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# Perceived Location of Self

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By

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**Perceived Location of Self**

A THESIS

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Abstract

Evidence suggests that the perceived location of the self is changeable. I replicated Legennhager et al (2007) where participants experienced a perceptual illusion of a relocated self, created by having a participant wea r virtual reality goggles that present another's perspective. The goals of this research were to give physiological response evidence to the sentiment that the self is able to be relocated. Many experiments rely only on self-report, despite the wealth of evidence showing that self-report and surveys are often misleading (Dollinger, et al. 2009). Selected from general psychology courses, participants were paired into groups of two. Participants wore virtual reality glasses that were connected by a video cable to a video camera. The camera was fixed on another participant's head, so that the participant was viewing his/her counterpart in three dimensions from above via Vuzix VR (virtual reality) glasses. The researcher appeared to be rubbing the participant on the arm. The BIOPAC system was utilized to measure the physiological response, including galvanic skin response, of the participants, during the experiment. The hypothesis was that the participants would have a physiological response to perceived touch.

*Keywords:* micromho (μmho), physiological biofeedback, self, virtual reality, embodied cognition, self-schema

# Perceived Location of Self

"Tell me, where is fancy bred, in the heart, or in the head (Shakespeare, 1596-1598)?"

## A brief history of the self

The search for the self is a primal and antiquated pursuit, but it transcends time. Since Homo *ergaster* (the first hominid with language capabilities) could utter the first contrived sounds in an attempt to communicate, hominids pondered their existence (Ruhlen, 1996; Aiello & Wells, 2004). As long ago as 5,000 B.C.E., evidence for the search for a localized self appears in the tombs of Egypt. In ancient Egypt, embalmers removed the brain of the deceased through the nose during mummification (Breasted, 1937). The brain was discarded because they did not think that it was necessary in aiding their leader in the after-life (Breasted, 1937; Santoro, Wood, Merlo, Anastasi, Tomasello, & Germano, 2009). Instead, they preserved the heart in the chest cavity of the pharaoh. To ancient Egyptians, the words "mind" and "heart" were interchangeable (Breasted, 1937; Santoro et al, 2009).

The cardio-centric-self view endured for thousands of years. Homer, the ancient Greek poet regarded the heart as the primary organ of the soul, saying that it was the seat of intelligence and emotion (Phillips, 1973). Typically, the accepted belief was that the self was located somewhere within the chest cavity (Lykouras, Poulakou-Rebelakou, & Ploumpidis, 2010) or possibly in the liver (Gardiner, 1919).

The first documented challenge to the cardio-centric belief came from Democritus of Abdêra (Grammaticos, 2008). Democritus's argument was that the self was a characteristic of the whole person; he wrote, "the brain watches over the upper limbs like a guard, as citadel of the body, consecrated to protection…the brain, guardian of thoughts and intelligence," the heart, "the queen, the nurse of anger" and the liver, "the center for desire" (Crivellato & Ribatti, 2006).

Democritus's most famed student, Hippocrates, the father of Western medicine, cosigned the idea that the brain was the seat of the self, maintaining that "men ought to know that from the human brain and from the brain only arise our pleasures, joys, laughter, and jests as well as our sorrows, pains, griefs and tears" (Hippocrates, 400 B.C.E.; Stone, 1937). Plato and Orpheus also contended that the self was a tangible entity that existed within the head (Pandya, 2011). Plato added that the self survived on a hedonistic principle of good v. bad and pain v. pleasure (Calkins, 1917; Gardiner, 1919).

The brain was understood to be the seat of the self. However, Aristotle did not agree with that concept. *Tabula Rasa*, an original hypothesis of Aristotle's explained that the mind was a blank slate and that all experiences were written onto it. People draw their understanding about the world around them based on the experiences that they have (Aristotle, 350 B.C.E.). Aristotle also speculated that without sensation and perception, there was no learning or intellect (Aristotle, 350 B.C.E.; Weiss, 1969). Aristotle theorized that the brain was a cooling tank for the blood and that there was an organ designated to bring together the senses sensus communis (common sense), which made up the self (Blankenberg & Mishara, 2001; Crivellato & Ribatti, 2006; Pandya, 2009). Despite Plato and other's relocating of the self to the head, the cardio-centric belief remained the popular and accepted location of the self for several hundred years. Lucretius was the final well-known philosopher to continue with the concept of the heart-centered self (Lucretius, 1977).

The dawning of the first millennium A.D. brought with it a new understanding of the human psyche and biology. Localizing the immaterial concepts of mind, self, and soul within the confines of a meaty organ that resides within the skull was no longer sufficient. The self instead, began to spread across the body. For example, many ancient scientists believed the soul resided within the heart, lungs, or the liver. However, Hippocrates posited that the seat of the self was in the brain. Aristotle's *tabula rasa* theory transferred the mind to the parameters of the human body, that is, it is not localized to one organ but the entire human system.

Other scientists of ancient Greece found that blood vessel and nerves were different structures and that nerves branch out from the spinal cord or the brain (Šimon, Marečková-Štolcová, Páč, 2010). Galen of Pergamon performed nerve ligation experiments and concluded that the brain controlled all motions of the muscles through conduction of the cranial nervous system and the peripheral nervous system (Temkin, 1973). He was also the first to notice that the size of the brain changes throughout the extent of a person's life. Through empirical research, Galen demonstrated that the brain was the central executive for humans and that it controlled body movements and mental processes. However, Galen's efforts became a casualty of the Dark Ages and would be forgotten for another thousand years (Maudgil, 1998).

As the Dark Ages (Middle Ages; 500-1400 C. E.) approached, the development of technology and understanding ceased. Scientific exploration was denounced, and religion took precedence above scientific progress. Despite flourishing scientific evidence during the first four hundred years A.D., Aristotelian theories of the heart-centered-self remained largely uncontested until the mid-16$^{th}$ century. Finally, the Renaissance and the Age of Discovery initiated. With it, the Renaissance brought a new thirst for discovery and understanding. For example, an early scientist, Andreas Vesalius (1514-1564) conducted dissections on human criminals (human dissection was banned by the church for over 1,000 years) and argued that the brain and the central nervous system were the center of the self (Gross, 2009).

Soon after Vesalius's death, René Descartes began his own research. Descartes described the human body as a mechanical entity with physical properties but he believed that the soul was intangible and did not follow the laws of nature. Descartes believed that the soul was seated in the pineal gland, deep inside the brain. He proposed a bidirectional feedback loop between the mind and body, stating that the mind directly influenced the body but that the body could also influence the mind. Before Descartes, the mind-body theory existed, but only in a unidirectional frame, in which the mind influenced the body and not the other way around (Damasio, 2005).

*Tabula rasa*, originally Aristotle's theory, is more often attributed to John Locke. Locke was a great free-thinker of the Renaissance. Current assessment of the contemporary notions of identity and self are normally linked to Locke's theory of mind. He postulated that the self was defined as a string of consciousness and that we are born with a blank slate. However, the difference between Locke's and Aristotle's views is that Locke contended that humans are boorn with innate ideas and are molded by experience which is rooted in the sense perceptions (Nimbalker, 2010). Locke defined the self as a "conscious thinking thing, (whatever substance, made up of whether spiritual, or material, simple, or compounded, it matters not) which is sensible, or conscious of pleasure and pain, capable of happiness or misery, and so is concerned for itself, as far as that consciousness extends" (Locke, 1690). Locke's work influenced many noted philosophers after him, including Voltaire, Hume and Hobbes, the writers of the Declaration of Independence, and even Sigmund Freud (Baird, 2008).

Descartes scientific approach to the understanding of humans and human behavior influenced many great modern thinkers. Descartes's most famous predecessor, David Hume was influenced greatly by him, but not because he agreed with him (Damasio, 2005). Hume's views were the opposite of Descartes's rationalistic interpretations of human behavior. Hume adopted a naturalistic approach to the understanding of human nature and attempted to establish an experimental methodology in this pursuit (Hume, 2010). He concluded that humans are not driven by reason, rather, desire and innate ideas were mythical. According to Hume, we cannot have an understanding of something that we have not experienced (Millican, 2002). Hume believed the self was a complex bundle of experiences or perceptions, each perception is connected to all other perceptions through experiences, causation, and familiarity (Cassam, 1991).

**The empirical pursuit of the self.**

For several thousand years, scientists and philosophers have searched for an understanding of the self, to no avail. During the Industrial Revolution, science and medical advances reached a paramount (Easterlin, 1995). Before the Industrial Revolution (1750-1850), scientists were unable to observe and measure human behavior in a reliable or valid manner. All existing theories of the self were conjecture and based upon non-empirical observations. During the Industrial Revolution, tools such as the tachistoscope began to appear and suddenly, scientists were able to reliably observe, measure, control, and predict human behavior (Ferree & Rand, 1937).

Hermann von Helmholtz and his student, Wilhelm Wundt (also known as the father of experimental psychology), are the first scientists credited with merging the scientific method with the study of human behavior (Bowler & Morus, 2005). Helmholtz used a galvanometer to measure the speed at which a signal is carried across a nerve fiber. The galvanometer was a sensitive timing device; on it, a mirror was attached to a needle and the beam reflected was used to measure the speed of the signal as it traveled across the sciatic nerve in a frog's calf. Scientists previously believed the speed of signal transmission was immeasurable (Glynn, 2010). Helmholtz's discovery was the beginning of the understanding of nerve impulses and consequently, the foundation of an understanding of an embodied self.

Wundt's staunch decree on physiology and human behavior led him to the assumption that if a self did, in fact, exist, it was irrelevant. Wundt contended that humans could only be studied in terms of observable phenomena (Wundt, 1904). Wundt's work sparked the zeitgeist of the early 20th century. Psychologists began doing case studies and experiments in which the focus was to observe human behavior. The combined efforts of Helmholtz and Wundt removed the importance of the brain from the equation and reinvented the idea of an embodied self.

Sir Charles Sherrington, famous for coining the term 'synapse', focused on identifying the core of human reflexes and actions. Sherrington was a faithful dualist; he believed that the body was a machine of substance, whereas, the soul was immaterial and could not be attached to any aspect of the body (Zeman, 2007). Sherrington proposed that it is possible for nerves and the spinal cord to 'think' before a nerve impulse even reaches the brain. A reflex is an action that essentially occurs without thought (i.e., a knee-jerk reaction). Sherrington discovered the synapse, which was the connection to the reflex arc in neuron theory (Burke, 2007). He alleged that the reflex was a cluster of organized nervous action. Walking is an instance of a chain reflex. We now know that the mechanism for performing innate actions such as walking and breathing are within the nervous system, once they are automated (Molnár, 2010). By severing neuronal paths to the brain and stimulating nerves, Sherrington observed that a reaction to electrical stimulation still occurred (Molnár, 2010).

Reflexes were originally thought to be purely innate until Ivan Pavlov discovered the conditioned reflex. While measuring salivation rates among dogs, Pavlov unexpectedly learned that when presenting a dog food with the sound of a bell ( or metronome, electric shock, whistle, etc.), the dog would associate the bell with food and eventually salivate when presented with just the sound of the bell, the presence of food was not necessary (Todes, 2002). Contributions made by Sherrington and Pavlov are important to embodied cognitive science because they suggest that we are not of our brain; rather, our brain is part of us. It is not necessary for all actions to be consciously processed through the brain.

**The social self.**

The notion of "walking a mile in someone else's shoes" in the sense that to occupy a different body is to attain a different self, has a long history. For example, in the Odyssey, Odysseus's mates were morphed into pigs and became very disgruntled about losing their human bodies (Homer, 2010). In the $20^{th}$ century, Franz Kafka wrote about poor little Gregor Samsa who arose one morning to find himself in the state of a cockroach (Kafka, 1915). More recently, Hollywood has exploited this idea in movies such as "Big," "13 Going on 30," "Freaky Friday," "Being John Malcovich", and the list goes on. Perhaps there is a deeper, more philosophical theme behind these light-hearted tales. If it were possible to leave one's own body and enter the body of another, would humans be able to learn empathy? Do our souls exist beyond our bodies (Bloom, 2004)? When does life begin? When does consciousness begin? The goal of the current research is to add evidence to the existing body of "embodied" science, to identify a relocatable self, and to support existing theories that the self is an illusion.

"Potential social Me" (James, 1910), "ego ideal" (Freud, 1925), "ideal self" (Horney, 1950), "individual self-regard" (Rogers, 1951), and "imagined self" (Levinson, 1978) are all examples of a "possible self" (Markus & Nurius, 1986). Possible selves are attributed to the discrepancy between the current self and the self that one wishes to be. That discrepancy is often ascribed to self-esteem but possible selves can take on any form. A possible self can be a doctor or a criminal. The possible self, for most, is evidenced in the need to be better, which fuels fears, motivations, and needs. Possible selves are amalgamations of what we know, what we have experienced, and what we wish to know and experience. When developing a possible self, we draw from the past and make aspirations about the future.

So what keeps our possible selves from becoming a criminal or a doctor or anything in between? Research suggests that acting as if a possible self is one way to make the potential self real. People who role played were more inclined to balance out cognitive dissonance and eventually relate to their perceived role (Elms, 1966). Empathetic fantasy ability was crucial to attitude changing behavior (Elms, 1966). When being placed in a role, people are more likely to identify with that situation in the future. The situation even appears to be bidirectional: the easier it is for one to identify with others, the broader that person's base of possible selves becomes. In short, it seems the only way to understand fully someone else's role is to live either directly or vicariously in their body.

**Current trends.**

The bulk of our current understanding suggests Galen's concept of the self is no longer adequate. New frontiers in neuroscience highlight the brainstem as the house of the soul; "if there be a soul in each of us, surely, it is enshrined here" (Temkin, 1973; Pandya, 2011). Self, psyche, mind, soul, etc. are words that are often interchangeable, yet they have different meanings. 'Self' will be the acknowledged vernacular for the purpose of this research. The accepted theory that the self exists within the human brain does not hold for new theoretical perspectives. An emerging field of science has introduced new ways of looking at human behavior and understanding.

If the soul were tied to the brain, like many believe, then it would not be possible to relocate the self. However, embodied cognitive science is based on the assumption that the self is a constructed illusion and that it is contained in the space of the body and within its surroundings and affordances (Chemero, 2007; Chemero & Turvey, 2007; Noë, 2009). Humans are “in the world and of it” (Noë, 2009). The way that people interact in their world and the effect that the world has on them defines how they learn and who they become. Humans often incorporate tools into their body schema or they use them as an affordance. An affordance is a tool or item that allows one the ability to do something they would not typically be able to accomplish with just their hands or feet or the knowledge they possess (Kelso, 1995). People often attribute knowledge to the brain, when in reality, much of what we know, we only think we know. After being asked “do you know what time it is,” someone who is wearing a watch is likely to say “yes” without actually knowing the time the same would work for a GPS when asking for directions (Noë, 2009). Sometimes the tools to which humans have access to become a part of the extended self. If it holds true that individuals can extend themselves, then it is possible that they can alter the location of their perceived self (Leggenhager, 2007).

It is difficult to envision the self outside the confines of one’s own body plan (a head, two arms, two legs, and a torso) (Guterstam, Petkova, & Ehrsson, 2011). Yet, participants had that experience during an experiment in which they mistook a rubber hand for their own hand. When a rubber hand was placed in close proximity with their own hand and stroked, fMRI activity showed similar patterns to when their actual hand being touched (Ehrsson, Wiech, Weiskopf, Dolan, & Passingham, 2007). The rubber hand illusion shows that participants quickly adopt the new hand into their body schema and will sometimes actually try to use it as their own (Newport, 2010).

Participants have been able successfully incorporate fake limbs into their own body schema (Guterstam, Petkova, & Ehrsson, 2011). People who use wheelchairs often report feeling as though it is a part of their body schema and that it makes them uncomfortable when others touch their chair. Is it possible for one to incorporate a new body into their schema? In one experiment, participants inhabited the virtual body of a mannequin. The participants wore virtual reality (VR) glasses that displayed the back of a mannequin. The mannequins were stroked with a dowel rod while the participant viewed the action as if it were them. Participants reported feeling as if they were being touched, though they knew they were not. Participants also reported feeling that they inhabited another body throughout the experiment (Leggenhager, 2007). Men were able to inhabit and even own the body of a female, as reported through self report and heart rate (Slater, Spanlang, Sanchez-Vives, & Blanke, 2010). When men were virtually immersed into a woman's environment, they witnessed another woman slapping them (only in virtual reality, no men were harmed in the data collection of this experiment), participants reported that they felt as though they were going to be slapped, and their heart rate spiked while being threatened (2010).

Participants donned VR glasses and head mounted displays in another experiment. The camera of one participant recorded his/her movements and was relayed to the glasses of the other participant in real time, such that the participants shook hands with what looked like their own body, while inhabiting another body. During another portion of the same experiment, participants were paired with a mannequin whose stomach was subsequently slashed, the video was relayed to the participant's glasses. When participants' galvanic skin response (GSR) was measured, results indicated that the participants reacted as if they saw their own body being threatened (Petkova & Ehrsson, 2008).

There are solid applications hidden deep within the past research, applications that can help the population as a whole. A malleable self schema suggests therapeutic strategies. For example, six participants with amputated hands and phantom limb pain had a mirror placed vertically on the table in the place of their missing hand, so that their existing hands were superimposed onto the felt position of the phantom limb (Ramachandran, 1996). The participant would move it's normal hand and view it in the mirror, where it looked as if both hands were moving. Participants reported that it felt as if both hands were moving (1996). After repeated practice with the mirrors, participants reported a permanent loss of phantom pains (1996). Since this experiment, virtual reality applications replace mirrors and participants in a case study reported that phantom pains disappeared after several trials (Murray, Patchick, Pettifer, Caillette, & Howard, 2006; Murray, Patchick, Caillette, Howard, & Pettifer, 2006).

Visual feedback therapy via virtual reality and mirrors are effective in treating single-limb pains but is it useful for whole-body pains? Fibromyalgia is a chronic condition characterized by joint and muscle pains, stiffness, fatigue, and depression (Chakrabarty & Zoorob, 2007). Mirror methods were used to treat a patient with fibromyalgia, the results showed that patient's pain diminished by almost half (8.00:4:93), whereas in the placebo conditions, pain only decreased by .67 (Ramachandran, 2010).

Virtual reality technology and body swapping have been used to assist patients affected by eating disorders (Gorini, Greiz, & Guiseppe, 2010). Participants with eating disorders experienced a virtual environment where food was presented to them and physiological data was recorded, (2010). When participants experience virtual environments within the confines of a therapist's office, it assures that they have real emotional experiences and that they are in a place that they can be treated during the triggering event, not after the fact, or when it is too late (2010). These tactics can also be used to aid in body dysmorphia disorders. Participants have the virtual experience of owning a body with an inflated belly. After residing in the body for four minutes, the participants were observed carrying themselves as though they had an inflated belly as well. This perception caused a temporary manipulation of body perspective (Normand, Giannopoulps, Spanlang, & Slater, 2001).

Perhaps the most serendipitous discovery with virtual reality treatments is its effectiveness on treating people with posttraumatic stress disorder (PTSD). Once a week for 14 weeks, first responders to the World Trade Center (WTC) disaster site, who met PTSD criteria were treated in therapy sessions (Difede, Cukor, Patt, Giosan, & Hoffman, 2006). Participants was separated into two groups, one group received traditional therapy and the other group were immersed into a virtual environment with graded hierarchical exposure to stimuli (from photos up to a reenactment). Participants in the traditional therapy group typically failed to improve after treatment (only three of nine participants' conditions enhanced), whereas participants in the virtual reality group no longer met the criteria for PTSD after treatment (five of eight participants no longer met the criteria, yet all of the participants in the non-exposure group still met criteria after treatment) (2006). Similar results were found with participants from the Vietnam War era, Iraqi War era, and WTC victims when presented with stimuli of their respective experiences (Rothbaum, Rizzo, & Difede, 2010). Participants were presented with olfactory, audiovisual, and tactile stimuli. Sixteen of the 20 participants no longer met DSM requirements for PTSD after treatment (2010). Virtual reality and the search for a localized self have been successfully implemented into clinical settings.

At present, the issue of the self is anything but resolved. Many current theories holding that the self is in the brain exist, while other theories go as far as to maintain that the self is a spiritual entity and it lives on even after the body is gone (De Santo, et al, 2009). In contrast, some current theories maintain that the self is illusory (Carter, 2002). However, more contemporary evidence suggests that, perhaps, the self is a construct that inhabits the whole body and even parts of our personal space (Chemero & Heyser, 2005; Noë, 2009). If these new theories are correct, then perhaps it is possible to relocate the self. In one study, participants place their hands on a table and a wooden slab is placed upright between them but to the far right side of the body. A rubber hand is placed in a position that is similar to that of the participant's own hand. A towel is placed over the arms to hide the deficiency, and the rubber hand is stroked. Participants reported feeling as though they were being touched, yet they knew that they were not actually being touched (Petkova & Ehrson 2008).

**The experiment.**

Participants wore head mounted cameras and virtual reality glasses that had a three-dimensional (3-D) display from their counterpart's point of view. Participants were oriented to the body of their fellow participant by following directions that they received via a script, as presented by the researcher. Following set up and orientation, a baseline measure of the participants' galvanic skin response (GSR) was recorded before exposing them to the experiment and again at varying times during the experiment. The participants were stroked with a pencil on their arms both synchronously (at the same time) and asynchronously (at different times) while GSR data was being recorded. Following the experiment, participants were asked whether they felt as though they were being touched when they knew they were not and they were asked if they felt as though they had swapped bodies with their counterpart. I believe that there will be a significant difference in GSR response between touch types (self, sync, and other) and the baseline. Also, I predict that participants will report feeling touched and having a body swapping illusion.

# Method

## Participants

Participants were recruited from undergraduate General Psychology classes. A total of 16 undergraduates participated in the experiment, however, the data from one participant was removed from due to experimenter error. Participants ranged in age from 18 to 22 (10 males and 5 females) with the average age being 19.733 (*S.D.* =1.1). All participants were subject to all conditions. Participants engaged in the experiment as partial fulfillment of the course requirements. Participants were paired with another participant and they experienced the study in tandem. All participants reported having normal or corrected-to-normal vision.

## Materials

### Virtual reality glasses.

The Vuzix Wrap 920 (Appendix A) glasses had the style and fit of a pair of sunglasses. The eyewear connected to video devices with video-out capabilities and composite video connections. The monitor on the glasses was one half inch; however, the display was a virtual 67-inch screen as seen from 10 feet. The feedback was in the format of a three-dimensional display. The input settings were adjustable via a controller that connected to the glasses through a video cable. A Vuzix lightshield (Appendix B) was placed over the outside of the glasses to block out residual light from the outer rims of the glasses.

### Head mounted display.

A Go Pro HD Helmet Hero ® wearable camera (Appendix C) captured the movements of the participants. This camera recorded 1080p (pixels) HD video and recorded at 30 frames per second (fps). The mounted helmet camera was a headlamp-style apparatus with a vented helmet straps mount laced through a vented helmet. The camera was encased in a waterproof quickrelease case that afforded head mounting. The camera battery was a rechargeable 1100 mAh lithium-ion battery. The chargeable battery was utilized to minimize the number of cords necessary for each participant. A SanDisk® 4 GB memory card was placed in the camera for real-time streaming. Video of the experiment was not saved onto the SD card.

**Helmet.**

Adult sized Schwinn Merge Q-Star Microshell bicycle helmets were used for this experiment (Appendix D). The visor was removed for unobstructed viewing. The camera was affixed through the flow vents in the front of the helmet with the vented helmet straps mount that was included with the wearable camera. Bicycle helmets were the most natural headgear available.

**BIOPAC.**

Galvanic skin response (GSR) was recorded with the BIOPAC MP35. The MP35 measured subtle and sudden changes in electrodermal activity. GSR is the measurement of the activity of the eccrine sweat glands. Electrodes were placed on the fingertips because they have a high concentration of these sweat glands. "Responses are a function of the pre-secretory activity of eccrine sweat glands and the filling of the sudorific tubules. The combination of these sudorific elements serves to increase the conductivity of the skin when activated (BIOPAC, 2009)." Electrical conductance is a function of increased activity in response to a presented stimulus, touch. Evidence supports the theory that touch will elicit a physiological response, if the touch is calming, the GSR will be reduced if the touch type causes anxiety, the GSR will elevate (Wilhelma, Kochar, Roth, & Gross, 2001). In other words, if the touch is calming or welcome, the GSR will be lower than the baseline. If the touch is unwelcome or causes anxiety, the GSR will be higher than the baseline.

GSR data was collected via the GSR100 amplifier on the MP35. The GSR100C module was employed as the amplifier, and the electrodermal response transducer (transducer TSD203) was used for calibrating the GSR. BIOPAC general-purpose, disposable, pre gelled electrodes (EL503) were attached to the participants' index fingers and MP40 leads were toggled from the electrodes to the amplifier.

Hardware Setup.

On the dropdown menu in the BIOPAC AcKnowledge System, the Gain switch was set to GSR100C. The unit of measure for the GSR100C is the µmho (micro mho) (µmho = µsiemens. The mho is the reciprocal of the unit of measurement for resistance, the ohm) (BIOPAC, 2009). The conductance range was set to 0-20 µmho, indicating a low conductance range for mild stimulation. Once calibrated, the recording began and the researcher pressed the F9 key on the keyboard to indicate that a touch was initialized. This was a manually placed event marker.

**Survey and demographics.**

Upon arrival to the experiment site, participants completed a demographic survey (Appendix E) and an informed consent form (Appendix F). The demographic survey included questions about age, ethnicity, visual acuity, etc. Each participant was warned of the possible discomfort they may undergo during the procedure caused by the helmets and multitude of cords attached to them. Participants were reminded that they could withdraw from the process with no penalty. All participants chose to continue with the experiment. After the experiment, participants completed the final two survey questions. The questions were: "Did you feel as though you were being touched even though you knew you weren't" and "Did you feel as though you swapped bodies with your peer". Upon completion of the experiment, participants were debriefed on the nature of the research. Participants were thanked for their participation and dismissed.

**Procedure**

Prior to the experiment, participants received a demographic survey and an informed consent form (Appendix E & F). In the experiment room, the cart holding the BIOPAC computer was situated in the right back corner, to avoid intrusion of the participants' space. Behind the BIOPAC cart, there was a table and two chairs (Appendix G). Vuzix wrap 920 glasses were given to each participant for the duration of the experiment. The glasses were matched with a Vuzix Lightshield, which obstructed residual light from entering the line of vision around the brim of the glasses. Participants wore helmets that had the HD Helmet Hero attached via the camera mounting system. The camera of participant A was toggled to the glasses of participant B with video cables and vice versa. Electrodes were placed on the right index finger of each participant and the lead was clipped onto it. The lead of participant one was connected to the MP35 machine, which records data.

After being attached to all of the equipment, the researcher began recording Micro MHOs of galvanic skin response. The participants were asked to demonstrate the arm motions of the Hokey Pokey to help orient them to their new body. Participants were given a rest period of about 30 seconds, in which they were able to sway, ask questions, or just get more comfortable. After the rest period, the researcher announced that baseline measurements would be taken and asked the participants to remain as still as possible. Baseline was taken for 30 seconds and another rest period was given. After this rest period, the participants extended their right arm, palm down, while the researcher and researcher's assistant stroked the participant's arm with the eraser end of a pencil. The participants were touched at the same time (synchronously), or asynchronously (either of the two participants were touched at a chosen interval) touch type was counterbalanced to avoid a practice effect and confounding variables After the response of the first participant was taken, the leads were placed on the electrodes of the other participant and their response was measured as well.

**Design**

The design of this study was a one-way within participants repeated measures ANOVA. The independent variable, touch type, had four levels (baseline, sync, self, and other). The dependent variable was a continuous measure of GSR in µmhos measured at 50 units per second. An independent samples *t*-test was used to measure the prediction rate in perceived touch (as reported on the survey) and actual GSR. The same was performed to measure the prediction rate between perceived swap and GSR.

Table 1

*Design of the unit and rate of measurement for the perceived location of the self experiment.*

| | Participant |
|---|---|
| Baseline | µmhos; 50 per sec. |
| Self | µmhos; 50 per sec. |
| Sync | µmhos; 50 per sec. |
| Other | µmhos; 50 per sec. |

**Data Analysis**

The output from GSR data tends to be noisy. To reduce noise, the data was resampled to reduce measurements from 200 per second to 50 per second. Then, baseline measures were taken from random moments of rest instead of from the announced baseline measures. Next, outliers were smoothed within the GSR output so that they were equaled to the nearest end-points using AcqKnowledge BIOPAC software (Merletti & Parker, 2004; Acq*Knowledge*® 4 Software Guide, 2008). Winsorised estimators are usually more robust to outliers, however, there are alternatives to Winsorizing, such as trimming the means which would have a similar effect (Tukey, 1962). Winsorizing was chosen over other forms of normalizing data in order to preserve similar *n* (Tukey, 1962).

In Winsorizing, the top five percent and bottom five percent of data are extracted from the sample. The extracted data is transformed into the top and bottom scores of the top and bottom (respectively) quartiles, such that 97 with a high score in the upper quartile being 78, would be converted to 78. Winsorizing is used to preserve that existing data without removing it (Tukey, 1962).

Finally, standardized scored were calculated across participants. Because participant response was extremely variable, it was necessary to compute standardized scores (Field, 2005). Participants who felt that being touched was invasive and thus made them feel uncomfortable were likely to present with elevated GSR data, whereas participants who felt comfortable in the experiment were likely to have reduced GSR data.

A one-way repeated-measures analysis was performed on touch type. The independent variable consisted of four levels (baseline, self, sync, and other). An independent samples *t*-test identified the differences between perceived swap and the means for each touch type and an independent samples *t*-test was used to identify the differences between perceived touch and the means for each touch type.

**Results**

A one-way with-participants analysis of variance was performed on the perceived location of the self. The independent variable was touch type (baseline, sync, self, and other) and the dependent variable was GSR (μmhos). Also, independent samples *t*-tests were used to analyze the effect that two predictors (perceived touch and perceived swap) have on GSR data. Analyses were performed with SPSS syntax and general linear model, repeated measures. Mauchly's test of sphericity was significant for all participants, likely due to high power. Greenhouse-Geyser was used for a robust sphericity violation (Greenhouse-Geyser, 1959).

No outliers remained after resampling, smoothing, Winsorising, and standardizing the scores. The original sample of 16 was reduced to 15 due to experimenter error. After transformation, there was a significant difference for each participant across each touch type.

An independent samples *t*-test indicated that the perception of being touched does not predict the mean difference between baseline GSR and the touch type other GSR ($t$ = -1.151, $p$ = .163). An independent samples *t*-test also indicates that the perception of being touched does not predict the mean difference between the touch type self GSR and the touch type other GSR ($t$ = -1.463, $p$ = .191).

Only 47% of participants reported feeling touched, 53% reported no touch. Whereas, 53% of participants reported feeling as though they swapped bodies, while 47% reported no perceived swap. Using a MANOVA, there were no main effects reported for perceived touch nor perceived swap.

Table 2

*Statistics for perceived touch, swap, and the interaction of touch and swap*.

| Perception | F | Sig. | Effect Size | Power |
|---|---|---|---|---|
| Perc. Touch | .660 | .551 | .155 | .124 |
| Perc. Swap | .851 | .262 | .080 | .083 |
| Swap*Touch | .455 | .955 | .241 | .185 |

An independent-samples *t*-test indicated that the perception of swapping bodies does not predict the mean difference between baseline GSR and touch type other GSR. An independent-samples *t*-test also indicates that the perception of being touched does not predict the mean difference between the touch type self GSR and the touch type other GSR. Finally, an independent samples *t*-test also indicates that there are no main effects between the mean difference of perceived swap and perceived touch.

## Discussion

As previously discussed, we explored whether or not participants reported feeling a perceived body swap or a phantom touch via self report. We also looked at whether they had a physiological experience induced by the phantom touch. Finally, we observed the relationship between their perceptions and physiological responses. All touch types were significantly different for all participants. These results did not correspond with the hypothesis that baseline and the other touch type would be significantly different and that the other touch type and the self touch type would not be significantly different. The results of the body swapping experiment suggest that humans are easily fooled. However, the self-report did not match the participants' physiological response. Participants reported feeling touched when they knew they were not being touched and reported a perceived body swap only about half of the time but their physiological response suggests that they felt the swap and touch when they did not think that they had. Their physiological responses indicate a possible deficit between their perception and their physiological response.

The outcome of this experiment suggests that embodied cognitive science is more accurate traditional views of psychology. If we rely only on our brain, our senses and perceptions would not only be less important but they may not exist at all. Our bodies often respond to stimuli when our brain does not respond. Sherrington and Pavlov showed that it is possible to react to environmental triggers without consciously processing them in the brain.

There were a few limitations in this experiment. First, the *n* of the experiment was relatively small (15 participants). While it may not be necessary to add more participants to the sample, perhaps recording more observations would identify a clearer conclusion as to whether or not participants responded similarly to the self and other touch conditions. Also, participants were able to see and talk with their counterparts prior to participating in the experiment and in at least one case, the participants were already friends and they signed up together. Having prior exposure to their new body could have been an intervening variable.

With technological advances also come experimenter error and glitches in technology. During one trial, a participant's camera turned off and he did not tell the experimenter right away. Also, it is possible that participants were not calibrated correctly with BIOPAC, which could have attributed to the large discrepancy between GSR among participants. In addition to technology glitches, it is possible that having a large number of new tools incorporated to the self schema could have been distracting to the participants. Participants wore glasses, lightshields, electrodes, cameras, and helmets and they were all connected with cords. It is likely that having to adjust and integrate so many new and often bulky items at once could have made it difficult for the participants to concentrate on the tasks at hand.

In this experiment, the participants' GSR relied on the response to visual stimuli only. We know that the more senses that are incorporated into our experiences, the more real the experience becomes to the participant (Rothbaum, Rizzo, & Difede, 2010). An appeal to more senses would almost certainly induce representative results from the participants. Unfortunately, a limitation of all virtual reality applications is that a true and immersive virtual environment is costly and difficult to construct.

Furthermore, the experiment may have been too short. Data was only recorded for about six and a half minutes for each pairing of participants, that barely more than three minutes for each participant. In the future, the same experiment should last longer and more measurements should occur. Also, participants will not see each other prior to the experiment and they will be separated by a partition so they are unable to see their own body in the foreground.

The results produced by this experiment and experiments like it leave us with innumerable opportunities. The evidence uncovered by this body of research lends us the tools for testing societal implications and for reducing prejudice. If participants are able to role model and feel empathy without being engrossed in a VR environment (Elms, 1966), then it is possible for participants to have a stronger empathy bond for others when they have actually "walked a mile in their shoes." These types of VR applications have been successfully implemented in addiction research, PTSD treatment, immersion therapy phantom limbs, eating disorders, and pain management (Ramachandran, 1996; Chakrabarty & Zoorob, 2007; Giorini, Grei, & Guiseppe, 2010; Rothbaum, Rizzo, & Difede, 2010; Difede, et al., 2006). These VR applications could also be useful in improvements for prosthetics and the treatment of individuals with paralysis. Paralyzed patients report feeling that the staff who manipulate their bodies for physical therapy and other treatments are too rough with them. They feel that health professionals think that they cannot feel anything, so it does not matter whether or not they are gentle with them. Possibly, in a VR environment, these professionals can see what it is like to be moved in such ways and to see if they feel it.

This research advances empirical evidence of the knowledge of the perceived self. Using VR to identify a locatable self has implications in answering moral questions about identity and personhood. If the self is constructed and only exists based on a feedback loop between the environment, the person, biology, and experiences, then it is possible to identify when life essentially initiates.

With an access to new technologies and virtual reality applications, it is possible for us to truly identify the location of the self. The results of this experiment suggest that the self is an illusory entity that changes form based on context and can actually be transferred to a new being. With these contributions to the field of embodied cognitive science, it is possible to answer the questions of Hume and Locke. Locke said that the self is a conscious thinking thing but it seems to be a feedback loop and not two individual concepts. Consciousness and the self would not exist without one another and they influence each other. As far as Descartes is concerned, his theory that the self is located in the pineal gland is disproven with this body of knowledge. In addition, we know that a previous belief of a bodily self that is attached to the human anatomy is erroneous. The true empiricists, Galen, Sherrington, Pavlov, etcetera, have nodded in the correct direction. Their research is evidence that humans do not process everything through a central executive, rather, they automate familiar activities, which leave resources for activities that are not so familiar.

In the multi-million year pursuit for the localized self, philosophers have hypothesized the origins of the self to be tied to the body and others have equated it to an entity unattached to a physical body. Scientists have noted that the self is a culmination of feedbacks between the body, the environment, culture, and biology. The truth is, if the self is in fact an illusion, it will always be difficult to measure or identify. However, the capability to ascertain a moveable self is a grandiose step toward understanding humans and human nature.

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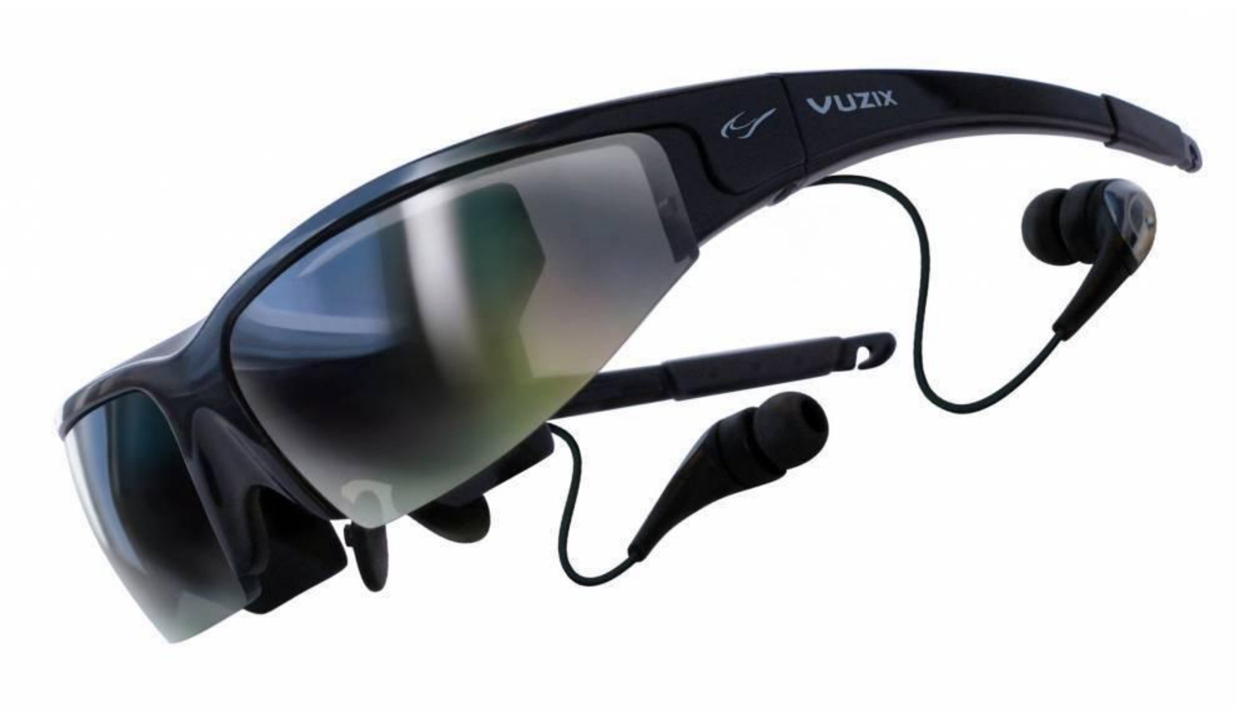
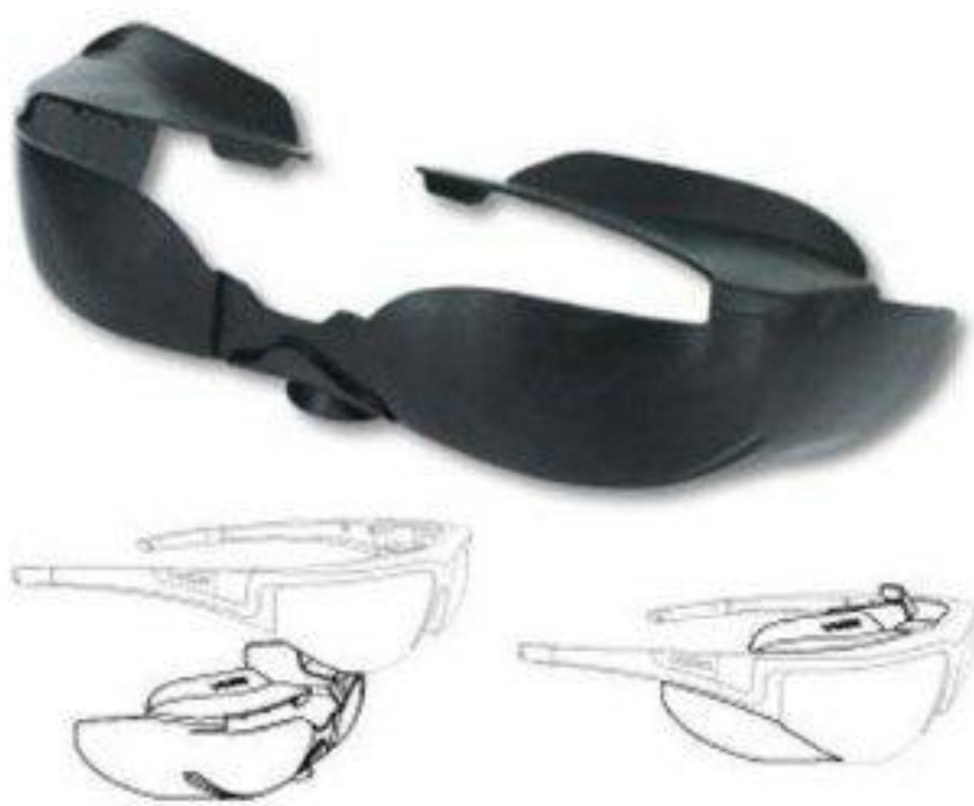
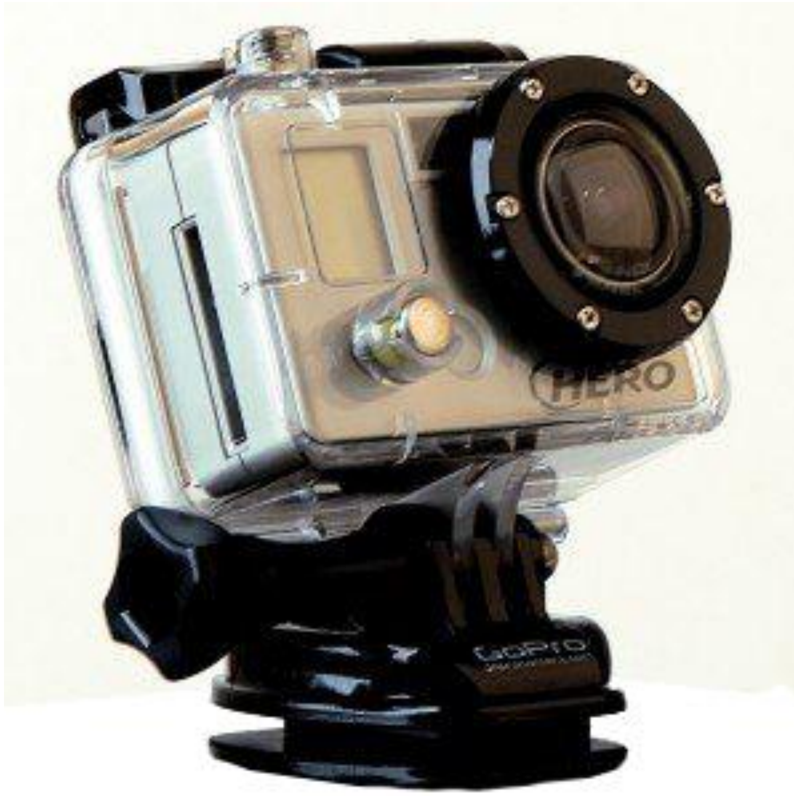
Appendix A



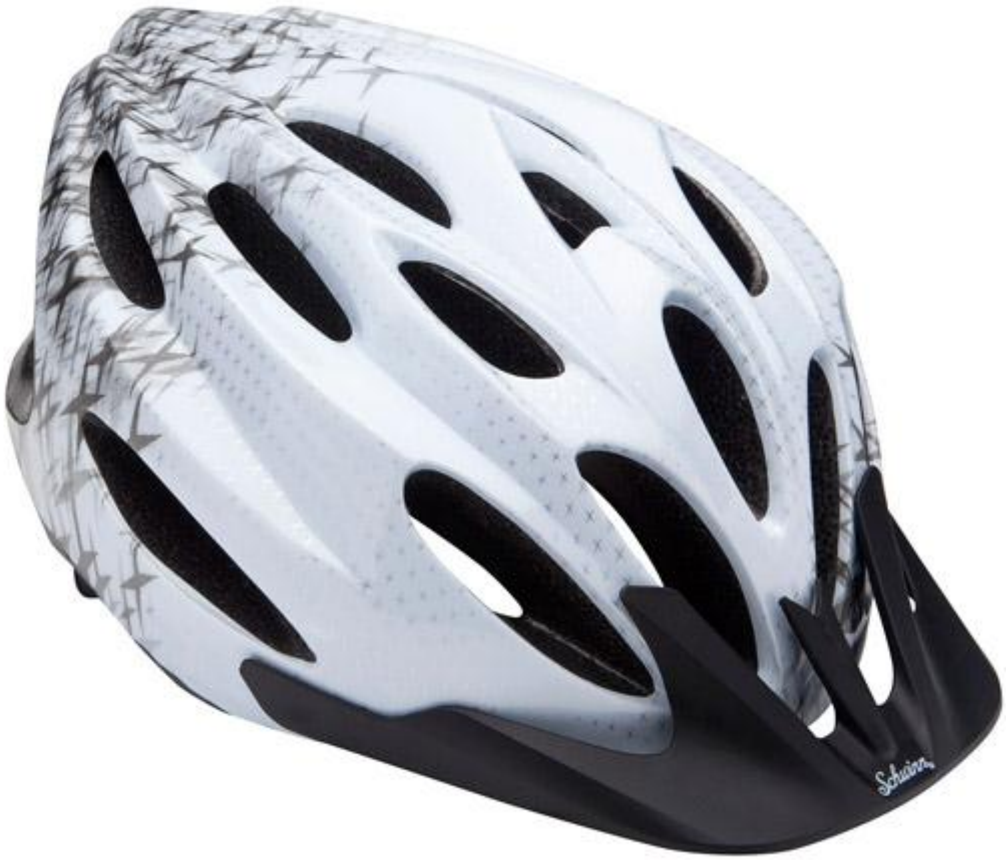
# Appendix B



Appendix C



Appendix D



# Appendix E

______________________________

(Researcher use only)

Participant number

Please indicate your answer to the following questions in the space provided:

1. Sex (M/F) __________ Age __________

2. Do you wear contact lenses (Y/N)? __________ or glasses (Y/N)? ________

3. During the experiment, did you feel as though you were being touched even when you knew you were not?

(Y/N) __________

4. During the experiment, did you feel as though you inhabited another body? (Y/N)_______________

How would you describe your ethnic/ancestral/cultural background? (Please check at least one, but check all that apply)

_____African

_____Asian

_____Caucasian

_____Hispanic

_____Native American

_____Other (Please Explain in one or two words) ____________________

Appendix F

**UNIVERSITY OF CENTRAL OKLAHOMA** **INFORMED CONSENT FORM**

Research Project Title: **Embodied Cognition**

Researcher(s) and contact information: Katherine Jones (kjones59@uco.edu), Bruce Rehburg (brucerehburg@hotmail.com), and Dr. Mickie Vanhoy (mvanhoy@uco.edu) You may also contact the Research Administrator or Dr. Vanhoy at (405) 974-5707 or ucok-admin@sona-systems.net

**A.** Purpose of this research: The relationship between cognition and perceptual systems is seemingly unclear, but recent research suggests that cognition may likewise be described in perceptual phenomena. The goals of this research are to give physiological response evidence to support existing experiments, where participants perceived physical touch and their physiological response mocks their cognitive perception.

**B.** Procedures/treatments involved: Research will take place in a small laboratory. Participants will experience a three dimensional world in someone else's body. The participant will be touched on the arm with a wooden dowel rod and sometimes, the RA will be touched. Other times, both will be touched at the same time. We will measure physiological response to touch and to perceived touch. You will be wearing virtual reality glasses and we will be measuring responses, such as blood pressure, heart rate, and galvanic skin response.

**C.** Expected length of participation: No more than ____1______ hour(s).

**D.** Potential benefits: We happily share this learning experience with General Psychology students who may be contemplating psychology as a major course of study. Because some students may perceive psychology only as the practice of psychotherapy, potential majors need to know that other specialties exist and that some psychologists spend their days doing research. Other than a better understanding for the field of psychology, there is no direct benefit for participants in this experiment.

**E.** Potential risks or discomforts: No harm or discomfort is anticipated in this research greater than that ordinarily encountered in daily life or during routine physicals or psychological examinations or tests. If the participant at anytime feels uncomfortable with being touched by a wooden dowel rod, he or she may exit the experiment with no penalty.

**F.** Medical/mental health contact information: If you would like to visit with someone regarding sensitive or special concerns about this project or other issues please feel welcome to visit the UCO Student Counseling Center at (405) 974-2215 or http://www.ucok.edu/student_counseling.

**G.** Contact information for researchers appears above. You may also contact the Research Administrator at ucok-admin@sona-systems.net. Should you have any additional questions please contact the Chair of the UCO Institutional Review Board at (405) 974-5497 or at irb@uco.edu

**H.** Explanation of confidentiality and privacy: Your name or identity will not be associated in any way with the research findings; information about you remains confidential and will not be kept after the semester ends. Your name or other uniquely identifying information will never be in any record that can be identified with you. We do not request student ID numbers either.

Results are reported only about groups of people or by a number that conceals your identity. All results are reported in summary form, except on occasion when an individual example may be given, at which time no name or other identifiable information will be given. Anonymous data are stored in electronic or hard copy form by individual researchers. Only the student researchers and their instructors have access to the data.

Most psychology journals expect that researchers retain data for five years following publication. Individual researchers destroy anonymous data after the standard retention period (see above) has passed. Records (separate from research data) regarding which students completed their participation assignments are purged from electronic sources or shredded by individual instructors/researchers after final grades are recorded. Paper and electronic data will be kept for five years and informed consent forms and demographic information will be kept for three years.

The fact that you did or did not participate in a specific experiment or study is part of a record available to your Psychology instructor. Psychology instructors have to know which studies you completed in order to know how much research participation credit you earned (in order to determine whether that course requirement was satisfied). They do not need nor do they receive any other information.

**I.** Assurance of voluntary participation:

**AFFIRMATION BY RESEARCH PARTICIPANT**

I, being at least 18 years of age, voluntarily agree to participate in the above listed research project and further understand the above listed explanations and descriptions of the research project. I also understand that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time without penalty. I have read and fully understand this Informed Consent Form. I sign it freely and voluntarily. I acknowledge that a copy of this Informed Consent Form has been given to me to keep.

Participant's Printed Name: _______________________________________________

Participant's Signature: __________________________________________Date _____________

Appendix G