in important ways. Furthermore, future research should explore the effects on non-male targets. As discussed in Chapter 3, the anthropometric proportions of a target can provide cues of sex, but understanding the generalizability of the effects seen here are important. Furthermore, outfits like dresses, rarely worn by men, may interact with illusory effects in interesting ways due to their effects on the silhouette. To draw on the "geons" example discussed in Chapter 2, suit trousers are bifurcated to match the geons of the prototypical human form in matching two legs at a feature level. However, a non-bifurcated skirt may obscure these presence of two, distinct legs which may impact the ways humans perceive and interpret the bodies of others. Studying illusions of size in female targets may also be a particular concern given our finding in Phase 1 that women appear to be more informed about, and potentially influenced by, suggestions from experts.

Regardless of manipulations, all stimuli should include full contextual information to maintain the stronger external validity by yielding more accurate height estimates for targets than a target presented void of realistic contextual cues. Also, it is critical that those interested in studying any social biases that may be associated with height to measure perceived height rather than rely on objective height.

Future research should also consider other methodological changes. For example, the current study did not collect race/ethnicity information from participants, so we are unable to confirm any “other-race” effects. Another limitation may have been in the ratings used to evaluate social attribute perceptions, which may not have been sensitive enough to detect perceived differences. An additional scale of formality may have also clarified the effects outfit design. However, an additional limitation in this dissertation is the problem of alpha inflation. We ran many statistical analyses in the exploratory phases of the research, increasing the likelihood of false positives. We feel relatively confident in our primary finding that monochromatic suits make wearers appear slightly taller than outfits that combine dark and light separates (e.g., jacket and pants). We predicted these data based on the opinion of suit experts and the basic psychophysical data.

Conclusion

The scientific merit of this study results from its test of the generalizability of size illusions found in simple, geometric stimuli to illusions induced by clothing design. In particular, we focused on lightness and segmentation manipulations. The lightness manipulation did not translate well to real-world stimuli (people’s clothes), but the segmentation manipulation did. Research exploring illusions in clothing traditionally ignored the influence of contextual cues and anthropometric cues, both of which could constrain the impact of these illusions. Our findings also suggest that the presence of context is more likely to affect the overall accuracy of height estimations rather than directional bias in those estimations. Finding general rules that determine how variation in clothing design influences body perception would provide a step toward predictively modeling body perception in a variety of clothing contexts.

The broader impact of this study can be seen in any domain where perception of height is critical. As discussed earlier, a person’s height can influence the amount of income he or she earns and perception of important social attributes such as leadership skills, attractiveness, and status. The accuracy of height estimation, if reliably influenced by clothing choice, might also help forensic professionals obtain better descriptions of perpetrators from eye witnesses. In short, the findings of this study may indicate that clothing influences the variability of height estimates and perceptions in potentially predictable ways.

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Vita

Michael Patrick Lee

Education

University of Kentucky:
- Ph.D., Experimental Psychology, Spring 2018 (expected)
- M.S., Experimental Psychology, August 2014
- Human-Technology Interaction Certificate, August 2014
- B.A., Psychology, May 2012, Summa Cum Laude

Selected Awards and Honors

2016 Outstanding Graduate Student in Cognition, Learning, and Performance
2012 Graduation- Departmental and University Honors
2012 Outstanding Psychology Major Award
2012 Oswald Research and Creativity Award
2012 Maurice A Clay Award for Outstanding Graduating Senior in College of Arts & Sciences
2011 Summer Research and Creativity Grant

Professional Experience:

Employment

2017 (fall) - present	Senior User Researcher III at Bose Corporation Manager: Polly Tandon (polly_tandon@bose.com)
2017 (summer)	User Researcher II (contractor) at Bose Corporation Manager: Polly Tandon (polly_tandon@bose.com)

Internships

2016 (summer)	Usability Intern at Newell Brands Manager: Noel Simpson, M.S. (noel.simpson@newellco.com)
2014 (fall) - 2016 (spring)	Human Factors Intern at General Electric – Appliances and Lighting Manager: Will Seidelman, M.S. (will.seidelman@gmail.com)
2012 (summer)	Human Factors Intern at General Electric – Appliances and Lighting Manager: Cathy Emery, Ph.D. (cathy.emery@uky.edu)

Research Assistant

2011- present	University of Kentucky Center for Visualization and Virtual Environments Adviser: C. Melody Carswell, Ph.D. (melody.carswell@uky.edu)

Teaching Assistant

'17(sp), '16 (fa), '14(sp+su)	Applications of Statistics in Psychology (PSY 216). University of Kentucky. Professor: Steven Arthur, Ph.D.
'16(sp), '15(fa), '13(sp+fa)	Cognitive Processes Advance Lecture/Lab (PSY 427). University of Kentucky. Professor: Larry Gottlob, Ph.D. & Jonathan Golding, Ph.D.
'12 (fall)	Introduction to Psychology (PSY 100). University of Kentucky. Professor: Jonathan Golding, Ph.D.

Peer-Reviewed Publications

Popham, J., Lee, M., Sublette, M., Kent, T., & Carswell, C. M. (2017). Graphic vs. Text-Only Résumés: Effects of Design Elements on Simulated Employment Decisions. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 61, No. 1, pp. 1242-1246). Sage CA: Los Angeles, CA: SAGE Publications.

Kent, T. M., Carswell, C. M., Lee, M., & Sublette, M. A. (2017). Do Aesthetic Design Principles Predict Visual Appeal of a Simple Control Panel?. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 61, No. 1, pp. 1414-1418). Sage CA: Los Angeles, CA: SAGE Publications.

Chen, H. T., & Lee, M. (2017). Re-designing A Practice Test Into A Game. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 61, No. 1, pp. 1234-1236). Sage CA: Los Angeles, CA: SAGE Publications.

Popham, J., Lee, M., Carswell, C.M., … (2016). Flashy or Functional: The Impact of Graphical Content on the Effectiveness of Résumés. *Proceedings of the 2016 International Annual Meeting of the Human Factors and Ergonomics Society*. Washington, DC

Kent, T. M., Fu, B., Walls, B. D., Seidelman, W., Sublette, M.A., Lee, M., Carswell, C. M. (2016). Does an Abstract Weld Pool Visualization Help Novice Welders Assess the Performance of a Weldbot?. *Proceedings of the 2016 International Annual Meeting of the Human Factors and Ergonomics Society*. Washington, DC

Lee, M., Carswell, C. M., Miller-Spillman, K., & Sublette, M. (2015). Clothing & HF/E: A Hedonomic and Eudaimonic Look at the Original Wearables. *Proceedings of the 2015 International Annual Meeting of the Human Factors and Ergonomics Society*, Los Angeles, CA

Lee, M. P., Carswell, C. M., Seidelman, W., & Sublette, M. (2014). Environmental Control Issues in a New Energy-Efficient Building. *Ergonomics in Design: The Quarterly of Human Factors Applications*, *22*(4), 8-14.

Lee, M. P., Kent, T., Carswell, C.M., Seidelman, W., & Sublette, M. (2014). Zebra-Striping: Visual Flow in Grid-based Graphic Design. *Proceedings of the 2014 International Annual Meeting of the Human Factors and Ergonomics Society*, Chicago, IL

Seidelman, W., Carswell, C. M., Kent, T., Lee, M., Fu, B., & Yang, R. (2014). User Centered Design of a Hybrid-Reality Display for Weld Monitoring. *CHI '14 Extended Abstracts on Human Factors in Computing Systems.* Toronto: ACM.

Seidelman, W., Carswell, C. M., Kent, T., Lee, M., Fu, B., & Yang, R. (2014). Development of a Hybrid Reality Display for Welders through Applied Cognitive Task Analysis. *Proceedings of the Human Factors and Ergonomics Society 58th Annual Meeting*. Chicago, IL: Human Factors and Ergonomics Society.

Lee, M., Carswell, C.M., Seidelman, W., & Sublette, M. (2013). Green Expectations: The Story of a Customizable Lighting Control Panel Designed to Reduce Energy Use. *Proceedings of the 2013 International Annual Meeting of the Human Factors and Ergonomics Society*, San Diego, CA: The Human Factors and Ergonomics Society

Sublette, M., Carswell, C.M., Seidelman, W., Lee, M., & Seals, W.B., (2013). Further Explorations of the “White Space” Bias in Users’ Anticipation of Task Workload. *Proceedings of the Human Factors and Ergonomics Society 57th Annual Meeting*. San Diego, CA: Human Factors and Ergonomics Society.

Crouch, J., Lee, M., Carswell, C.M., Patrick, T., Seidelman, W., & Sublette, M., (2013). The Impact of Aesthetic Design on Bus Shelter Usability. *Proceedings of the Human Factors and Ergonomics Society 57th Annual Meeting*. San Diego, CA: Human Factors and Ergonomics Society.

Lee, M., Carswell, C.M., Seidelman, W., & Sublette, M. (2012). The design of product comparison tables and its effects on decision making. *Proceedings of the 56th Annual Meeting of the Human Factors and Ergonomics Society,* Boston, MA: The Human Factors and Ergonomics Society