MEASURING NEURAL RESPONSES OF APPAREL PRODUCT ATTRACTIVENESS

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This is dedicated to my role model, inspiration,
friend, and mother – *Audrey Touchette*.
Thank you for your endless support, love, and strength.

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ABSTRACT

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Neuromarketing is the process of analyzing marketing dilemmas or complexities through brain wave collection. One of the most widely used theories to study neuromarketing is frontal asymmetry theory (Davidson, 1984), which states that positive affects and approach behaviors are localized in the left frontal hemisphere, while negative affects and avoidance behaviors show greater activation in the right frontal hemisphere. The present study used EEG brain wave analysis to record participant reactions to attractive and unattractive apparel products, using the frontal asymmetry theory as the theoretical framework. A sample of 17 female university students was connected to electrodes while watching a slideshow presentation of attractive and unattractive apparel products. Results of this study show that statistically significant (P<0.05) frontal asymmetry existed when participants viewed attractive and unattractive apparel products. This study is significant because it opens the door for EEG brain scanning to be used as a metric for measuring consumer reactions.

TABLE OF CONTENTS

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

DEFINITION OF TERMS

Alpha Power: the sum of all data points in the range from 8 to 13 Hz per time unit, which has an inverse relationship to cognitive activity (Smit et al., 2007)

Amplitude: the height of an electrical or EEG wave; typically measured in microvolts (Demos, 2005)

Artifact: any recorded signal in EEG which does not originate in the brain (Duffy et al., 1989)

Brain: the highly complex organ responsible for the thoughts, feelings, decisions and actions of all human beings (Pradeep, 2010)

Electrode: a small metal cup that is placed directly on the scalp to measure EEG recordings (van de Velde, 2000)

Electroencephalography (EEG): noninvasive neuro-imaging equipment which uses very small and highly sensitive electrodes to record the electrical signals produced by brainwave activity (Pradeep, 2010)

Emotion: a subjective, unconscious experience characterized primarily by psychophysiological expressions, biological reactions, and mental states (Gaulin & McBurney, 2003)

Frequencies: EEG signal is amplified and filtered by band-pass filters that separates raw signals into smaller parts or lengths; typically measured in hertz (Demos, 2005)

Frontal Asymmetry: when an uneven activation occurs between the left and right frontal lobes (Davidson et al., 1990)

Lateralization: when one hemisphere of the brain specializes in a task greater than the opposing hemisphere (Kalat, 2013).

Marketing: the process of matching products with people by ensuring the designs and presentations or products are compatible with consumer preferences (Ariely & Berns, 2010)

Neuromarketing: the use of clinical information about brain functions and mechanisms to measure and explain what is happening inside the mind of the consumer (Fugate, 2007)

Neurons: the basic working units of the brain and the central nervous system designed to transmit information to other nerve, muscles, or gland cells (Pradeep, 2010)

Product Attractiveness: the level of hedonic satisfaction from the form or appearance of a product (Bloch, 1995)

Wave: the visual representation that is associated with electrical activation and deactivation of neurons, which cycle continues up (peak) and down (trough) (Demos, 2005)

Synapses: the points between neurons where contact and communication between neuron cells are made (Pradeep, 2010).

CHAPTER I

INTRODUCTION

The former director of Harvard's Laboratory of Neurophysiology, J. Allan Hobson, once stated that, "we are our brains and our brains are us. The more we learn about the brain-mind, the more we learn about the nature of our selves," (Hobson et al., 1999, p. xi). The quote by Hobson can be seen as an overarching goal of the field, neuromarketing. By using neuroscientific methods to solve the complexities of the marketing world, this budding field has the potential to dive deeper into the thoughts and emotions of consumers. Neuromarketing is defined as the applications of neuroscience methods to analyze and understand human behavior in relation to marketing (Wilson et al., 2008). Since its birth 30 years ago, the neuromarketing field has been aiding industries, such as economics, advertising, and product development, through research on topics such as product policy, pricing, communication, and branding. Specially, neuromarketing focuses on analyzing consumers' emotional responses to various pieces of the marketing mix (Morin, 2011). Emotions are the gatekeeper to further processing in the human brain. Emotions outweighed cognitive factors in explaining planning behaviors. Emotions have a direct influence on individual's behaviors, whether it is what to wear that day, or what to purchase at the store (Morris et al., 2002). Therefore, neuromarketing research attempts to study emotions to broaden the insight of the consumer purchasing process.

Traditionally, if a company wanted to analyze the reactions of consumers to their products, they would use market research methodologies such as focus groups, interviews, or surveys. These traditional research methods, which rely very heavily on self-report from the subject, typically hold some type of bias (Ariely & Berns, 2010; Fugate, 2007; Morin, 2011). It is very difficult for a consumer to explain their *true* feelings about a product due to several factors such as embarrassment, haste, or they just don't know how to clearly communicate their opinion (Ariely & Burns, 2010). Using neuromarketing approach, consumers' subconscious reactions can be measured by recording brain reactions. Before any physical human reaction occurs, fluctuations in brain activity take place (Fugate, 2007). By collecting these neural impulses from consumers, it is possible to analyze the immediate emotion behind their behavior. In order to study these spontaneous reactions of consumers, neuromarketing typically uses electroencephalography (EEG) because of its high temporal resolution and strong validity and reliability in measuring emotions (Morin, 2011). EEG works by quantifying the electrical impulses when the brain is activated. The collection of these impulses is done using sensors, which are called electrodes.

The apparel industry has highly inundated the marketplace with brands, product choices, and styles for consumers. By analyzing consumers' insights through a neuromarketing approach, the apparel industry could be streamlined to create, advertise, and sell products that directly fit with the consumerdesires. While there have been many studies that have researched apparel attractiveness using conventional methods, there is a void in neuromarketing research where apparel product attractiveness must be address. Therefore, the purpose of the present study is to apply the well-developed frontal asymmetry theory to measure apparel product attractiveness using EEG technology. The frontal asymmetry theory maintains that each hemisphere of the brain, left and right, is specialized for positive emotions-approach behaviors and negative emotions-avoidance behaviors accordingly (Davidson, 1984). When one of the hemispheres elicits a stronger reaction, it is said that emotional hemispheric asymmetry is demonstrated. This study attempts to explore if hemispheric asymmetry actually exists when consumers view apparel products they feel are attractive and unattractive. By researching consumers' neurological reactions to apparel products, this study will reveal if the frontal asymmetry theory can be applied in analyzing product attractiveness within the fashion industry.

CHAPTER II

LITERATURE REVIEW

Nervous System and Brain Structure

The human brain is one of the most intricate and detailed organs in the human body. This complicated network of nerves and cells controls every decision that people make on a daily basis. Therefore, the study of the nervous system, called *neuroscience*, is crucial to the research of consumer decision-making.

The scope of neuroscience can include studying the nervous system on multiple levels, including molecular, cellular, functional, and medical aspects. The nervous system controls thoughts, motions, and feelings throughout the entire body. The nervous system itself can be broken down into two main sections: the central nervous system and the peripheral nervous system (Demos, 2005). The central nervous system includes the entire brain and the spinal cord. The peripheral nervous system retrieves the information from the spinal cord and is responsible for delivering it to the rest of the body. This is accomplished through the network of nerves that surround the brain and spinal cord. The central nervous system is further subdivided into somatic and autonomic nervous systems. The somatic nervous system is in charge of all voluntary actions that humans may carry out while the autonomic controls the involuntary actions that happen in the body (Williams & Herrup, 1988). To further organize its duties, the autonomic nervous system is broken down into the sympathetic and parasympathetic nervous system (Demos, 2005). These two systems work together to control actions that people carry out through a series of activation messages. These are delivered from the sympathetic nervous system, and deactivation messages that are sent from the parasympathetic nervous system. This back-and-forth coordination helps various muscles and limbs understand how and when to stop moving. By understanding the central and peripheral nervous systems, neuroscience research can understand the production, transference, and execution of the human thought process.

To further understand the transference of information and thoughts, there must be a deeper understanding of the brain and all of its components. The most prominent part of the brain for functioning is called the cerebrum (Whitehead, 1900). The cellular layers on the outermost part of the cerebrum are called the cerebral cortex (Demos, 2005). In general, the cerebral cortex is responsible for higher-level functions in all mammals. This is divided into four lobes, which have names that correspond with the cranial bones that are located above them. These lobes, which are shown in Figure 1, are the frontal lobe, parietal lobe, occipital lobe, and temporal lobe (Demos, 2005; Whitehead, 1900). The occipital lobe is located at the back, or *posterior*, end of the cortex. This area is the hub for visual information that enters the brain. When a stimulus is taken in through the eyes, it is delivered to the occipital lobe where it develops meaning and experience for the person. Severe damage or destruction to this area can cause cortical blindness, even if they have functioning eyes (Kirtley & Sabo, 1983). People with this condition cannot imagine visual scenes because their occipital lobe cannot comprehend the information (Kalat, 2013). Located in front of the occipital lobe, is the parietal lobe. Receptors in this area of the brain receive information from muscles and joints all over the body, which results in physical feelings or sensations (Whitehead, 1900). This area converts these sensations into spatial information and even some numerical information for comprehension (Kalat, 2013). Located below the occipital lobe is the temporal lobe. This portion of the brain is essential for understanding auditory material. The type of processing that this area gives humans includes hearing, language, and highly advanced visual capabilities, including perception of movement and recognition of human faces (Carter, 2009; Kalat, 2013). The fourth lobe that constitutes the cerebral cortex is the frontal lobe. Planning of movements, recent memories, and some aspects of emotions are all stored in this lobe (Carter, 2009). The frontal lobe specifically has been an area of interest for consumer behavior research. This is because this lobe holds the majority of the brain's dopamine-sensitive neurons, which have a strong effect on motivation and emotions. Dopamine is as neurotransmitter that is released by the brain to give a rewarding or pleasurable sensation (Carter, 2009). The more dopamine the brain releases, the more likely it is that a person will repeat the action that initiated this feeling. This effect could create a routine or pattern for an individual over time. Therefore, consumer researchers strive to discover more about the frontal lobe, dopamine releases, and how this emotional pattern could potentially be applied to a product or brand. The prefrontal cortex is located in the front portion, or anterior portion, and is the densest part of this lobe giving it extreme importance and capabilities to hold information (Whitehead, 1900). This area can be attributed to human attention, memory, social awareness, character, motivation, and planning (Demos, 2005).

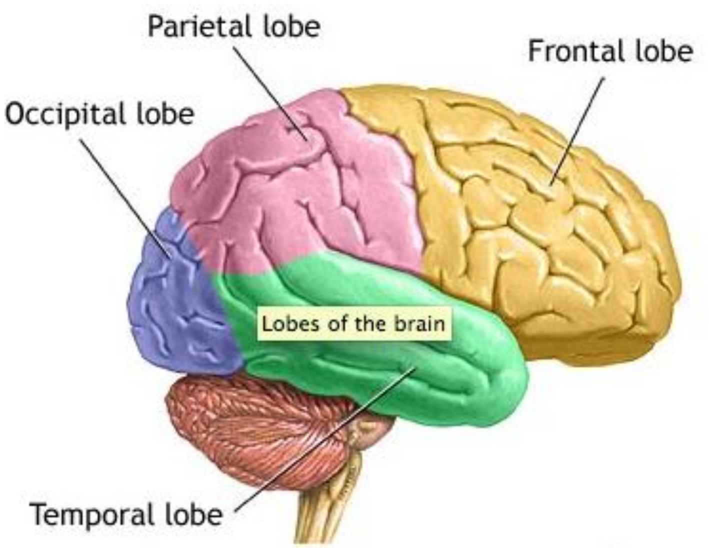

Figure 1. The Lobes of the Brain (University of Maryland Medical Center, 2008)

Beneath these four lobes lies the limbic system, which is integral in developing emotions and memory (Carter, 2009). The limbic system includes the hypothalamus, thalamus, hippocampus, and amygdala (Carter 2009). The thalamus is a pair of structures that processes sensory information before the output is sent to the cerebral cortex. Just below the thalamus is the hypothalamus, which is responsible for survival functions and is the center of communication for the autonomic nervous system. Between the thalamus and the cerebral cortex sits the hippocampus. This large structure is critical for storing specific types of memories that include details of individual events. Lastly, the amygdala controls a multitude of emotional responses. Many nerves in this area establish feelings of fear, anxiety, rewards, punishments, and even surprises (Carter, 2009). The limbic system forms a border around the brain stem, which is located at the back of the brain, sometimes referred to as the *hindbrain*. The stem holds up the brain and contains the reticular activating system and is also responsible for regulating sleep and wakefulness.

Holistically, it is critical to understand the brain and its functions in order to fully grasp consumer behavior. By looking into specific sections of the brain, especially the frontal lobe, researchers have the opportunity to delve into a deeper discussion on consumer thought process, purchase motivation, and the emotions behind product selection.

Brain Communication

With all of the various structures and components of the nervous system, it is difficult to understand how communication can occur in such an efficient manner. The answer to this question begins with the two types of cells that make up the nervous system: neurons and glia.

A neuron is the most basic unit of communication and has the sole function to receive and transmit information to other cells. They are structurally composed of dendrites, a cell body (soma), an axon, and presynaptic terminals, which are shown in Figure 2. To begin the journey of information transfer, the first piece to discuss is the dendrites. These branching fibers are lined with synaptic receptors to reach out and receive messages from other neurons (Hockenbury, 2010). If dendrites have a greater surface area, then they are able to receive and communicate more with others. From there, information is given to the cell body, also known as the *soma*. This structure contains the nucleus, ribosomes, and mitochondria, which carry out most of the metabolic work for the cell to have energy (Hockenbury, 2010). After moving through the soma, data is transferred to the axons. These long and thin fibers are the information senders for the neuron. A neuron can have countless dendrites, but only contains one axon. For this reason, axons are very long and can reach about a meter in length. Axons are covered with an insulating material that is called a myelin sheath, which helps the speed and accuracy of the messages traveling through it. Small branches stick out from these long axons and form presynaptic terminals, also called end bulbs, boutons, or terminal buttons (Kalat, 2013). No matter how they are referenced, these swelling points are where the axons release chemicals to cross between neurons that are receiving the messages.

Though they carry out the same process, neurons can be divided into two basic types: motor neurons and sensory neurons. Information that travels through motor neurons is going away from the central nervous system and into muscles all around the body (Hockenbury, 2010). The signals that wire through these neurons come from the motor cortex, which is located in the back or posterior portion of the frontal lobes. Sensory neurons are specially produced to be very sensitive to stimulation from light, sound, and touch sensations (Carter, 2009).

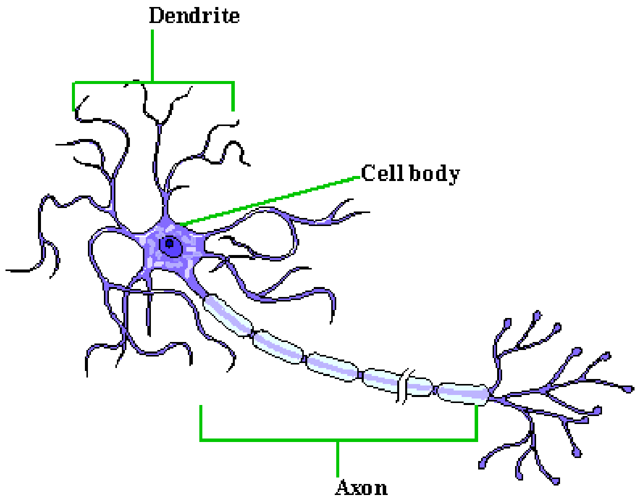

Figure 2. Diagram of a Neuron (Pradeep, 2010)

Another unit within the nervous system is called glia. Glia, or *neuroglia*, is much smaller than neurons and more plentiful in the nervous system. One of the functions that glia perform is helping to synchronize the activity of axons (Kalat, 2013). This is performed by glia wrapping around the presynaptic terminals of axons and assisting in the message sending. Another major function they carry out is removing the waste that is created by neurons (Carter, 2009). This includes removing dead neurons, reabsorbing transmitter chemicals, and even viruses and fungi (Carter, 2009).

Neuronal communication, carried out by motor neurons, sensory neurons, and glia, can transpire in either an electrical, chemical, or a combination of the two called an electrochemical reaction. When a neuron has no disturbances, it remains at a polarized level, which means that there is a stable and equal electrical charge inside and outside of the cell (Hockenbury, 2010). This charge is known as a resting potential of a neuron (Kalat, 2013). When an electric nerve impulse, or *action potential*, is generated it travels from the soma to the presynaptic terminals (Kalat, 2013). Action potential is simply used to denote any type of message that is being sent to another neuron. Now that the nerve is stimulated, it no longer has equal electrical levels, and it is therefore called depolarization. To have an effective stimulation, the action potential must break the neuron's threshold of excitement. If the impulse is too weak, it will stop in an all-or-nothing fashion, which is called the *all-or-none law* in neuroscience (Kalat, 2013). Besides the electrical impulses in the chain reaction of action potentials, there are also very important processes that involve the body's sodium and potassium channels. When the axon surpasses its threshold of excitement, both the sodium and potassium channels open in the neuron. Sodium ions then rush into the axon, which gives an overwhelming positive charge to the axon. This allows the sodium channels to open until the peak of the action potential takes place (Carter, 2009). Due to the depolarized state of the axon, potassium ions force the potassium gates to reopen so they can exit. After a few milliseconds, the action potential ends and the channels are closed and enter a refractory period (Hockenbury, 2010). During this period, cells will not allow any further action potentials, which helps the neuron fully regain its polarization. This can last anywhere from 1 to 4 milliseconds, depending on the individual (Kalat, 2013).

The process of action potentials represents the electrical portion of the electrochemical reaction of neuronal communication, while synapse and neurotransmitters involve chemical reaction of the communication system. Synapse refers to the gap between neurons where neurotransmitters are released (Kalat, 2013). There are about 100 chemicals that are believed to be neurotransmitters, which help code the specific messages traveling through neurons (Carter, 2009). When the action potential impulse makes its way through the axon it enables calcium molecules to enter at the presynaptic terminal. The calcium helps the release of the neurotransmitters from a small sac at the end of the terminal, called a vesicle, so they can catch onto the receptors of the receiving, or *postsynaptic neuron* (Hockenbury, 2010). The neurotransmitters are coded for a specific type of message or action for the postsynaptic neuron to carry out. The major categories of neurotransmitters include amino acids, monoamines, acetylcholine, neuropeptides, purines, and gases (Kalat, 2013).

The neuronal process involves electrochemical reactions, which occurs every time the human brain encounters stimuli. For example, when a consumer views a piece of clothing, action potentials are being fired for different types of processes. These could include approaching the product if the consumer thinks it is fashionable or attractive, or rather looking away and directing attention elsewhere if it is deemed unattractive. In either situation, action potentials are fired and breaking threshold of excitement, and giving the atom a depolarized state, forcing the body to have a reaction. Neurons would also be discharging synapse and various neurotransmitters to alert the brain to the type of stimulus, and also to make conclusions on further actions. Therefore, it is essential to understand the process of action potentials in order to fully grasp the process of consumer decision-making. By studying this concept, it is possible to recognize the outcome of purchase intention by researching the pathway of reactions in the brain.

Brain Lateralization

The cerebrum of the brain is divided into right and left hemispheres. It is a well-documented fact that both right and left hemispheres of the human brain are not created equal (Demos, 2005). When one hemisphere specializes in a task greater than the opposing hemisphere, it is called *lateralization.* The term lateralization also is used in conjunction with *brain asymmetry*, which refers to activation in one hemisphere being greater than the opposing hemisphere. The origin of lateralized specialization is thought to stem from a combination of evolution, heredity, development, experiences, and pathological factors (Toga & Thompson, 2003). There is even evidence of this in fetuses at about 29 to 31 weeks of gestation (Toga &

Thompson, 2003). To fully understand differences of each hemisphere, it is important to recognize how they interact and connect to the rest of the body. The left hemisphere of the cerebral cortex is attached to almost all skin receptors and muscles on the right side of the body. On the other hand, the right hemisphere is connected most parts of the left side of the body (Demos, 2005). The only exception to this is the trunk and facial muscles, which are controlled by both hemispheres (Kalat, 2013). Since the majority of people are right-handed today, many individuals have a strong left hemisphere dominance (Demos, 2005).

There are also certain differences in these hemispheres due to growth and development of the brain. For example, the right hemisphere typically protrudes towards in front of the left hemisphere. This leaves the left hemisphere normally sticking out in the back of the brain. Also, the right frontal region has been found to be wider than the left frontal region (Toga & Thompson, 2003). It is also known that men and women have differences in lateralization. This is mainly because women's brains have a thicker corpus callosum, which increases the communication between the two sides of the brain. Many researchers relate this to women having an easier time expressing and understanding interpersonal emotions (Demos, 2005).

Not only are the right and the left hemispheres different anatomically, but also by the functions that they perform. One of the earliest discoveries in brain lateralization dealt with the specialization of the left hemisphere and language development. Broca's area and Wernicke's area have even been named in the left hemisphere as two of the most influential places for language comprehension in humans (Toga & Thompson, 2003). Since the left hemisphere coordinates with the usage of the right side of the body, there is a common understanding that right-handed individuals often have a sense of language and speech comprehension (Stone et al., 1996). Other functions that the left hemisphere has been linked to are logic, math, analytical reasoning, reading, writing, grammar, spelling, and verbal memories (Demos, 2005). Therefore, if a subject shows strong left hemisphere activation during a decision, scientists could conclude that their brain is making a more logical or rational decision (Stone et. al., 1996). Damage to this hemisphere generally results in people who have language conditions such as aphasia, paraphasia, and alexia, and also difficulty with logic, math, and judgment problems.

In contrast, researchers have discovered that the right hemisphere is closely tied to recognizing emotions, music comprehension, creativity, visual-spatial processing, facial recognition, and empathy (Beeman & Chiarello, 1998). When a strong presence of the right hemisphere is shown, it can be stated that a person is making a more emotional decision or thought process. If there is damage to this area of the brain, people tend to be monotone, unable to recognize expressions, and may not be able to understand humor or sarcasm (Beeman & Chiarello, 1998). When split-brain subjects were asked to recognize emotional difference of photos, the right hemisphere held the dominant answer (Stone et al., 1996). Another large responsibility of the right hemisphere is determining spatial relationships (Beeman & Chiarello, 1998). A study in 1993 documented the struggles of a young woman who had right hemispheric damage and her trouble navigating her way through her own house (Clarke et al., 1993).

Overall, it can be stated that there is long-standing research to substantiate the fact that each hemisphere has specific functions that it is responsible for. This body of research clarifies the functions and qualities of each hemisphere, benefitting multiple research disciplines. Specifically, marketing studies that measure brain asymmetry may use this information to better understand the thought process of their subjects. These studies helped to reveal new aspects of consumer behavior and pave the way for deeper understanding in why consumers behave the way they do.

Theoretical Framework

Emotions are brief, difficult to control, and involve a vast number of systems in the human body such as muscle activity, facial movements, vocal changes, and shifts in the autonomic, endocrine, and central nervous system (Davidson, 1984; Ekman, 1980; Izard, 1997; Tomkins, 1980). Emotions have a critical role in the decision making process for all humans. Affects and emotions directly influence day-to-day attitudes and thought process (Morris et al., 2002). Before any cognitive thoughts or behaviors are made, people develop emotions first, which then forms the basis for rational thinking, and eventually results in a behavior (Poels & Dewitte, 2006). Therefore, cognition and emotions are interdependent of each other, and research must reflect this relationship. While most previous studies focus on consumers' cognitive process (Poels & Dewitte, 2006) using measures of consumers' cognitive verbal or written responses, the emotions that occurred previous to cognitive process are actually the gatekeeper to gain deeper insights into the whole process of consumer decision-making. As emotions are the basis for behaviors and intent, the portions of the brain that control emotions must be clarified and understood.

Frontal Asymmetry Theory

The frontal lobe has been of particular interest in studying emotions because of its relationship with the neurotransmitter, dopamine. The majority of the brain neurons that contain the neurotransmitter dopamine are held in the frontal lobe. Emotional decision-making is based on the release, or lack thereof, of this particular neurotransmitter. Emotions that release a lower amount of the neurotransmitter dopamine produce an avoidance behavior. An emotion that displays a high level of dopamine release can result in approach behaviors, which result in repetition or patterns, like purchase intention and brand loyalty. From a muscular standpoint, there is even more support for the importance of the frontal lobe in emotional research. When a person displays approach behavior, they typically execute muscle movements to be closer or investigate the situation. This type of action is controlled by fine motor skills, which is responsible by the left-frontal region of the cerebral cortex. Correspondingly, avoidance behaviors, which are usually instinctive and automatic (Davidson, 1982), have found to be predominantly controlled by the right hemisphere (Luria & Simernitskaya, 1977).

One of most notable neurological theories in emotion is the frontal asymmetry theory, developed by Dr. Richard Davidson (Morin, 2011). Davidson's frontal asymmetry theory, which originated in the mid 1980's, posits that the anterior, or *frontal,* regions of the left and right hemispheres are lateralized in positive emotion-approach and negative emotion-withdrawal behaviors (Davidson, 1984, 1992a, 1992b, 2002, 2004). The significance and strength of Davidson's theory comes from the combination of the emotional valence model and motivational direction model. The hemispheric lateralization is observed because emotions contain approach or withdrawal elements. In other words, emotions are associated with right or left asymmetry depending on the complemented approach or withdrawal behavior. By combining these two models, Davidson has proven that the activation in the left frontal hemisphere is related to positive affects and approach behaviors and the activation in the right frontal hemisphere is associated with negative affects and withdrawal behavior (Davidson, 1984; Tomarken et al., 1990).

Most of early research on the frontal hemispheric lateralization began in clinical studies of brain damage or severe depression (Davidson, 1984). Findings of these clinical studies showed that patients with left hemispheric damage displayed more negative affects (Alford, 1933; Goldstein, 1939; Robinson & Benson, 1981; Sackeim et al., 1982) and lesions, or injuries, to the right frontal hemisphere led patients to display emotions such as happiness, euphoria, frequent laughing and joking (Denny-Brown et al., 1952; Gainotti, 1969; Sackeim et al., 1982). Likewise, other previous clinical studies found that depressed subjects presented a much stronger activation in the right frontal hemisphere than the left frontal hemisphere (Flor Henry et al., 1979; Perris & Monakhov, 1979; Schaffer, Davidson, & Saron, 1983). Lateralization of the left and right-frontal hemispheres was further validated by studies conducted on normal populations. For example, Davidson et al. (1990) utilized EEG on the left and right frontal locations to demonstrate significant asymmetrical activation during emotional films. The sample was individually tested using positive and negative films that lasted approximately 60 seconds in length. When participants reported that they were happy during the film clips, there was a much greater activation in the left hemisphere. The right hemisphere showed significant activation when subjects reported feelings of disgust during the clips.

Some of the most fascinating research that demonstrates the asymmetrical relationship between right and left hemispheres come from Davidson’s work with infants (Davidson, 1984; Davidson & Fox, 1982; Fox & Davidson, 1987, 1988). Many of these studies evaluate approach and withdrawal activities along with affect, as the frontal asymmetry theory posits that emotions contain these behaviors. For example, activation in left and right frontal locations was recorded as the infants were alone, when their mothers entered the room and approached them, and when a stranger entered the room and approached them. When their mothers entered the room, significant activation in the left frontal hemisphere was shown. Not only that, but the infants facial expression markedly changed along with their arms literally reaching out towards their mother. The movement of the arms is a very explicit demonstration of an approach behavior.

When the infants were alone, significantly higher right activation was shown, along with crying. As strangers entered the room, the infant's facial expression shifted, along with higher right frontal activation.

There have been a multitude of other studies that support Davidson's frontal asymmetry theory, giving it firm reliability in the neuromarketing field. Tomarken, Davidson, Wheeler, and Kinney (1992) constructed an EEG experiment of considerable sample size (N=90) to further ground this theory. Using a scale titled, PANAS-GEN, respondents rated 20 emotional descriptors according to how they generally felt. Significant test-retest and internal consistency reliability supported that subjects with higher left-frontal activation reported positive affects, including enthusiasm, pride, and excitement, and less negative affects. The opposite pattern for relatively higher right-frontal activation also proved statistically significant (Tomarken et al., 1992). Similarly, Wheeler et al. (1993) validated Davidson's frontal asymmetry theory using EEG by instructing subjects to watch several film clips, which all varied in seriousness, humor, and context. Participants completed paper-and-pencil surveys at the pre-film stage, during the film, and post-film. By matching the results of paper and pencil surveys with the hemispheric activation from EEG analysis, they reinforced that higher left frontal activation correlated with intense positive emotions and higher right frontal activation with intense negative emotions (Wheeler et al., 1993). More recently, Vecchaito et al. (2011) using TV advertisements as the stimuli confirmed the frontal asymmetry theory. Participants (N=11) were shown commercial video clips that varied subject matter, and asked to record the pleasantness they felt while viewing. The activity in the left frontal cortex, particularly in the alpha band, was positively correlated with high marks of pleasantness. Conversely, the right frontal hemisphere showed greater activation than the left during clips that participants rated "unpleasant".

In summary, using multiple methodologies and subject bases, including showing videos, images, facial expressions, or normal versus depressed populations, Davidson and his colleagues have confirmed that positive emotions-approach behaviors have consistently shown higher activation in the left frontal hemisphere, while negative emotions-avoidance behaviors spike activation in the right frontal hemisphere while employing EEG (Davidson & Fox, 1992; Davidson, 2004; Elliot & Covington, 2001; Henriques & Davidson, 1991; Wheeler, Davidson, & Tomarken, 1993). This pattern of differential hemispheric activation has been found in a variety of population samples such as depressives (e.g. Davidson, Schaffer, & Saron, 1985; Perris & Monakhov, 1979), normal adults (e.g, Ahern & Schwartz, 1985; Davidson, Ekman, Saron, Scnulis, & Friesen, 1990; Tucker, Stenslie, Roth, & Shearer, 1981) and infants (e.g.,Davidson & Fox, 1982; Fox & Davidson, 1987). In accordance with Davidson's frontal asymmetry theory, this study seeks to examine if the left or right frontal hemisphere is dominant while viewing of apparel products that have varying levels of attractiveness. The research hypothesis is as follows:

H1: There is an existence of frontal brain asymmetry when viewing attractive and unattractive apparel products.

Neuromarketing

Over the past 30 years, psychophysiological measurements have embarked on a whole new field in marketing. Neuromarketing, which was devised by Professor Ale Smidts of Erasmus University in 2002, is defined as the use of neuroscience techniques to aid in solving marketing problems (Hubert & Kenning, 2008; Lewis & Bridger, 2005). Though the term "*neuromarketing*" was detailed only 11 years ago, research in this field began in late 1990's with studies headed by Gerry Zaltman at Harvard University (Lewis & Bridger, 2005). Another closely related term is *neuroeconomics*, which is defined as analyzing the neural correlates of the financial decision making process (Hubert & Kenning, 2008).

Zaltman's book, *How Customers Think*, chronicles the early experiments that demonstrate how useful and pertinent it is to blend consumer studies and psychophysiology together (Zaltman, 2003). He explains that 95% of the human decision-making process is subconscious, and therefore cannot be detected by traditional methods of research. Though paper-pencil surveys, questionnaires, focus groups, and other subjective measures have been effective for many years, they do not track and detail the initial reactions that occur during a consumer's thought process (Lewis & Bridger, 2005). When a consumer is deciding on a product or thinking about a choice, there are hundreds of subconscious messages running through their head that they can't articulate through a traditional method (Ariely & Berns, 2010). Using traditional methods of research, a subject must reiterate and interpret their own thoughts before responding, which involves the conscious mind making decisions and could possibly miss capturing what their true feelings are. Hubert and Kenning (2008) emphasizes broadening the research methods of consumer behavior and exploring the vast potential and fascinating alternatives that could possibly be found.

However, there are some cautions about using neuromarketing for any field. Neuromarketing research could possibly make consumers feel vulnerable, and potentially exploited, due to the amount of data that is being collected from their brain (Fugate, 2008). Personal privacy and fear of being "brain washed" is a strong reason why the field isn't growing particularly fast. Other challenges of neuromarketing include costly equipment and relatively complex data analysis. Despite arguments that neuromarketing may be too complicated or costly, Zaltman (2000) maintains that this field can open the door to unbiased and unfiltered opinions of consumers on products, advertisements, and other marketing decisions. Between the time that humans sleep and are active during the day, conscious thoughts only fluctuate about 10 to 20% in the brain (Zaltman, 2000). If conscious processes are not the dominant state of human brains, then why have consumer research methods been limited to only studying them? By using neuromarketing techniques, subjects won’t have to worry about detailing their emotions because their inner thoughts, which stem from immediate unbiased reactions in their brain, are being recorded (Fugate, 2007). Therefore, it is critical that the mind must be studied further in order to fully understand the insights of consumers.

Current Applications in Neuromarketing

The traditional marketing mix including product, price, communication, distribution policies, and branding helps corporations to determine the offerings and features of an existing or emerging products. Neuromarketing can aid each one of these categories by discovering a consumer’s true emotions and opinions of a product (Hubert & Kenning, 2008). A review of the advancements in neuromarketing has been divided by each piece of the marketing mix to demonstrate the absolute need to continue this type of research.

Product policy incorporates all decisions that satisfy the needs and demands of the target consumer, therefore making it one of the most important elements of the marketing mix (Cooper, 1979). The traditional measure of research in this area is self-reports, but has shortcomings in revealing a consumer’s true opinion about a product. In fact, self-reports commonly contrast the actual emotions of subjects because they cannot correctly reconstruct and interpret their own thoughts onto a survey item (Bagozzi, 1991). Neuromarketing on product policy allows companies to correctly identify optimal product and advertising design in accordance with their customer's preference. For example, Erk et al. (2002) examined how product design affects the brain of the consumer. Using the fMRI, pictures of several cars including sports cars, limousines, and smaller cars were evaluated by consumers on their perceived attractiveness. It was found that the attractiveness of the car was positively related with activation of the nucleus accumbens. Erk et al. (2002) also concluded that assuming there is a relationship between a consumer's thoughts of attractiveness on a product and purchasing decision, the activation of the nucleus accumbens could potentially be seen as an indicator for prediction purchase intention. Britt (2004) also confirmed that there was a connection between product policy and neural activation. Through a partnership with Daimler Chrysler, 66 pictures of sports cars, sedans, and small cars were shown to male volunteers while connected to fMRI. The subjects were asked to rate each car on its attractiveness. Confirming Erk et al. (2002), sports cars led the way in attractiveness. The nucleus accumbens, an area for reward or planning to reward oneself, was highly activated during images of the sports cars. Since sports cars are typically expensive, it is logical to see why they would activate the rewarding section of the brain in the participants (Brit, 2004).

Another application of neuromarketing research to the marketing mix is through price policy. Price is particularly critical for brands that are competing in extremely saturated markets, such as the apparel industry (Hubert & Kenning, 2008). This field of neuromarketing research aims to articulate the psychophysiological reactions of consumers when they are faced with complex economic abstracts, such as price fairness, willingness to pay, perceived utility, and product value. In relation to pricing, Knutson et al. (2007) investigated neural correlates of price elasticity (the price and the demand of the product are interrelated). Subjects underwent fMRI analysis while they viewed products and the pricing information, and then were asked to make a decision on whether they would like to purchase it or not. The results concluded that activation of the nucleus accumbens indicated product preference, while activation in the insula and medial prefrontal cortex coordinated with products having high prices (Knutson et al., 2007). Their data supported the notion that insula activation in the brain reflected feelings of loss. This feeling of loss has also been seen when products with high prices are shown, which demonstrates the negative pricing effect. Another neuromarketing research on pricing examined the positive impact of high prices for a product (Plassmann et al., 2008). Participants tasted wine while connected to fMRI and viewed the pricing information while shopping. The results from this study were that high priced wines were consistently rated as tasting better along with activation in the medial prefrontal cortex and anterior cingulate cortex. The benefits of this study are twofold. First, it gave a neural representation of what happens when high price skewing is in effect. Secondly, it also distinctly showed where high price points show activation in the brain.

The communication from brand to consumers has also been an important topic in neuromarketing research as consumers continue to be bombarded with thousands of advertisements everyday (Hubert & Kenning, 2008). In general, neuromarketing research on communication addresses the way that consumers process and store brand advertising. For example, two studies by Kenning et al. (2007) and Plassmann et al. (2007) have looked at the effects of attractive advertisements on various brain regions. While being measured by an fMRI scanner, subjects were asked to rate different advertisements on their attractiveness level. The results revealed that advertisements that were rated as highly attractive had brain activation in regions that are associated with emotional decision-making, namely the ventromedial prefrontal cortex (Plassmann et al., 2007). Later, Kenning et al. (2007) concluded that these attractive advertisements could also act as a rewarding stimulus since there was activation in the ventral striatum and nucleus accumbens as well. The advertisements featuring positive facial expressions were consistently rated as very attractive (Kenning et al., 2007). As Kenning et al. (2007), attractive advertisements can elicit a positive reaction in a consumer's mind.

Lastly, brand research has been an influential topic in neuromarketing because companies want to determine if their brand information actually impacts the purchasing decisions of consumers (Hubert & Kenning, 2008). Brand research in neuromarketing focuses on neural areas and processes that were used to understand brand information. Deppe et al. (2005) used fMRI scanning while subjects were given hypothetical buying decisions between two very similar products. The findings of this study revealed that the mind has a "winner-take-all" effect when dealing with brand information. Only the participants' favorite brands showed extremely strong connection with emotional decision-making processes in the brain. All other brands that were rated lower did not have much effect on areas such as the ventromedial prefrontal cortex, which is known for emotional processing. Schaefer et al. (2006) also solidified the prefrontal cortex is significant in processing brand information. Using fMRI experimentation, subjects were shown car logos of several car manufacturers and asked to imagine driving the car. Subjects also recorded how familiar they were with these car brands. Significant changes in the medial prefrontal cortex were shown when subjects were very familiar with the brand, indicating that the familiarity of a brand could act as subconscious decision-making even before a consumer begins to think about the advantages or disadvantages of that brand. The findings of Schaeffer et al. also confirmed that the prefrontal cortex is vital to branding strategies for companies and how consumer's store information.

As an emerging field, it is clear to see that neuromarketing applications can help a variety of issues in the realm of business. This area is moving towards the goal of constructing models or measures that could help accurately predict consumption related issues in all industries (Fugate, 2007). Furthermore, with the fast innovations of neuromarketing, companies and consumers can be spared of unnecessary advertising and promotions since their needs could be more precisely discovered. In addition, psychophysiological measures have the potential to reconfigure and improve conventional understandings on consumer behavior (Fugate, 2007). One area that has been specifically researched is the attractiveness of a product or an advertisement (Britt, 2004; Kenning et al., 2007; Plassmann et al., 2007). Their findings indicated that products and advertisements with a high level of attractiveness show significant activation in the left frontal hemisphere, which is associated positive affects and approach behaviors. However, there has *yet to be* a neuromarketing study that discovers the effects of attractiveness in the apparel industry, creating a void in the literature that must be filled.

Apparel Product Attractiveness

As discussed, *product* is one of the most crucial elements of the marketing mix. The job of a designer, whether for apparel or another industry is to create an attractive product for the customer, thereby increasing the sales of the company (Bloch, 1995). The form or attractiveness of a product, specifically apparel and clothing, can directly contribute to the success of a company in multiple ways. First, in the cluttered and competitive industry that is the fashion market, product attractiveness can easily gain attention from a customer (Jones, 1991). Also, exterior appearances of the apparel product can communicate information about the brand to consumers (Nussbaum, 1993). This may eventually lead to brand identities and recognizable corporate character, which could gain top of mind thought in consumers (Bloch, 1995). Next, an attractive product simply has the power to give consumers sensory pleasure and stimulation. Due to its critical importance, apparel attractiveness has been studied extensively (Bell, 1914; Bloch, 1995; Eckman & Wagner, 1994; Nussbaum, 1993; Nussbaum, 1988). For example, the silhouette of a men's tailored jacket was used as stimuli in Eckman & Wagner's (1994). A 100-point scale of attractiveness was given to 172 male subjects while viewing the various suit silhouettes. It was found that the jacket length was the most important attribute for attractiveness on the men's suits (Eckman & Wagner, 1994). Bloch (1995) also recognized the importance of attractiveness and determined that the success of a product could be based solely on just the exterior appearance. It was emphasized that attractive merchandise with positive psychological responses had the power to increase consumers' involvement with the product. When positive emotions are elicited by a product, approach behaviors are produced. Examples of these approach responses could be viewing, listening, or touching the product in a retail or online environment. These all enhance the likelihood that consumers will purchase the product, continue visiting the retail location, and eventually develop brand loyalty (Bloch, 1995).

CHAPTER III

METHODOLOGY

Electroencephalography (EEG)

EEG is a non-invasive neurological measure that quantifies brain activity by picking up electrical impulses caused by brain activity. EEG technology captures extremely precise time resolution, and graphical images of peaks in neural activity (Davidson, 1988). The first electrical activity to be recorded from a human brain was conducted by Hans Berger in 1929 using a very primitive form of EEG (Berger, 1929). While this was met with both skepticism and praise, it opened the door for further discoveries of electrical pulses measured on the scalp. This was a large advancement from previous brain research, which has involved freezing brains and slicing them into pieces to look at results (Fugate, 2007). Later, Jasper and Carmichael (1935) further refined the EEG methodology and applied it into fields such as psychology and clinical neurology (Magoun, 2003). Since the refinement of Jasper and Carmichael, this tool has been used to diagnose conditions involving brain pathology, such as epilepsy, sleep disorders, and issues involving the nervous system (van de Velde, 2000). Throughout the years, EEG methodology and research has been critical to the growth of many fields. It has prevailed as a brain wave analysis method that is adaptable and reliable in several disciplines.

As previously mentioned, an excited neuron creates an action potential when it becomes depolarized. This process releases electrical messages that are seen as waves, which generates output for EEG recordings on the scalp (van de Velde, 2000). The *frequency* of these waves is typically recorded in the unit of Hertz (Hz). Slower frequencies are usually less than 10 Hz and faster waves are greater than 13 Hz (Demos, 2005). The height of the waves is measured in microvolts (μV), also referred to as amplitude. Raw data from brain waves are given in the units of Hertz, and must be filtered. The term "filtering" data means that the raw output is being organized into like bands. There are four categories of brain wave bands that are recorded by EEG: delta, theta, alpha, and beta. Each of these band categories has been correlated with activities that are typically seen during testing (Demos, 2005).

- Delta (0.5 – 4 Hz): *sleep activity*
- Theta (4 – 8 Hz): *concentration, meditation*
- Alpha (8 – 13 Hz): *attention, alertness*
- Beta (13 – 30 Hz): *reflection or analytical thought*

EEG detects amplitudes and frequencies of brain waves using *electrodes* that are applied directly to the scalp. The most common type of electrodes is small metal cups but many laboratories are using self-adhesive electrodes as well (van de Velde, 2000). After conductive gel is placed on the electrode, it is placed on the scalp of the subject. Though there are still many methods of electrode placement for EEG testing, the most common and widely accepted is the 10-20 system (Jasper, 1958). The name stems from the inter-electrode distances, which is separated by 10 to 20% proportion of the head, and covers the frontal, central, parietal, and occipital positions (Figure 3). As displayed in Figure 3, there is a certain coding for the locations of the electrodes on the brain (van de Velde, 2000). The letter "F" stands for frontal, "T" for temporal, "C" for central, "P" for parietal, and "O" for occipital lobe. There is no central lobe, therefore the "C" is used merely as an identification for the center of the scalp. The lowercase "z" denotes that the electrode is in the midline of the head. The even numbers (2, 4, 6, 8) stand for positions on the right hemisphere while the odd numbers (1, 3, 5, 7) are locations on the left. The two sites with the letter "A" represent the earlobes and the site "G" is used to represent the *naison,* which is the above the bridge of the nose between the eyes. Next to the “G” location are two electrodes with “Fp” which stand for the pre-frontal locations of the brain. This study recorded EEG activity on left and right midfronal sites, F3 and F4 as suggested by Davidson’s frontal asymmetry studies. As mentioned earlier, there is a vast amount of research on the frontal regions and affective asymmetry, which is why this study will use locations F3 and F4 (See Davidson, 1988 for full review). Though there are several locations that could be used in the frontal region, these two sites have been extensively studied using Davidson’s (1990) theory. Many researchers have concluded, along with Davidson, that F3 and F4 display an accurate representation of whether hemispheric asymmetry occurs through these sites (Davidson, 1990; Davidson, 1988).

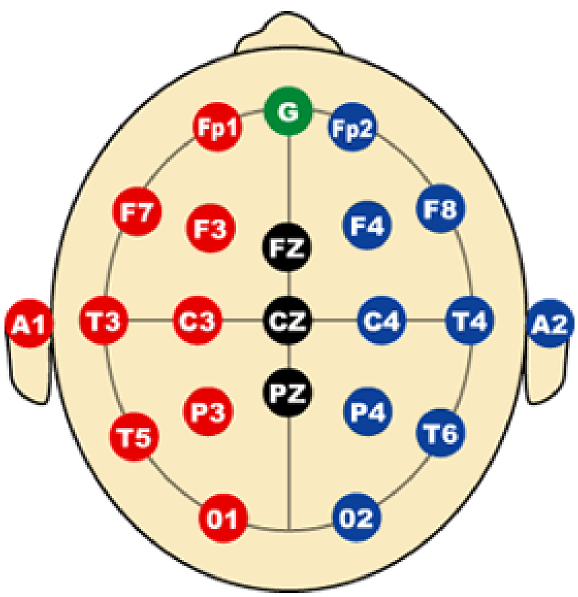

Figure 3. The International 10-20 System of Electrode Placement (Immrama Institute, 2012)

There are several benefits in using EEG as a primary measure for neural activity. Due to the concrete separation of waves, this tool can effectively distinguish the concentration or attentiveness of a subject during a given task (Dirican & Göktürk, 2011). It can also be applied when determining how engaged a participant is in a particular assignment. Since action potentials and depolarization are constantly being measured on the scalp, EEG recordings also have very high temporal precision (Dirican & Göktürk, 2011). During every second of data collection, hundreds of wave measurements are being recorded (van de Velde, 2000). For this reason, EEG has been very effective in experimentation that involves separate phases that a subject experiences. For example, studies where various stimuli must be presented to a subject are well suited for EEG. This is because during each individual stimuli presentation, there will be a plethora of data points to be analyzed for the study. From there, modern EEG software and analysis methods make segmenting each of these stimuli fairly simplistic. By analyzing these segments, concrete values and conclusions can be made from each of the stimuli that are presented to the participants. For this reason, EEG has been highly valuable in comparing studies that involve multiple stimuli that must be analyzed for similarities or differences.

A common disadvantage to EEG analysis comes with biological and neural movement in patients. When a subject is distracted by anything else besides the stimuli, attention in the brain may cause unwanted action potentials and waves to be created. When these undesirable waves, usually called *artifacts*, are found in data, it could cause the analysis to be wrongly interpreted. Typical artifacts that are seen in EEG testing are usually due to eye movements (either blinking or shifting eyes), and muscle activity from the jaw, neck, or head. Due to the frequency of these artifacts, there have been many types of artifact removal methods developed by EEG researchers (van de Velde, 2000). One of the most recommended ways to detect these artifacts, though time consuming, is visually analyzing the data. Since this might be difficult for longer and more complex experimental set-ups, there are several software programs to help researchers remove these artifacts.

In addition to EEG, there are other important psychophysiological tools that are being used to study the neural representations of consumer emotions such as magneto encephalography, positron emission tomography, and functional magnetic resonance imaging. Magneto encephalography (MEG) maps the brain by using magnetometers to record the magnetic field activity produced by electrical currents (Fugate, 2007). MEG excels in measuring perception, attention, and memory, but has shortcomings in terms of complicated analysis and limited spatial resolution (Bercea, 2011). Another type of neurological measure is the positron emission tomography (PET). For this type of tool, a type of glucose molecule must be emitted into the body. This molecule, specifically called fludeoxyglucose, gives off rays that are detected by the machine (Fugate, 2007). While PET has great spatial resolution and shows chemical changes, radioactive materials have a very short life making testing very time sensitive (Bercea, 2011). Lastly, functional magnetic resonance imaging (fMRI) uses blood flow to record activity in different areas of the brain (Fugate, 2007). There is great support for fMRI in terms of its reliability and validity in data measurements. Despite these advantages, subjects must remain still during testing since the machine requires them to lay flat, there is low temporal resolution, and it is extremely costly to use the equipment (Bercea, 2011).

Methodological Considerations in EEG Research

Emotions can be extremely complicated to measure, let alone to conduct research on. A set of methodological considerations should be reviewed before utilizing EEG to analyze affects or approach-avoidance behaviors (Davidson et al., 1990). First, it is important to verify that an intended emotional reaction is actually extracted from subjects. An elicitor often can produce multiple emotions during experimentation. Caution should be taken by the researchers to not presume that the intended emotion for the study is actually produced. Davidson et al. (1990) suggests that investigators should verify with each subject that the elicitor generated the emotion that is being analyzed. Second, the methodology should ensure that epochs of discrete emotions during experimentation are separable and confirm that different emotions are not incorrectly grouped during EEG analysis. Thirdly, measures for a study should have a fast time constant to adequately represent the rapid nature of emotions, which typically last approximately four seconds in length (Eckman, 1984). For this reason, EEG is recommended due to its precise time resolution compared to other psychophysiological methods. Fourth, when setting up the stimuli for an affective study, there must be at least two emotions, which will be compared. There are inherent flaws in studies that only compare one emotion to a baseline measurement. For example, there is no way to conclude if the physiological changes are caused by the single specific emotion being tested or if they are associated with another type of emotion. Another consideration is that researchers determine if their emotional stimuli all hold the same intensity for each subject. If two emotions are to be studied, they must differ physiologically, but they also must hold the same level of intensity. Problems can arise in analysis if these emotions vary in intensity level. For example, when this is not safeguarded it is not possible to tell if the results of the study are due to differences in intensity or if they are associated with an emotion. This methodological error could lead to incorrectly associating physiological reactions with emotions. The issue can be remedied by completing a pre or post survey to ensure that participants do not have varying levels of intensity for each stimulus. Lastly, data for each emotion must be collected in sufficient time duration. When utilizing EEG data, it is recommended that a minimum of 10 seconds should be obtained across all cases of the targeted emotion.

Stimuli

A collection of 30 photographs of women's tops were identified from various retailers. The attractive and neutral products were chosen from online retail sites such as H&M, Zara, Forever 21, and contemporary designers from online sites such as Net-A-Porter.com and Barneys.com. Different price points for these products were chosen because the generation Y consumer may shop in fast fashion, but is highly influenced and attracted to young designer products as well (Yarrow & O'Donnel, 2009). Since the study used Generation Y as participants, unattractive women's tops were gathered from online sites that did not advertise to this group as their target market. This included the retailer Norm Thompson, which typically categorizes its target customers from age 60 – 70. Only product pictures, not featuring any models or logos were displayed on a PowerPoint presentation. This was done to prevent bias that could potentially be caused based on the model's figure or brand familiarity. A pilot study was conducted with three graduate students in order to check the appropriateness of the products and ease of use on the survey.

Following previous research (Gakhal & Senior, 2008; Stoll et al., 2008), a survey was administered to a sample population as a means of identifying apparel products of varying levels of attractiveness. Based on the suggestion from Sperry & Hernandez (2008), the subjects for the survey was recruited from those who have basic knowledge of the stimuli; in this case was apparel, in order to critically rate it. Therefore, participants (N=25) were all female with ages ranging from 18 to 20 years old, and recruited from an introductory apparel merchandising and design course. Similar to Gakhal and Senior (2008) and Stoll et al. (2008), participants were given 10 seconds to rate attractiveness of apparel product presented. The presentation order of thirty product pictures was randomized so that no order effect would to seen. The participants rated the attractiveness of these pictures using a 10 point Likert scale where 1 is very unattractive and 10 is very attractive. (Stoll et al., 2008; Vecchiato et al., 2011). This was done in a university classroom on a projector so that all participants in the room had a large, clear view of the product that they were rating. Three most attractive products with mean values close to 10 and three least attractive products with mean values close to 0, and three neutral products with mean values close to 5 were selected for the EEG experiment as stimuli (Stoll et al., 2008).

The nine tops (three from each attractiveness group) were put together into a PowerPoint presentation. Based on methodological considerations suggested by Davidson et al. (1990), each stimulus remained on the screen for a period of 10 seconds and was preceded by a white screen interval of 10 seconds. The addition of a white screen interval was necessary in order to separate different emotions elicited by each picture stimulus (Gakhal & Senior, 2008; Vecchiato et al., 2011).

Pilot Study

Preceding EEG testing, a pilot test was conducted with three graduate students to determine possible problems in the EEG experimental design such as task description, experiment setting, and timing of test session. Participants were asked to complete an EEG experimentation of what would be performed on the final sample. After participants completed to pilot study, they were all asked for their feedback on the experimentation. As a result of the pilot test, refinements were made to the experimental procedures. For example, a script was developed in order to ensure a consistent process and explanation for each participant. It was identified that participants needed time to acclimate to the temperature and slight noise when they initially entered the environmental chamber. Additionally, there should be time to answer any questions that participants had before beginning EEG testing, as many probably have never had experience with it before.

Subjects

Seventeen right-handed participants for the EEG experiment were chosen from a separate apparel course at the university. A small sample size has been suggested by previous EEG studies that also have an exploratory nature and are analyzing preliminary evidence in frontal asymmetry (Rosenfield et al., 1996). The ages of these participants ranged from 19 to 21 years old and were either minoring or majoring in the apparel merchandising and design program at the university. The use of right-handed students is necessary because of the hemispheric specialization that is strengthened by the consistent use of the writing hand (Davidson, 1990). Since all participants were right-handed, they are all assumed to have more attuned left hemispheres (Kalat, 2013). The use of homogeneous participant groups in terms of handed-ness has been suggested as a critical step in developing validity for EEG experiments (Davidson, 1990). Participants received extra credit points in this course as an incentive for participation.

EEG Recording

The EEG testing took place in an environmental chamber to reduce visual distractions and control environmental factors of the experiment setting (Figure 5). During all individual subject trials, the temperature remained at 23° Celsius (73.4° Fahrenheit) with humidity at 40%. The chamber only included a desk with a laptop (Dell, model E5500) to display the presentation along with another computer stand for EEG recording. Participants were briefed on the purpose of the study and signed consent form before any testing took place. A copy of the script used for experimentation is provided in Appendix A. The script began by introducing each participant to the equipment that they would be involved with and their task in the experimentation. Participants were given one minute to acclimate and adjust to the chamber's settings and informed the importance of being relaxed, focusing on stimulus presentation, and avoiding movements that could produce artifacts. They were given a 10-second notification before the presentation began in order to remind them to relax and focus on the products.

The EEG used was a NeXus-10 biofeedback system manufactured by Mind Media Inc. The elastic cap was placed on the head of the participant utilized the International 10-20 Electrode Placement system (shown in Figure 4). This method for placing electrodes is internationally recognized and standardizes the reproducibility of EEG studies over time and among various subjects (Niedermeyer, 2004). The actual "10" and "20" stand for the measures of the distance on the head based on the proportions of the subjects skull (Niedermeyer, 2004). EEG signals were recorded from the frontal cortex in locations F3 and F4, referring to the vertex (CZ) on the top of the head and two ear clips as well. The use of two electrode locations along with the ground CZ location is referred to as a two-channel EEG set up and very common within this vain of research (Demos, 2005). It has been consistently proven that F3 and F4 are reliable measures of emotions, especially affects concerning the approach-avoidance theory (Davidson, 1990; Davidson, 1988). Following the instrument standards, small areas of the skin were cleaned with wet cotton and a water-soluble paste was placed on the electrodes in order to obtain good electrode connections. The paste used is manufactured by the brand Ten20® and did not contain any chemicals that would irritate the skin of the participants.

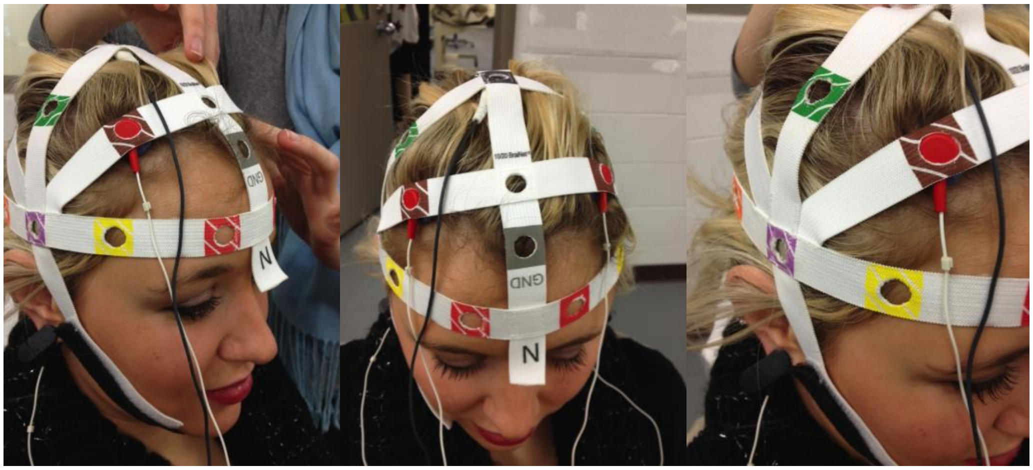

Figure 4. Examples of Electrode Placement on a Subject

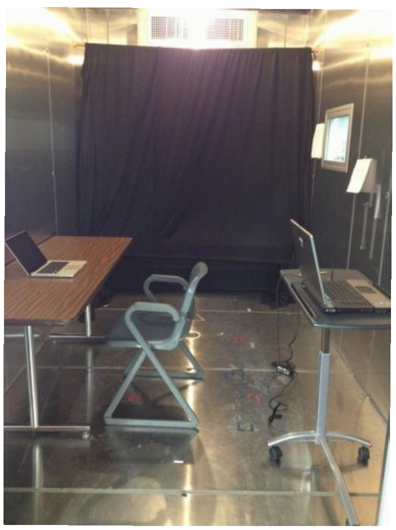
Figure 5. Example of the Experimental Set Up in the Environmental Chamber

The photographs of the nine apparel stimuli (three from each attractiveness group) were presented in random sequence on a high-resolution computer monitor. Each stimulus remained on the screen for a period of 10 seconds and was proceeded by a blank white screen interval of 10 seconds. Following the PowerPoint presentation, participants were walked out of the chamber to complete a post survey. Participants were shown the nine stimuli that they just viewed in the chamber and rated each product's attractiveness using a 10-point Likert scale, where 1 is very unattractive and 10 is very attractive. In addition, they were asked to rate their purchase intention for each of the stimuli using a 10-point Likert scale, where 1 is unlikely to purchase and 10 is very likely to purchase. Following the post-survey, the graduate assistant removed any conductive gel that remained in the participant's hair or on scalp before they left the testing area. Participation took approximately 30 minutes including the delivery of instructions, the actual hook up of the EEG equipment, the recording of the subsequent EEG, and collection of survey data.

EEG Quantification

EEG recordings were quantified at a rate of 256 samples-per second (SPS) only in the alpha band from F3 and F4. Alpha waves have been a particular area of interest for EEG research, including the present study, since this band demonstrates attentiveness of the participants that are involved. For example, when a subject is relaxed and sitting still with their eyes closed, alpha waves tend to be high in amplitude (Andreassi, 2000; Davidson, 1984, 1990, 1992a, 1992b). If the individual then opens their eyes, mental processing begins, and alpha waves will decrease in amplitude. This is because the eyes will place attention and awareness on the visual or task that is in their surroundings. For this reason, alpha wave *power*, or energy in the alpha band, is known to have an inverse relationship with cognitive activity (Tomarken et al., 1990). Therefore, Davidson's frontal asymmetry theory postulates that during positive stimuli, alpha wave power would be *lower* in the left hemisphere than the right. Due to the inverse relationship of alpha power with neural activity, having lower alpha power in the left hemisphere than in the right hemisphere would actually demonstrate that there is more activation in the left hemisphere than in the right hemisphere. Davidson (1987) has developed several formulas (e.g., right-left/right+left; right-left/right+left alpha power; right-left/right+left alpha power spectrum density) in order to simplify this inverse relationship. These formulas help create an *asymmetry score* that has positive relationship between the formula output and hemispheric activation, such that a higher asymmetry score represents higher activation.

Amplitude was computed at a rate of 32 (SPS). The SPS is based on the Nyquist theorem, which states that when a signal waveform is being measured, the rate in which it is sampled should be *at least* twice the frequency of the wave. Since the alpha band has a frequency of 8 to 13 Hz, this sampling rate satisfies the theorem. Every data set was transformed from raw signals in alpha band to amplitude calculated using root mean square (RMS) equation by the software provided on the BioTrace laptop. RMS amplitude is defined as the square root of the mean divided by time of the square of the vertical distance of rest state (Ward, 1971). This equation for amplitude is commonly used for complex waveforms that do not have a repeating pattern, similar to this experiment. EEG recordings were then visually inspected for muscle or eye blink artifacts. A peak of 50 microvolts was used in order to quickly indicate where artifacts needed to be removed in each participant's data set (Hansen, 2011). When artifact was identified on one channel (e.g., F3), the matched data from this other channel (e.g., F4) was removed so that the EEG data were always collected from corresponded points in time (Davidson et al., 1990).

Data Analysis

A Fast Fourier Transform (FFT) was applied to each set of data using MATLAB software operated by an assisting engineer in order to transpose complexities into sine waves sections (Davidson, 1990). FFT is used in wave analysis in order to show the frequency composition of a piece of data based on time (Ramirez, 1985). The FFT yielded power spectrum density (PSD) of different frequencies in the alpha band (8-13 Hz). Alpha PSD has been found to be an extremely reliable measure for emotional performance and psychometric properties (Davidson, 1990). Excellent internal reliability specifically using alpha PSD have been demonstrated, Cronbach's alpha (α) = 0.80- 0.95, along with acceptable test-retest stability, with correlation values ranging from r = 0.65-0.75 (Tomarken et al., 1992). As discussed, alpha power is inversely related to hemispheric activation; therefore, higher alpha scores would indicate greater activation in a hemisphere. Alpha power density was calculated by summing the power values across all 1-Hz areas within the alpha band, called *bins*, then dividing that sum by the number of bins (Tomarken et al., 1992). Hanning Window was also run through MATLAB software to reduce leakage in the data. By using a window function on the data, the data is better represented in terms of the frequency spectrum of the data. Specifically, this is conducted by refining time data to a periodic form, since most EEG experiments don't collect data in a "stop-start" fashion (Ramirez, 1985). Window functions are also extremely effective in preventing artifact spikes in power values (Tomarken et al., 1992). When using window functions, there is a slight discarding process of averages in order to best represent the data, called overlapping. Typically, Davidson and colleagues (1990) have used either 75% or 50% overlapping when analyzing EEG alpha bands. For this reason, 50% overlapping was applied to the Hanning Window process in MATLAB.

In order to determine the difference in asymmetry for each picture stimuli in different attractiveness categories, an asymmetry index, or equation was used. The index in the present study was determined by taking the difference between right and left PSD (Right – Left), divided by the sum of the right and left PSD values (Right + Left) (Pivik et al., 1993). Davidson (1988) describes this particular equation as a convenient and easy way to show the direction of asymmetry between groups. Not only does this equation provide a normal distribution for the data, but is also one of the most consistently used asymmetry measures within affective asymmetry research (Davidson, 1988).

CHAPTER IV

RESULTS

This analysis was composed of all artifact-free EEG data for the three product group that had varying levels of attractiveness. Due to the small sample size and exploratory nature of this experimentation, reliability of frontal asymmetry was not tested. However, the reliability and validity of frontal asymmetry metric has been confirmed by previous research as an effective measure of affective asymmetry. Davidson and many others have proven that the anterior alpha band at locations F3 and F4 is extremely consistent with a Cronbach's alpha (α) of 0.94, test-retest correlations ranging between 0.66-0.73, along with great consistency reliability (α=0.85) (Davidson, 1992a, 1992b, 1995; Stoll et al., 2008; Tomarken et al, 1992; Vecchiato et al., 2011).

Table 1. Post-survey Scores

Attractiveness Groups	**Mean**	**Standard Deviation**
Attractive	7.2745	2.5619
Neutral	4.9804	1.8492
Unattractive	2.3137	1.4351

To validate the level of attractiveness in each product group, the mean and standard deviation were analyzed based on the results from the paper and pencil post-survey. Table 1 illustrates mean and standard deviation of self-reported attractiveness (on a 0-10 scale) in response to the three attractive, three neutral, and three unattractive apparel product pictures. Along with the post-survey results for mean attractiveness level for each product group, participants' purchase intentions (on a 0-10 scale) in response to the three attractive, three neutral and three unattractive apparel product pictures were also measured. The attractive product group was, rated highest on the attractiveness scale, followed by the neutral product group, and the unattractive product group. The same pattern also followed suit in measures of purchase intention from the participants.

Table 2 displays the mean and standard deviation scores of frontal asymmetry metric for each attractiveness group. The mean value for the attractive product group was created by averaging all asymmetry scores across the three attractive product images. The same process was also used to determine the asymmetry score means for the neutral and unattractive product groups as well. As discussed, a positive asymmetry score from a stimuli indicates that there was a *left frontal dominance*, or positive affect and approach behaviors, while a negative score denotes *right frontal dominance*, also known as negative affect and avoidance behaviors (Davidson, 1984, 1992a, 1992b). The finding shows that the attractive apparel products had the highest mean asymmetry score (.001), which denotes left frontal hemisphere dominance. The unattractive group resulted in the lowest asymmetry score (-.002), therefore showing the greatest right frontal hemisphere activation. The mean of the neutral group fell in between both of the opposing groups (-.001). Therefore, the results of present study are in accordance with Davidson's (1990) theory of affective frontal asymmetry. Figure 6 gives a graphical representation of these mean frontal asymmetry scores to demonstrate that contrast in the attractiveness groups.

Table 2. Frontal Asymmetry Scores

Attractiveness Groups	**Mean**	**Standard Deviation**
Attractive	.0014	.0374
Neutral	-.0011	.0376
Unattractive	-.0028	.0347

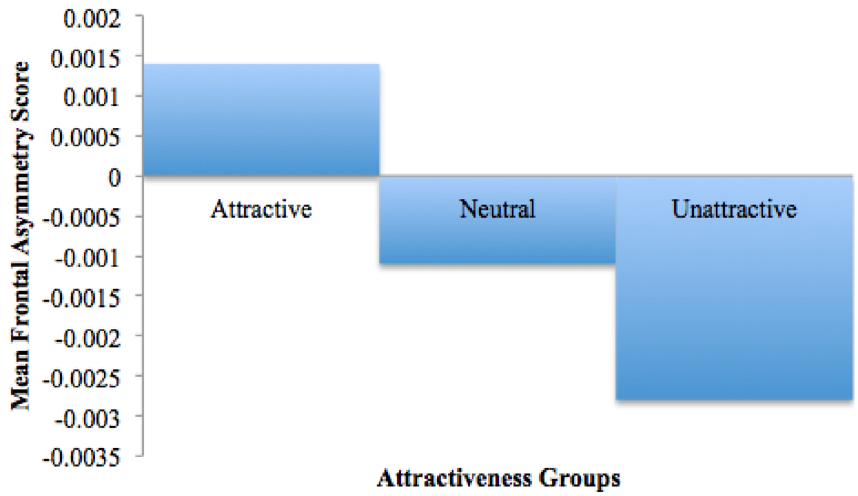

Figure 6. Bar Graph of Mean Asymmetry Scores for Each Group

A repeated measures analyses of variance (ANOVA) and Bonferroni multiple comparisons of means were run on these groups to determine if the difference between their asymmetry scores were statistically significant. The factors for the analysis were the asymmetry scores of each attractiveness group (attractive, neutral, unattractive). With $F(2,15)=8.315$, the difference of these group's asymmetry scores was significant with p-value of .000 (Table 3).

Table 3. Repeated Measures Analysis of Variance (ANOVA) and Bonferroni Post-Hoc Test

Attractiveness Groups	**F**	**Mean****	**Standard Error**	**Bonferroni*****
Attractive	8.315*	.0014	.001	A, B
Neutral		-.0011	.001	A
Unattractive		-.0028	.001	A, C

* Based on Wilk's Lambda (P < .0001)
** A higher mean score indicates more left frontal hemisphere activation
*** Means for groups with the same letters are not significantly different from one another (P < .05)

The hypothesis of the study, which was to determine if there is an existence of frontal asymmetry when viewing attractive and unattractive apparel products, is supported based on these results. The ANOVA demonstrates that there is a statistically significant ($p < .05$) frontal asymmetric difference between the attractive and unattractive product groups. However, there were no significant differences between the neutral group and the attractive or unattractive groups.

CHAPTER V

CONCLUSIONS AND IMPLICATIONS

Analyzing brain activations of consumers can reveal their subconscious and unfiltered thoughts and lead to a more precise and direct understanding of consumer behaviors. (Ariely & Berns, 2010; Lewis & Bridger, 2005; Morris et al., 2002). The present study attempted to give the first glimpse at the possible association between apparel product attractiveness and frontal asymmetry. Supporting Davidson's (1984) frontal asymmetry theory, the present study revealed that a statistically significant difference of frontal asymmetry ($P<0.05$) exists between attractive and unattractive apparel product groups. The results suggest that attractive apparel products were accompanied by peaks in the left frontal hemisphere which are related to positive affects and approach behaviors and unattractive apparel products were partnered with activations in the right frontal hemisphere, which has been proven to be associated with negative affects and avoidance behaviors. This confirms previous research findings that the left frontal hemisphere is associated with positive emotions whereas the right frontal hemisphere is associated with negative emotions (Davidson, 1984, 1992a, 1992b, 2002, 2004). For example Davidson et al. (1990) reported that happy film clips were accompanied by higher left frontal activation, while film clips that included emotions such as disgust, showed a significantly high right frontal activation. The same principle was confirmed in the present study. Attractive apparel items, which would hypothetically make a person happy and want to approach, had a high left frontal asymmetry score, while the unattractive items, that would make a person want to avoid it, had a high right frontal asymmetry score. Therefore, the present study demonstrates that the attractiveness level of apparel items elicits an emotional reaction, but that it also is in conjunction with the frontal asymmetry theory.

The present study also confirms the findings from previous frontal asymmetry research in other product categories. Stoll et al. (2008) showed that attractive packaging was linked to significant activation in the left frontal hemisphere, while unattractive packaging peaked the right frontal cortex. In addition to packaging attractiveness, a similar pattern of frontal asymmetry has also been present in the automobile and advertising attractiveness (Erk et al., 2002; Kenning et al., 2007; Plassmann et al., 2007). In all of these studies, whether the stimuli were a car or print advertisement, the significant left frontal activation for attractiveness and right frontal activation for unattractiveness have been proven. The present study suggests that frontal asymmetry can be associated with apparel product attractiveness. Therefore, it can be concluded that frontal asymmetry exists with various product categories at varying levels of attractiveness.

Consumers in fashion industry have a highly impulsive and emotional decision-making process for purchases (Milosavljevic et al., 2011; POPAI, 2012; Zaltman, 2003). Emotions are the precursor to actions; therefore it is vital that the fast paced fashion industry invests in neuromarketing studies. The current study reveals a new layer of perspective into fashion consumption. Through our results, it has been demonstrated that the attractiveness level of an apparel item does elicit emotional reactions and approach and avoidance responses. In a real-world setting, a type of approach responses in apparel shopping could be picking up an item of clothing, or clicking on it for more detail in an online boutique. Avoidance responses would be the opposite, such as walking past a display or scrolling through a page online. Therefore, the frontal asymmetry theory could potentially be used as a guide to measure emotional reactions and their coordinating behaviors to various aspects of the fashion industry. Using the activity in the left and right frontal cortex as an index in the fashion industry could aid in advertising effectiveness, product appeal, logo and brand selection, and even media selection. For example, apparel companies could use the frontal asymmetry theory to test the emotional reactions of their target customers to the next season's advertising campaigns. By using the frontal asymmetry theory, executives and designers could measure the asymmetry scores of each frontal cortex while viewing the advertisements. After data analysis is completed, this would produce an emotional metric to determine what type of affects could occur before it's even shown to the public market.

Future Research and Limitations

Fashion consumption is highly emotion driven. As the frontal areas of the cerebral cortex has an important role in emotional decision-making, further research on the relationship between frontal asymmetry and fashion consumers could contribute to a deeper understanding of consumers' emotional responses to fashion stimuli. Furthermore, there lies potential for frontal asymmetry to be used for reexamining existing research on apparel products. For example, Eckman & Wagner (1994) used a Likert scale to determine what the most attractive silhouette was for a men's suit. It would be interesting to examine if frontal asymmetry exists in this scenario. By applying EEG frontal asymmetry, future research would be able to examine emotional responses of each suit's silhouette and validate the previous results from its self-report method.

While this study was the first to discover if frontal asymmetry existed based on varying levels of apparel product attractiveness, its exploratory nature also had several methodological limitations. The sample size of this study was small (N = 17) and was a convenience sample from the university's campus. Therefore, it is not generalizable to the overall population. This study particularly investigated frontal asymmetrical activations of Generation Y consumers due to their importance in the fashion industry, but as brain develops and matures just as humans do through age (Kalat, 2013), different consumer age groups such as boomer and mature consumers might have different relationships of frontal asymmetrical activity with emotional responses. Also, there have been neurological studies that have demonstrated that male and female brains differ in brain lateralization (Demos, 2005). For example, the thicker corpus callosum in female brains could increase the communication between both hemispheres in the brain (Demos, 2005). Therefore, it would be interesting for future research to analyze how gender might play a role in the asymmetry of frontal activation during expression of certain emotion and motivation.

Another limitation is that only two sites (F3, F4) were used to measure emotion. While these have been previously proven to have a strong relationship to emotional valence and motivational direction, prefrontal region sites (F1, F2) have also been emphasized. Davidson's latest research that supports asymmetry theory focuses specifically on the prefrontal cortex (PFC), and how it relates to the affective process (Davidson, 2004). The most prominent area of the PFC that has recently been demonstrated to control emotional thoughts is the orbital area (Davidson, 2004). Specially, the orbitofrontal and ventromedial regions are proven to be involved with various aspects of emotional process and solidified as emotional hubs in the neural reactions to unpleasant and pleasant scents (Rolls et al., 2003). While the orbitofrontal PFC has shown its specialization for approach, or reward related decisions, the opposite action, avoidance responses have been discovered in the right ventromedial PFC (Clark et al., 2003; Davidson, 2004). Future research could validate if the results of this study also occur in the prefrontal regions. Another limitation in the area of EEG locations is that only one site on each hemisphere was measured. By using more electrodes in the frontal region on the left and right hemispheres, one could get a deeper understanding of asymmetrical activity when viewing apparel products.

There were also several limitations in terms of the experimental setting that this study was produced in. The participants were looking at the products as if they were considering purchasing the items online, but their surroundings did not reflect the actual shopping context. Specific surroundings could potentially have the possibility to change the participant's reactions to the products. Also, there was no direct occasion for viewing these apparel products during experimentation. Viewing the products when thinking about shopping for a certain occasion, such as going attending a wedding or for an upcoming job interview, could also alter the neural reactions of participants. Future research could validate frontal asymmetry in various contexts and situations on the participants. This would also make the data more applicable to real world experiences of the fashion industry. Lastly, EEG data analysis involves several complex formulas and programs to review. Due to the enormous amounts of data points that are recorded, evaluation can be extremely difficult and time consuming. There are several computing programs that have tried to aid in the complexity of EEG data, and could be considered for future research.

APPENDIX A

COPY OF SCRIPT FOR PARTICIPANTS

Participant Script

The first step we are going to take is placing two electrodes on your head. The lab assistant will have to separate some of your hair because measurements will not be accurate unless the electrode contacts the scalp. Also, we are going to conductive gel to increase the strength of the data. This gel will easily come out of your hair and off of your head after experimentation and a mirror and cleaning pads will be provided. Lastly, you should remove any earrings or necklaces before the recording takes place.

(Electrode placement)

Now that that the EEG is fully connected we are almost ready to begin. In a few moments, we will go into the environmental chamber where experimentation will take place. You will be watching a slide show of 10 women's tops that are separated by blank white slides. I want you judge the attractiveness of these products as if you were shopping on an online retail site. Also, to obtain the best data, it is very important that you stay still during the experimentation. We will give you a few moments to get comfortable, but once the presentation starts please refrain from moving your hands, feet or head. All you have to do is relax and focus on the presentation.

(Enter the chamber)

We're going to give you a few moments to get acclimated to the sound and temperature in here. The presentation will begin in a few moments.

(Wait 1 minute for acclimation)
(10 seconds before presentation)

The presentation is about to begin. Please relax and focus on the products. Thank you.

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