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# The Role of Activation in the Relationship between Power Posing and Task Performance

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# The Role of Activation in the Relationship between Power Posing and Task Performance

by

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# Abstract

This research analyzed the psychophysiological effects that expansive and contractive body poses have on the human body. Participants were asked to hold either an expansive or contractive body pose for two minutes prior to participating in a Color-Word Interference Test (CWT, which induced stress) and a gambling task (which measured risk tolerance). Heart rate variability (HRV) and electrodermal activity (EDA) for each participant was measured to gauge stress throughout the experiment. Positive and negative affect scales were used to measure mood before and after posing. Results of this research did not support our hypotheses, which were: 1. Expansive, dominant poses would cause an increase in performance on the stressful task, a decrease in both psychological and psychophysiological stress response, and an increase in risk tolerance and 2. Contractive, submissive poses would yield the opposite effect. This research was unable to find a connection between posture, risk tolerance, and feelings of improved mood.

## Contents

## List of Figures

## List of Tables

## The Role of Activation in the Relationship between Power Posing and Task Performance

It is established that internal feelings and motivations of human beings are revealed through nonverbal displays, such as facial expressions and body posture (Navarro & Karlins, 2008). As humans that interact with each other, we understand that types of facial expressions and body postures are actions arising from the presence of emotions. In humans, happiness is often accompanied by a smile, while sadness is known to produce a frown. Research on body posture and emotion has showed that humans can accurately interpret emotions expressed through both a person's static body posture (Coulson, 2004) and a person's gait (Roether, Omlor, Christensen, & Giese, 2009).

Research has showed that human emotion can cause changes in nonverbal displays, and for facial expressions, this relationship has shown to be bidirectional – facial expressions can change human emotion to create feelings of happiness, sadness, and more (Soussignan, 2002; Wild, 2002). Research by Carney, Cuddy, & Yap (2010) suggested that body posture could impact human emotion through an activity referred to as Power Posing. Power posing is the act of utilizing the entire body to either increase or decrease the body's perceived size to form a high-power or low-power pose, respectively (Carney et al., 2010). Work by Carney et al. (2010) has suggested that power posing can change a body's response to stress as measured by salivary testosterone and cortisol.

The purpose of this study was to investigate the relationship between power poses and emotion measured through autonomic arousal. We aimed to test if power posing could alter a person's response to a mildly stressful task by lowering autonomic arousal responses. At the time of the current study's conception, work by Carney et al. (2010) was of great interest to the scientific community. Today, however, Power Posing has largely been debunked with many studies failing to support its claims (Simmons & Simonsohn, 2017). Like the many replication studies involving power posing, this study was unable to demonstrate that power posing could impact human emotion.

## Body Language and Emotion

**Facial Expressions.** Human emotions have observable effects on movement of the entire body, with much research focused on the face. Research on how the face reacts to human emotion has laid a foundation for understanding how the body reacts to emotional stimuli. Work by Paul Ekman has shown that happiness, sadness, anger, contempt, fear, surprise, and disgust have facial expressions that are each exhibited by human beings irrespective of age, culture, or geographic location (Ekman & Friesen, 1975). These are known as the Seven Universal Facial Expressions, and each expression has specific muscles that are activated to yield its presence. For example, a genuine smile indicating happiness involves the contraction of the orbicularis oculi and the zygomaticus major, which causes the lower eyelids and cheeks to flex, respectively. This also causes crow's feet to appear – which become more apparent with age (Ekman & Friesen, 1975). We use these facial expressions to communicate information about our environment as well as our current state of mind to other living creatures (Navarro & Karlins, 2008). To ensure that this information is properly received, humans have developed a bias for recognizing and interpreting facial expressions (Kanwisher & Yovel, 2006). This ability to detect facial expressions is strongest for negative expressions which are recognized faster than other facial expressions, even when mixed with a group of happy and neutral faces (LoBue, 2009). This strong inclination to recognize faces is primarily associated with the Fusiform Face Area (FFA) and the Inferior Frontal Gyrus

(IFG) in the brain. This bias is so strong that we often see faces where there are none; a phenomenon is known as pareidolia (Liu, Li, Li, Jie, & Lee, 2014).

Facial expressions not only provide a means to communicate emotion, but they can also affect emotional experience and emotional behavior. In (1990) Levenson, Ekman, and Friesen showed that facial expressions can influence emotions. In this work, participants were simply asked to flex different facial muscles to create specific facial expressions (including happiness, anger, and fear). While these expressions were held, physiological measures were taken. Results of this experiment showed that expressions can cause measurable physiological changes in heart rate, skin conductance, and finger temperature for humans. For example, an expression of anger yielded greater heart rate acceleration than a happy expression; skin conductance was higher for participants while wearing a fearful expression and lower for a happy expression (Ekman, 1990).

Sousignan (2002) conducted a similar set of experiments by having research participants unknowingly activate the muscles used in smiling and frowning, with the aim of determining if facial expressions can change one's mood. In this study participants held a pencil in their mouth in one of four different conditions. In the first condition (the control condition), the pencil was held using the teeth, with the jaw dropped slightly, and without any contact from the lips. In the second, participants were asked to hold the pencil with their lips, without using their teeth; this utilized the orbicularis oris muscle used to produce expressions of sadness. The final two conditions involved the pencil being held with the teeth, without any contact from the lips. Condition three required the lips to be pulled away from the pencil using the corners of the mouth; condition four required the same while also requiring the cheeks to be raised forming a Duchenne smile. While holding their pencils, participants were asked to view a set of humorous video clips. Out of the four conditions, participants holding a Duchenne smile reported having the most pleasant experience when viewing a set of humorous video clips while also rating those video clips more favorably on a humor scale (Soussignan, 2002).

In another work, it was shown that simply viewing an image of a happy or sad face could affect a person's mood (Wild, 2002). In this experiment, participants were shown a set of images on a computer screen containing a mix of happy, sad, and neutral faces. In response to these images, they were directed to either raise the corners of their mouths (corresponding to a happy expression), lower the corners of their mouths (corresponding to a sad expression) or keep the corners of their mouths stationary. Images were shown for six seconds along with on-screen arrows indicating how the participants should move the corners of their mouths. Findings showed that participants were able to smile faster after being shown images of smiling faces. Similarly, lowering the corners of their mouths occurred fastest after being shown sad faces (Wild, 2002). Wild's (2002) research shows that there may be a direct, bidirectional connection between facial expressions and emotions; either one can yield the presence of the other. Further research on nonverbal displays has shown that this bidirectional relationship may extend beyond facial expressions to include body posture, which could support the theory behind power posing.

**Body Posture.** Feelings of success, happiness, and power have been shown to cause individuals to expand and stretch their bodies to take up more space (Darwin, 1872; Navarro & Karlins, 2008). For example, countless sporting events end with the victors thrusting their arms in the air, expanding their torsos, and lifting their chins, thus causing their bodies to occupy more space. When experiencing negative feelings like depression or sadness, humans have a tendency to do the opposite; we shut down by hunching over and covering our torsos with our arms to decrease the space occupied by our bodies (Navarro & Karlins, 2008)**.** Along the same vein, research has shown that person's decision to occupy either more or less space can create emotions strong enough to influence behavior (Cuddy, Wilmuth, Yap, & Carney, 2015). An example of this is illustrated in an experiment where individuals occupying more space with their limbs and torso experienced self-reported feelings of elevated confidence. These individuals also engaged in more risk on a gambling task (Cuddy et al., 2015). These nonverbal bodily displays, that control the amount of space occupied, are known as power poses (Carney et al., 2010).

Power posing takes advantage of the placement of an individual's limbs relative to the torso to yield an increase or decrease in size. In the past, two types of poses have been studied; high-power poses and low-power poses. High-power poses are ones where the subject, either sitting or standing, spreads out to occupy more space – often much more space than what is needed. These poses have been shown to improve one's sense of confidence and reduce stress by raising testosterone and lowering cortisol (Carney et al., 2010). Figure 1 in Appendix A shows three examples of individuals doing a high-power pose. One notable characteristic of these high-power poses is the tendency for sensitive areas of the body, like the neck and torso, to remain uncovered and expanded. In figure 1-A and 1-B (Appendix A) the individuals are each adopting expansive poses with their limbs taking up more space than necessary.

Low-power poses are ones that cause the subject, sitting or standing, to shrink and occupy less space. These poses are known for reducing one's sense of confidence and increasing stress with a concomitant lowering of testosterone and raising of cortisol (Cuddy, 2015). These poses also have a tendency for the individual to cover up sensitive areas of the body while ensuring that the minimum amount of space is occupied by the body. Figure 2 in Appendix A shows three examples of low-power poses with their limbs and torso taking up less space than necessary. From this we can see that holding either a high or low-power pose can create a measurable physiological response.

After holding a high or low-power pose for two minutes, participants went through mock job interviews with trained coders. These trained coders were unaware of who did high or low-power posing before the interviews. During the interviews each participant was asked to explain why they were best suited for their job. After the interviews, coders rated participants based on their interview performance. The individuals that did high-power posing before the interview were consistently rated more favorably on factors including intelligence, confidence, and overall performance (Cuddy et al., 2015). The pattern to notice here is that the placement of limbs was shown to bring forth increases in social performance. In another experiment, participants were asked to participate in a gambling activity after holding either a high or low-power pose. In this activity, the chance of success was at fifty percent. The individuals that held the high-power poses were more likely to gamble. This increase in the desire to gamble indicated an increase in tolerance for risk (Cuddy et al., 2015). Based on the results of this study, it appears that there may be a link between these power poses, biological responses, and patterns of behavior.

**Power Posing Controversy**. Shortly after the Cuddy et al. (2015) study was published, power posing garnered the attention of researchers who attempted to replicate the results of the original study. Ranehill et al. (2015) conducted four experiments to measure power posing's impact on three power-related outcomes: risk-taking, abstract thinking, and negotiation. In two of the four experiments participants were asked to watch the Cuddy (2012) video on power posing. According to this study, while participants did experience feelings of increased power, these feelings did not translate to beneficial effects on any of the power-related outcomes.

As a rebuttal to the Ranehill et al. (2015) study, Carney, Cuddy, and Yap (2015) published a review and summary of 33 power posing experiments (including five of their own power posing experiments) to help elucidate the reasons why some studies – including the Ranehill et al. (2015) study – might not find positive impacts from power posing. These reasons include the duration of the pose, whether the pose was concealed, whether there was a social task for the participants to complete while posing, and whether the experimenter was familiar with the poses. Carney et al. (2015) noted that the Ranehill et al. (2015) study asked participants to hold poses for three times as long (poses were held for six minutes in Ranehill et al., 2015 compared to only two in Carney et al., 2010), they were not careful to conceal the purpose of the study, and they did not give participants a social task to complete while posing. Additionally, we note that of the 33 power posing experiments included in Carney et al., (2015), none of them used hormonal measures to verify whether power posing had any impact on testosterone or cortisol.

Afterward, Simmons and Simonsohn (2017) conducted a p-curve meta-analysis using p values from 24 power posing experiments cited in the Carney et al. (2015) paper on power posing (a total of 33 experiments were cited in the Carney et al., 2015 paper, however p values from nine experiments were excluded from the meta-analysis due to non-significant findings, unreported critical test statistics, and a failure to investigate down-stream effects of power posing). Simmons' and Simonsohn's (2017) analysis suggested that all the purported effects of power poses lacked empirical support.

Following Simmons and Simonsohn (2017), Gronau et al. (2017) published a Bayesian model meta-analysis of six preregistered power posing studies that tested for feelings of power. Like previous studies, these experiments had participants holding power poses for two minutes often while engaging in a simulated social task requiring participants to view a set of faces (Bailey, LaFrance, & Dovidio, 2017; Bombari, Schmid Mast, & Pulfrey, 2017; Jackson, Nault, Smart Richman, LaBelle, Rohleder, 2017; Keller, Johnson, & Harder, 2017). While they believed their analysis provided strong evidence for power posing's impact on felt power, they noted that this this effect diminished when limiting the analysis to individuals unfamiliar with power posing.

As a response to both Simmons and Simonsohn (2017) as well as Gronau et al. (2017), Cuddy, Schultz, and Fosse (2018) published a p-curve meta-analysis of 54 studies involving power posing – this included the 24 experiments from the Simmons and Simonsohn (2017) paper, plus an additional 30 experiments. According to their meta-analysis, power posing's impact on feelings of power holds significant evidentiary value. However, while Cuddy et al. (2018) theorizes that feelings of power should create changes in human behavior, they did not investigate this topic further, nor did they investigate Gronau et al.'s (2017) concern of whether knowledge of power posing mediated the effects. Lastly, they did not revisit their claims on power posing's impacts on salivary testosterone and cortisol.

Additionally, Cuddy and Carney – two researchers who spearheaded the investigation into power posing and published results claiming the efficacy of high-power poses – now disagree on the whether the effects of power posing are real. Cuddy maintains that the effects are real, referencing replication studies that have shown power posing to create feelings of power (Cuddy et al. 2018). Carney disagrees and believes the significant results from her power posing research with Cuddy were a direct result of data dredging (Peters, & Staff, 2016).

When the current study was conceived, power posing was a concept that, to our knowledge, had no replication studies. As such, our goal was to investigate this novel topic. However, at this time, it is well cemented that the effects of power posing have largely been debunked. While some power posing studies can replicate feelings of increased power, these feelings primarily occur for individuals who are already familiar with power posing (Gronau et al., 2017) and they have not been shown to facilitate changes in behavior (Ranehill et al., 2015; Simmons & Simonsohn, 2017).

**Changes in Mental Processing.** When designing the current study, we believed that changes in behavior due to body posture could be connected to changes in mental processing as specific emotions have tendencies that mitigate behavior. We theorized that changes in body language could change the emotional state of an individual. How humans process information is dependent on mood; by altering mood through power posing we believed we could create changes in how information is processed. We hoped that this relationship between posture, mood, and mental processing would help to explain changes in risk tolerance and confidence seen in previous work (Carney et al., 2010).

Research by Friedman & Elliot (2008) has shown that an increase in performance and persistence can be yielded simply by having individuals cross their arms while being asked to solve anagrams. Participants with crossed arms were willing to spend more time on anagrams, while finding more solutions to the anagrams. It is theorized that arm-crossing causes one to experience different feelings ranging from rejection and defensiveness to feelings of steadfastness[1] – depending upon the nature of the situation in which the gesture occurs (Freidman & Elliot, 2008). It Freidman and Elliot's study (2008), it appears that arm crossing made participants more steadfast. Here we see a change in mental processing in the form of increased performance and persistence, simply due to the placement of an individual's limbs. However, there is much more to be explored including physiological changes that occur along with differences in performance.

Based on the research available at the time of the current study's conception, both emotions and body language appeared to have a unique, bidirectional relationship where either one could cause visible, measurable changes in the other. In addition, both emotions and body language appeared to modulate behavior. Specific emotions seemed to promote favorable behaviors such as enduring risk and presenting oneself in a more intelligent, confident manner; meanwhile the presence of negative emotions appeared to create the opposite effect (Cuddy et al., 2015). Body

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[1] The message communicated from arm crossing can also depending upon the posture of the rest of the body. Crossed arms with a wide stance and an upright torso can communicate dominance, while crossed arms with a slouched torso and narrow stance can communicate the opposite (Navarro, 2008).

language and emotion seemed to be closely linked and it was our belief that cognitive arousal mediated this link.

## Activation Theory and Psychophysiological Measures

The cognitive activation theory of stress (i.e. cognitive arousal) states that there is an ideal level of stress that will lead to maximum performance in many living animals and humans (Yerkes & Dodson, 1908). Outside of this ideal stress level, performance will be hindered due to under-stimulation (cases where stress level is too low) or over-stimulation (cases where stress level is too high) for moderate to difficult tasks (Ursin, 2005).

Cognitive arousal can yield physiological changes in the human body due to activity in the autonomic nervous system. Two useful methods for measuring those changes are heart-rate variability (HRV) and skin conductance (Cacioppo, Tassinary, & Bernston, 2000). The autonomic nervous system has two divisions; the parasympathetic nervous system (PNS) – responsible for maintaining homeostasis – and the sympathetic nervous system (SNS) – responsible for managing arousal and the fight-or-flight response. Under periods of stress, the sympathetic branch is activated. This sympathetic activation leads to activation of eccrine sweat glands causing an increase in sweat production. This activation of the sweat glands plays a significant role in the increase of electrodermal activity (EDA): the skin's electrical properties and how they change as the skin's characteristics change (Cacioppo, Tassinary, & Bernston, 2000). This change in EDA can be measured via skin conductance which utilizes the placement of electrodes on the skin to collect information on the skin's electrical conductance. An increase in EDA indicates an increase SNS activity while a decrease indicates the converse (Cacioppo, Tassinary, & Bernston, 2000).

Changes in EDA activation are often used to assess SNS arousal during stressful tasks. For example, in a study on music reactivity to stressful films, Thayer and Levenson (1983) showed that stress experienced by an individual experiencing an unpleasant accident on film can be manipulated by changing the music played during the accident. Participants were asked to view one of three work-related accidents (involving accidental laceration, amputation, and impalement) while music was played with the goal of increasing, decreasing, or having no effect on the perceived stress. EDA results revealed that film scores chosen based on mood were successful at inducing the desired effect on stress. The horror film scores increased EDA stress readings above the control (where the control had no music) while light-hearted documentary music dropped EDA stress readings below the level corresponding to the control condition (Thayer & Levenson 1983). This study illustrates a strong connection between EDA responses and emotion induced by music.

In a study by Vrana and Gross (2004) participants were asked to view a slideshow of 24 separate faces from Ekman and Friesen's (1976) 'Ekman's Pictures of Facial Affect' which included eight joy, eight neutral, and eight angry expressions viewed for eight seconds each. While viewing the set of slides, equipment was used to measure physiological responses including EDA. An analysis of participants' EDA measures revealed elevated excitement when viewing joyful expressions along with decreased excitement when viewing neutral and angry expressions. This study provides another example of the connection emotion and EDA responses while illustrating the physiological impact that facial expressions can have on humans.

Heart rate variability involves the length of time existing between heart beats and represents how these intervals of time compare to each other. In healthy, calm humans the intervals existing between each beat are known to vary. This is due to the heart maintaining homeostasis as the body moves. Increases in stress can create multiple negative emotional experiences including panic and anxiety. These negative emotional experiences increase SNS activity which results in a decrease in HRV. As stress decreases and negative emotions disappear, the PNS becomes more active resulting in a more varied rate (Chevalier & Sinatra, 2011). Essentially, HRV and stress are inversely correlated. HRV can be assessed through frequency domain analysis; with most researchers focusing on the high frequency component (HF-HRV power) and the low frequency component (LF-HRV power). Together, the high and low frequencies create a LF to HF ratio (LF:HF). Increases in stress, increase LF:HF (thereby decreasing HRV) by either increasing LF-HRV power, decreasing the HF-HRV power, or both. Decreases in stress effect LF:HF in the opposite manner. In short, changes in LF:HF indicate changes in HRV. An increase in HRV indicates a decrease in stress, while a decrease in HRV indicates an increase stress (Jo, Lee, & Lee, 2013; Taskforce, 1996).

This connection between heart rate variability and arousal has been illustrated by numerous works, including that of Jo et al. (2013). In their research on the effect of stress on task performance, participants played games of Minesweeper on a personal computer while being exposed to one of five potentially stressful conditions; performance feedback condition, competition condition, time pressure condition, reward condition, and stress-free condition (control). For each condition, an experimenter verbally conveyed information to the participant, every 30 seconds, regarding his or her performance with the goal of eliciting a physiological response (e.g. for the competition condition, the experimenter would say “Try to play better!” or the experimenter would say “Speed up!” for the time pressure condition). The study showed a strong connection between heart rate variability and the stress applied. The stress group had a significantly higher change in LF:HF (ΔLF:HF), however, there was no connection between skin conductance and applied stress. It is possible that the stress condition in this study was not powerful enough to elicit reliable changes in EDA but the HRV measure was sensitive enough to show variations between stress conditions.

A useful way to create an experience stressful enough to yield both EDA and HRV readings is the Color Word Interference Test (CWT) created by Stroop (1935). The CWT (also referred to as the Stroop Task) is an activity where participants are shown a set of color words (e.g. green, blue, red, etc.). Upon seeing each word, participants must name the color of the color word's text rather than reading the word itself. In the CWT many of the color words shown to participants have a text color that is incongruent with the color word itself (e.g. the color word "red" displayed in blue ink). Stroop found that the task of naming the color of stimuli is more difficult (and takes more time per trial) when the stimuli is an incongruent color word, rather than a set of colored rectangles (see Appendix B). The increased difficulty experienced with identifying the color of an incongruent color word is known as the Stroop Effect (Stroop, 1935). The CWT has been used extensively (Minakuchi et al., 2013) and is stressful enough to create significant decreases in HRV (Boutcher & Boutcher, 2006), along with significant increases in EDA (Fechir et al., 2008; Tulen, Moleman, Steenis, & Boomsma, 1988). In a set of stressful tasks[2] Fechir et al. (2008) also reported the CWT to be the only task stressful enough to globally activate the sympathetic nervous system as measured by HRV, EDA, blood pressure, skin vasoconstriction, and activity of the trapezius muscle. These previous works have laid a strong foundation for the CWT's use as a stressful task in this study. It is our belief that similar effects will be observed with the CWT as a stressful task.

## The Current Study's Contribution

This study aimed to contribute to power posing research by using measures not seen in any previous power posing study. Firstly, the approach of using EDA and HRV to gauge the impact of power posing is unlike the measures used in the original study as well as some replication studies,

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[2] Stressful tasks included the CWT, spontaneous public speaking, timed mental arithmetic, singing a song aloud, and presentation of neutral, positive, and negative pictures (Fechir et al., 2008).

which used salivary samples to measure hormones (testosterone and cortisol), surveys to gauge self-reported feelings of power, and a gambling tasks to measure risk tolerance (Carney et al., 2010; Carney et al., 2018). The use of these measures also differs from unique power posing studies which have gauged the impacts of expansive and contractive postures through the use of positive vs negative word recall (Michalak et al., 2014), chair choice at the head of a table **(**Arnette & Pettijohn, 2012**)** and dishonest behavior (Yap et al., 2013). When reviewing a list of the latest literature on power posing and body postures for this study (a total of 64 publications), we found two studies that utilized a physiological measures to measure arousal. Of these two studies, one used startle response while holding expansive postures (Ceunen, Zaman, Vlaeyen, Dankaerts, & Van Diest, 2014) while the other measured heart rate and blood pressure continuously during the experiment (Nair, Sagar, Sollers, Consedine, & Broadbent, 2015). Our study is not the first to use physiological measures to gauge arousal, however we believe our measures (EDA and HRV) to be more effective at gauging cognitive arousal. While the original study (Carney et al., 2010) and some replication studies (Ronay, Tybut, van Huijstee, & Morssinkhof, 2016**;** Jackson, Nault, Smart Richman, LaBelle, & Rohleder, 2017) used inactive ECG leads placed on a participant's neck to help support their cover story, we found no published power posing studies that utilized EDA or HRV to gauge physiological arousal during, before, or after power posing.

The use of both positive and negative affect is novel as well. During our literature review, we found 34 studies that used subjective measures including self-reported feelings of power (Ceunen et al., 2014**;** Huang, Galinsky, Gruenfeld, & Guillory, 2011**;** Latu, Duffy, Pardal, & Alger, 2017), temporal perspective (Duffy & Feist, 2016), and feelings of agreement (Fuller & Montgomery, 2015). Of these 34 studies, only one study used affect (Wilkes, Kydd, Sagar, & Broadbent, 2016) to gauge mood. However, Wilkes et al., (2016) used negative affect exclusively. Negative affect has shown to correlate strongly with stress (Watson, & Clark, 1992; Watson, &

Pennebaker, 1989); high levels of stress are accompanied by high levels of negative affect. While self-reported negative affect gives insight into an individual's perceived stress, using positive and negative affect together, provides a stronger measure of mood (Watson, Clark, & Tellegen, 1988).

With these areas of power posing research largely unexplored, we believed that using these measures would provide a significant contribution to power posing research. These measures would also allow us to explore whether cognitive arousal mediated the link between body language and emotion.

## Purpose of the Research

Previous research suggested that body posture and emotion are closely linked (Carney et al., 2010) and it was our belief that cognitive arousal mediated this link. To investigate this link, the current study manipulated participants' body posture to observe and measure changes in autonomic arousal level during a stressful activity. To manipulate body posture, participants were asked to either hold high-power poses or low-power poses. To measure autonomic arousal, EDA and HRV were used.

## Hypotheses

This research aimed to determining the effect that power posing had on the arousal level, mood and perceived stress levels of an individual under stress. There were three hypotheses.

**Hypothesis 1: Stress Reactivity.** Similar to previous work conducted by Carney et al. (2010) to the extent that high-power poses buffer the effects of stress, we expected a quantifiable decrease in psychological stress responses, as indicated by self-report measures, EDA, and HRV. More specifically, individuals engaging in high-power posing were expected to show lower levels of skin conductance in the EDA measure and an increase in HF-HRV power compared to the low-power posing group, as lower levels of autonomic arousal and stress are associated with lower levels of skin conductance and higher HF-HRV power. We also expect lower reported levels of negative affect and higher reported levels of positive affect on the self-report measure for participants in the high-power posing group.

**Hypothesis 2: Risk Tolerance.** As a way of replicating Carney et al.'s (2010) measure of risk tolerance, we added a gambling task to measure risk tolerance. In their study, Carney et al., (2010) gave participants one dollar and gave them an opportunity to either flip a coin for a chance to win an additional dollar, or to keep the dollar they were given. To the extent that power posing affects risk tolerance, we expected that participants in the high-power posing group would be more willing to gamble with their money during the gambling task, as shown in previous study (Carney et al., 2010).

**Hypothesis 3: Task Performance.** Based on previous research we expect the participants in our study to experience elevated stress while participating in the CWT (Boutcher & Boutcher, 2006; Fechir et al., 2008; Tulen et al., 1988). Previous research has also shown that excessive stress can reduce task performance (Ursin & Eriksen, 2005). To the extent that the high-power posing condition reduced stress, we expected EDA and HRV stress responses recorded during the CWT to be positively correlated with task performance. This means that a decrease in stress should be accompanied by a decrease in errors on the CWT. For the low-power posing condition, we expected the opposite pattern (an increase in stress response leading to an increase in errors).

# Method

## Participants

This study recruited 44 college-aged students (28 male and 16 female) from the Rochester Institute of Technology (RIT). The goal for the sample size was 20 participants in each posing condition as determined by a power analysis (See Appendix C). Students from RIT were recruited through the Psychology department’s research participation pool using SONA, an online participant recruitment system.

**Exclusionary Criteria.** Participants unable to complete the poses or follow verbal instruction were excluded from participation. Any color blind participants were also excluded from participation as they would be unable to complete the CWT. Additionally, participants that were taking medication or were under the effects of any drug which could interfere with physiological recordings (See Appendix D), were either excluded or rescheduled for a time when they would not be using that drug.

## Independent Variables

There was one independent variable (power-posing), with two independent levels (high-power posing and low-power posing). Figure 1 and Figure 2 in Appendix A show examples of individuals doing high-power and low-power poses, respectively. One of these poses were given to each participant who was randomly assigned to the corresponding power posing group. Participants in each group held one standing power pose and one sitting power pose (see Appendix A).

## Dependent Variables

There were four normally distributed, interval, within subjects, dependent variables; psychophysiology measures: autonomic response measured via HRV and autonomic response measured via EDA, self-reporting surveys, and performance on the CWT.

## Design

**Power Poses.** The experimenter coached each participant on how to sit or stand to correctly hold each pose. While posing, participants were asked to think neutral thoughts (for example, the path that they took to get to the experiment room). This helped to ensure internal validity by showing that differences in performance and autonomic arousal were due to the different power poses used.

**Psychophysiology Measures.** The EDA and HRV measures were obtained using the Biopac MP36, a device using electrodes placed on the skin to continuously gather information on heart rate, HRV, and skin conductance/EDA. Electrodes gathering information on EDA were placed on the index and middle finger of the nondominant hand. Data for this measure was recorded though the Biopac MP36's SCL channel with a constant voltage of .5V and a sampling rate of 10Hz. Electrodes placed on the nondominant forearm, the left lower abdomen, and the right collar bone gathered data on heart rate. This was done via the Biopac MP36's ECG signal conditioner channel with the low and high frequency filters set to 1.5Hz and 45Hz, respectively, at a sampling rate of 1KHz.

**Self-reporting Surveys.** Participants were asked to complete the Positive and Negative Affect Scale (PANAS) assessment which acted as a measure of mood (Watson, Clark, & Tellegen, 1988) and stress (Ogden & Mtandabari, 1997). Completion of a PANAS assessment produces two scores: a positive affect score, and a negative affect score (Watson, Clark, & Tellegen, 1988). According to previous research, the positive affect score is a strong measure of overall mood, with high positive affect indicating high energy, concentration, and pleasure. Meanwhile the NA score is strongly correlated with a person's perceived level of stress; stress and mood are closely related, with excessive stress causing poor moods (Ogden & Mtandabari, 1997). As an additional way to measure perceived stress, a line rating was used; participants made a mark on a continuous, horizontal line that represented how relaxed or stressed they felt during the experiment. They were also asked about the true purpose of the study. If the response to this question indicated any knowledge of power posing, the participant's data was to be excluded from the analysis. Otherwise, their knowledge of power posing and its effects could have presented an experimental confound. Information on gender, age, education, and primary language were also collected. Self-report measures can be found in Appendix D.

**Stress Task.** For the stress task, the CWT was used to create an experience stressful enough to yield both EDA and HRV changes. The CWT was administered via an automatically-paced PowerPoint slideshow. Participants see each slide for a total of 1.5 seconds and saw a total of 200 slides during a three minute testing period. Participants verbally indicated the text color for each slide while the experimenter recorded the response as correct or incorrect. To help avoid confusion for the experimenter, participants were asked to avoid saying multiple responses for a single slide (in an attempt to correct oneself) during the CWT. Words were large enough to fill each slide and were displayed using the Aharoni font, on a light grey background to ensure visibility (see Appendix B). On each slide, the color words "GREEN", "RED", "BLUE", "WHITE", "YELLOW", or "BLACK" was displayed. Each word was shown in either green, red, or blue, white, yellow, or black pixels. The congruent trials (e.g. the word "Red" displayed in red pixels) were mixed randomly with the incongruent trials (e.g. the word "Red" displayed in green pixels).

Mixing congruent and incongruent trials is used in research involving the CWT to create randomness and keep the task's difficulty elevated (Boutcher & Boutcher, 2006; Minakuchi et al., 2013). With the hopes of creating the same effect, we did the same in our study.

## Procedure

After agreeing to participate, participants entered the testing environment individually for a single session. Before the experiment, participants were asked to provide written informed consent. Next participants asked if they were on any drugs that may interfere with EDA and HRV readings (see Appendix D) or if they were colorblind. One participant had recently used a drug on the list (cold medicine) and was rescheduled for the following week; all participants stated that they were not colorblind. Next, participants had electrodes attached to their skin that continuously recorded electrocardiogram (EKG; to derive HRV) and EDA readings for the entirety of the experiment. The experiment itself had three phases, which occurred in succession with limited lag – if any – between phases.

**Phase One: Baseline Period.** In Phase One, participants were seated in a neutral position while completing the self-report measures. These ratings helped to create a baseline representation of their psychophysiological activation. During this period HRV and EDA baseline readings were collected.

**Phase Two: Power Posing.** Phase Two began with the experimenter briefly teaching the participants their randomly assigned power poses for their condition. The experimenter also ensured that the names for the types of poses will not be revealed. This prevented the psychological effect of knowing how a specific pose was associated with power. When being asked to hold a pose, participants were shown a picture of the pose for them to mimic. The experimenter then ensured that the pose was properly replicated. Each participant held a total of two poses, done consecutively and held for a total of one minute each.

**Phase Three: Gambling and CWT.** In Phase Three, participants were asked to participate in both the CWT and a gambling task. Participants used a version of the CWT where color words were displayed on a computer screen. Participants verbally indicated the color word present on the screen while the experimenter marked the participant's answer as correct or incorrect. Incorrect responses were tallied to achieve a CWT score which was used to determine error rates for performance. While completing the CWT, participants were seated in a neutral position; they were seated upright with their feet shoulder-with apart. For the gambling task, participants were given $2 and a pair of dice. They had the option of keeping the $2 or rolling the dice for a 50% chance to lose their $2 or gain another $2. The CWT and gambling task was counterbalanced to account for order effects. The gambling task was lengthened, as necessary, (to match the length of the CWT) to avoid possible confounds.

## Data Reduction and Analysis

The experiment had five between-subjects dependent variables: autonomic response measured via HRV, autonomic response measured via EDA, two self-report surveys (the first survey was completed in Phase One, while the second was completed in Phase Two, after engaging in power posing), performance on the CWT, and risk tolerance (measured by willingness to gamble after). There was also one between-subjects independent variable (high-power vs low-power posing conditions). Participants were randomly assigned to either the high-power posing group or low-power posing group. Mean HF-HRV power, EDA, and self-reported stress level responses were created for baseline and stress phases. To create change scores, baseline EDA, HRV, PANAS, and line rating scores were subtracted from EDA, HRV, PANAS, and line rating scores recorded after posing.

**EDA and HRV Data**. Participant EDA scores (maximum, minimum, and average skin conductance) and HRV scores (HF-HRV power) measured from each test condition were normalized via a log transformation. Each participant's baseline EDA and HRV score was then subtracted from corresponding EDA and HRV scores from each test condition to create change scores. For the two posing conditions, EDA and HRV change scores were averaged. One outlier participant was excluded from the HRV analysis as this participant's score skewed the baseline HRV data (See Figure 3 and Figure 4 in Appendix E). To test Hypothesis 1: Stress Reactivity, an independent t-test was used to compare EDA and HRV change scores between low and high-power posing groups.

**Self-Report Data.** The completing the PANAS assessment produced two scores for each participant: a positive affect score representing the participant's self-reported overall mood at the time of the assessment, and a negative affect score which is highly correlated with the participant's perceived stress. Additionally, each line rating task produced a single score representing self-reported overall stress. To further test Hypothesis 1: Stress Reactivity, an independent t-test was used to compare positive affect scores, negative scores, and line rating scores between low and high-power posing groups.

**Gambling Data.** During data reduction, participants were assigned a number based on whether they gambled their money during the gambling task; participants who gambled were assigned a value of 1 while participants who did not were assigned a value of 2. To test Hypothesis 2: Risk Tolerance, a chi-square test was conducted which compared gambling rates between the low and high-power posing groups.

**CWT Data.** Participants' incorrect responses during the CWT were tallied to create CWT error rates. To test Hypothesis 3: Task Performance, an independent samples t-test was conducted, comparing error rates on the CWT between low and high-power posing groups.

# Results

## Hypothesis 1: Stress Reactivity

We expected participants who assumed the high-power poses to show lower autonomic arousal during the stress task compared to participants who assumed the low-power poses.

**Posing Condition.** An independent samples t-test comparing EDA scores for the posing condition showed no significant changes in skin conductance between the high-power ($M$ = .16, $SD$ = .29) and low-power posing ($M$ = .10, $SD$ = .14) groups; $t(41)$ = .99, $p$ = .36, $d$ = .26 (see Table 1 in Appendix F). An independent samples t-test comparing HRV scores for the posing condition showed no significant changes in heart rate variability between the high-power ($M$ = -.01, $SD$ = 1.15) and low-power posing ($M$ = .17, $SD$ = .86) groups; $t(41)$ = -.58, $p$ = .56 $d$ = .27 (See Table 2 in Appendix F).

**CWT.** Results of a Two-Way Mixed ANOVA revealed a significant main effect of CWT exposure on HF-HRV scores ($F(1, 41) = 22.66, p = 0, \eta_p^2 = .36$) and EDA scores ($F(1, 41) = 71.58, p = 0, \eta_p^2 = .63$; see Table 5 in Appendix F). There were no interaction effects between CWT exposure and posing group for HF-HRV ($F(1, 41) = .88, p = .35, \eta_p^2 = .02$) or EDA ($F(1, 41) = .36, p = .55, \eta_p^2 = .01$; see Table 5 in Appendix F). As expected, EDA scores were higher during the CWT ($M$ = 2.03, $SD$ = .93; see Table 6 in Appendix F) compared to baseline EDA scores ($M$ = 1.46, $SD$ = 1.07, $d$ = .56; see Table 6 in Appendix F); this is consistent with what we would expect to see in an individual with increased arousal (Fechir et al., 2008**;** Jo et al. 2013). However, HF-HRV scores during the CWT ($M$ = .85, $SD$ = .68) were also higher compared to baseline HF-HRV scores ($M$ = .20, $SD$ = .94, $d$ =.79; see Table 6 in Appendix F), which is the converse of what we would expect; increases in arousal or cognitive workload typically decreases HF-HRV (Fechir et al., 2008**;** Jo et al. 2013). These results are mixed, suggesting that the CWT was successful in inducing stress as indexed by EDA but not HF-HRV. Additionally, there was no interaction effect with posing group for HF-HRV ($F(1, 41) = .14$, $p = .71$, $\eta_p^2 = .00$) or EDA ($F(1, 41) = .63$, $p = .43$, $\eta_p^2 = .02$; see Table 5 in Appendix F).

**Self-Report Data.** We expected participants who assumed the high-power poses to report lower levels of negative affect and higher levels of positive affect on the self-report measure. An independent samples t-test comparing line rating scores, which represented perceived levels of stress, showed no significant changes in self-reported stress between the high-power (*M* = .02, *SD* = 1.17) and low-power posing (*M* = -.07, *SD* = 1.59) groups; $t(41) = .19$, $p = .85$, $d = .06$ (see Table 9 in Appendix F). These results suggest that there is no difference in self-reported mood and self-reported stress between the high and low power posing groups.

Results of a Two-Way Mixed ANOVA revealed a significant main effect of exposure to power posing on positive affect ($F(1, 41) = 8.16$, $p = 0$, $\eta_p^2 = .36$; Table 10, Appendix F); positive affect was lower after power posing (*M* = 25.84, *SD* = 6.90) when compared to the baseline period (*M* = 27.70, *SD* = 5.60, $d = .30$), suggesting that participants were in a worse mood after engaging in power posing (see Table 11 in Appendix F). There was no significant main effect of exposure to power posing on negative affect ($F(1, 41) = 8.16$, $p = 0$, $\eta_p^2 = .36$) when comparing negative affect at baseline (M = 13.37, SD = 3.20) to negative affect after power posing (M = 13.05, SD = 2.90, $d$ =.10; see Table 11 in Appendix F). This suggests that the power posing groups did not differ on mood before power posing. There were no interaction effects between exposure to power posing and posing groups for positive affect ($F(1, 41) = .88$, $p = .35$, $\eta_p^2 = .02$) or negative affect ($F(1, 41) = .36$, $p = .55$, $\eta_p^2 = .01$; see Table 10 in Appendix F). There was no significant main effect of posing group on mood for positive affect ($F(1, 41) = 2.83$, $p = .10$, $\eta_p^2 = .07$) or negative affect ($F(1, 41) = .05$, $p = .82$, $\eta_p^2 = .00$; see Table 10 in Appendix F).

### Hypothesis 2: Risk Tolerance

We expected participants in the high-power posing group to be more willing to gamble with their money during the gambling task. A chi-square test of independence showed no relation between willingness to gamble and posing condition ($X^2$ (1, $N$ = 43) = .16, $p$ = .69; see Table 12 in Appendix F). The result from this analysis suggests no difference in risk tolerance between high and low-power posing groups.

### Hypothesis 3: Task Performance

We expected EDA and HRV stress responses recorded during the CWT to be positively correlated with task performance. A correlational analysis showed that EDA stress responses were not correlated with task performance, $r$(43) = .03, $p$ = .87, (see Table 13 in Appendix F). An additional correlational analysis showed that HRV stress responses were also not correlated with task performance $r$(43) = -.1, $p$ = .54 (see Table 13 in Appendix F).

An independent samples t-test showed no significant differences in performance on the CWT between high-power ($M$ = 4.2, $SD$ = 4.0) and low-power posing ($M$ = 5.48, $SD$ = 5.5) groups; $t$(41)= -.86, $p$ = .39, $d$ = .27 (see Table 14 in Appendix F). Overall, participants performed well on the CWT with few errors.

# Discussion

## Summary

This research intended to demonstrate that preparatory power posing would cause significant changes in autonomic response to stress. However, results suggest that power posing has no significant effect on stress reactivity, risk tolerance, or task performance. Results also revealed no significant differences in the participants' self-reported feelings of well-being, suggesting that the perceived impacts of the power poses on each group were relatively similar. Based on this data, we can conclude that power posing does not appear to be an effective way to manage stress or improve one's mood. While the results of this research do not support the claims of the original Carney et al. (2010) study, it does however support the findings of other studies that have failed to demonstrate the purported effects of power posing (Garrison, Tang, & Schmeichel, 2016; Keller et al., 2017; Ranehill et al., 2015). This study's findings also agree with Carney's most recent comments on power posing being ineffectual (Peters & Staff, 2016).

## Limitations of the Current Study

**Timing and Power Posing.** While results of our study did not provide support for any of power posing's claims, we note that our study did have several limitations. Firstly, the impacts of power posing may not have lasted long enough to impact performance, stress response, or risk tolerance on the subsequent CWT and gambling tasks. We expected that the effects of power posing would last for 15 minutes and planned our study accordingly, with each participant finishing the CWT and gambling task within 15 minutes of posing. When designing the study, we based this on Carney et al.'s (2010) study design where salivary samples were collected 17 minutes after power posing (to measure testosterone and cortisol). However, we now understand that testosterone and cortisol have a time delay before measurable changes in these hormones can be detected, which necessitated the 17-minute delay in the Carney et al. (2010) study.

**Salivary Testing.** On the note of salivary testosterone and cortisol, an additional limitation of this study was the absence of salivary samples. The collection of salivary samples would have given us the opportunity to measure hormonal changes occurring during the study, while giving us additional data to compare with the Carney et al. (2010) study as well as previous replication studies. However, the costs associated with collecting, shipping, and analyzing salivary samples were beyond our budgetary constraints.

**CWT.** We also note that our data on whether the CWT was effective at inducing stress is mixed; EDA increased as expected, however HF-HRV unexpectedly increased which is the opposite of what we would have expected to see with increased arousal. For these reasons, cannot say that our method of applying the CWT had the intended stressful impact on our participants. Without the intended stress from the CWT, we cannot fully test our hypotheses regarding whether high-power posing acted as a buffer to stress experienced during the CWT.

Additionally, errors on the CWT for congruent trials (e.g. the word “red” displayed in red pixels) and incongruent trials (e.g. the word “red” displayed in blue pixels) were not differentiated when recording errors on the CWT. Instead, the experimenter kept a log of each participant’s total CWT errors. This approach made keeping track of errors easy for the experimenter, however it did not allow us to collect more detailed CWT data. Previous research has shown incongruent trials to be significantly more difficult due to the interference between the color and color word (Minakuchi et al., 2013; Boutcher & Boutcher, 2006), which causes more errors. In retrospect, using a video recording or computer software that automatically tracks each type of error would have prevented this issue and given us data indicating whether our CWT had the same effect.

**Risk Tolerance.** As a replication of Carney et al.'s (2010) study, our gambling task was used to measure risk tolerance. However, we understand that using a single dichotomous dependent variable (whether participants gambled) along with a small sum of money is not an effective way of operationalizing risk tolerance. Previous study has used significantly more robust measures to gauge risk tolerance including detailed questionnaires (Gramble & Lytton, 1999) and hypothetical scenarios (Barsky, Juster, Kimball, & Shapiro, 1997). We believe that using one of the more traditional measures of risk tolerance would produce more reliable data.

**Facial Expressions while Posing.** In our experiment, the experimenter gave each participant instructions on what to think about while posing, however there was no guidance on the expressions that the participants were permitted to hold. Additionally, participants were turned away from the experimenter while posing; this allowed participants to focus on their imagination more easily while posing, however we realize that this prevented the experimenter from monitoring participant facial expressions. We understand that facial expressions can have a significant impact on mood (Wild, 2002; Soussignan, 2002) and without knowing which facial expressions the participants held while posing, we cannot determine if facial expressions contributed to the study's results. In retrospect, the use of a video recording would have allowed us to monitor participant facial expressions while posing without the visibility of the experimenter interfering with each participant's ability to think neutral thoughts.

**A Neutral Posing Condition.** While the absence of a neutral group might appear to be an additional limitation, we believe it to be justified. We initially had planned on utilizing a neutral posing group, however, we removed this group in response to new research at the time suggesting that power posing was ineffectual (Ranehill et al., 2015; Simmons and Simonsohn, 2017; Gronau et al., 2017). With power posing's impacts being called into question, we believed that the addition of a neutral group to be excessive without first providing support for power posing's foundational claims.

**An Experimenter Present while Posing.** We note that the original power posing study (Carney et al., 2010) in addition to many replication studies (Bailey et al., 2017; Bombari, et al., 2017**;** Jackson et al., 2017**;** Klaschinski, Schnabel, & Schröder-Abé, 2017) had the experimenter leave the room while posing. When designing our study, were mindful of our experiment's location in a building with light to moderate foot traffic. To minimize distractions caused by noises, or passersby who might unintentionally see or be seen by the participant, we kept the door to the experimentation room closed during the study. We particularly believed that a participant being seen by others while connected to EDA/HRV leads and holding a power pose might create some embarrassment and have a measurable impact on our results. With the door closed during our study, we were unable to have the experimenter exit the room while the participant engaged in power posing; instead we had the participants face away from the experimenter while posing to allow the participants to focus on posing and neutral thoughts. In retrospect, while we might have minimized distractions occurring from outside of the room, we also might have made participants uncomfortable by holding them in a room with a complete stranger for nearly 20 minutes. This could explain why we saw a decrease in positive affect in both groups after power posing.

**A Limited Participant Pool.** Lastly, we also note that our college-aged participant pool only represents a sliver of the greater population. While we exhausted the resources available to us, we do believe that having a participant pool with a wider age range would have allowed us to collect data that more closely represents the overall population.

## Final thoughts on Power Posing Research

Although once considered to be a new technique useful for changing one's life (Cuddy 2012), today research has all but debunked power posing (Ranehill et al., 2015; Simmons and Simonsohn, 2017; Gronau et al., 2017). We find it curious that some studies have been able to replicate the results of the original Carney et al. (2010) paper. However, when reviewing studies that have had significant power posing results, we noticed that they tend to occur in social contexts. In our review of 64 power posing studies, we counted 34 replication studies that were able to find significant results where power posing had measurable impacts on participants including increased feelings of power (Bombari, et al., 2017) and positive vs negative word recall (Michalak et al., 2014). However, of those 34 studies, 25 occurred in simulated social contexts; for example in replication studies participants have been asked to hold power poses in front of images of others (Bombari, et al., 2017**;** Bailey et al., 2017), imagine their leadership status relative to others after posing (Arnette & Pettijohn, 2012) and recite a speech in front of a small audience while posing (Nair, et al., 2015). Additionally, many these replication studies did not control for participants who might be familiar with power posing, which is an important limitation as research has shown that knowledge of power posing can moderate the effect (Gronau et al., 2017).

Perhaps holding a power pose while thinking of others is a moderator of the power posing effect and helps to explain why some studies can produce significant results. While she maintains that the effect is real, Cuddy (Carney et. al., 2015) does recognize that power posing's benefits appear to exist primarily in social contexts. In both our study as well as in the latest replication studies, researchers have focused specifically on how holding a power pose impacts the individual, alone (rather than exploring an individual's response to power posing in a social setting), which might help to explain why our results do not support the claims of the Carney et al. (2010) study

(Gronau et al., 2017). However, irrespective of why some studies might produce significant results, the theory of increased feelings of power leading to measurable changes in behavior lacks empirical support (Gronau et al., 2017).

## Conclusion

When designing this study, we set out to learn whether the bidirectional relationship between emotions and nonverbal displays extends beyond the human face to body posture. Based on a review of our study's results in addition to the latest power posing literature, it appears that this bidirectional relationship does not exist for body posture. We also find it difficult to encourage further study on power posing's validity, due to the numerous replication studies published by researchers (Ranehill et al., 2015; Simmons and Simonsohn, 2017; Gronau et al., 2017) as well as the data dredging controversy involving the authors of the original Carney et al. (2010) study (Peters & Staff, 2016).

While research on power posing has been successful in garnering attention online with numerous replication studies (Peters & Staff, 2016) and a recording of a TED talk on power posing which has been watched online over 55 million times (Cuddy, 2012), it has been unsuccessful in proving to be a practical, useful technique. With what we understand about the human body and emotion, we can more strongly advocate for smiling (Soussignan, 2002) and viewing pictures of smiling faces (Wild, 2002) as a way of improving one's mood. While power posing has been debated and largely debunked, facial feedback is well-cemented as a reliable method of influencing an individual's mood.

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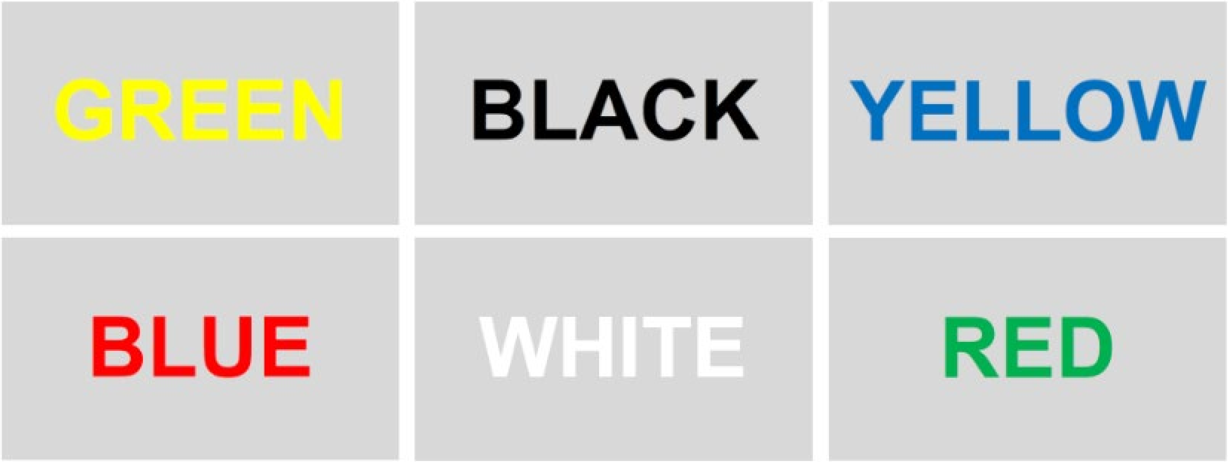
# Appendices

*Figure 1*.
Two examples of high-power poses where the subject is (A) sitting and (B) standing (Cuddy 2012). These high-power poses were used in the current study.

*Figure 2*.
Two examples of low-power poses where the subject is sitting (A) or standing (B) (Cuddy 2012). These low-power poses were used in the current study.

*Figure 3.*
Examples of color words that could be seen in a Color Word Interference Task. Here we see that the color of each set of text is incongruent to the color that the text spells, except for the word "BLACK", which is the congruent condition.



## Calculating Sample Size with G*Power

Using the G*Power software (Faul, Erdfelder, Lang, & Buchner, 2007), a power calculation was made to determine a total sample size of 20 participants for each posing condition. When the study was initially designed, there were three posing conditions, a high-power posing group, a neutral group, and a low-power posing group which meant a total sample size of 60 participants. However, once the power posing controversy began, we felt it more appropriate to focus on replicating the results of the original Carney et al. (2010) study by using the same two power posing groups, which meant a new total sample size of 40 participants.

For the current experiment, there are four normally distributed, interval, within subjects, dependent variables (autonomic response measured via HRV, autonomic response measured via EDA, self-reporting surveys, and performance during the CWT). There is also one independent variable (power-posing), with two independent levels (high-power posing and low-power posing). Therefore, a repeated measures between factors ANOVA was used to determine the required sample size for the current study.

The original power posing study, done by Carney (2010) reported significant changes in cortisol and testosterone for low-power and high-power posing. High-power posing for two minutes increased salivary testosterone and decreased salivary cortisol with an effect size of $r = .34$. Low-power posing for two minutes decreased salivary testosterone and increased salivary cortisol with an effect size of $r = .43$. Using an average $r$ of .385 along with a sample size converter provided by DeCoster (2012)[3], a value of f = .4172 was obtained and used in the power calculation.

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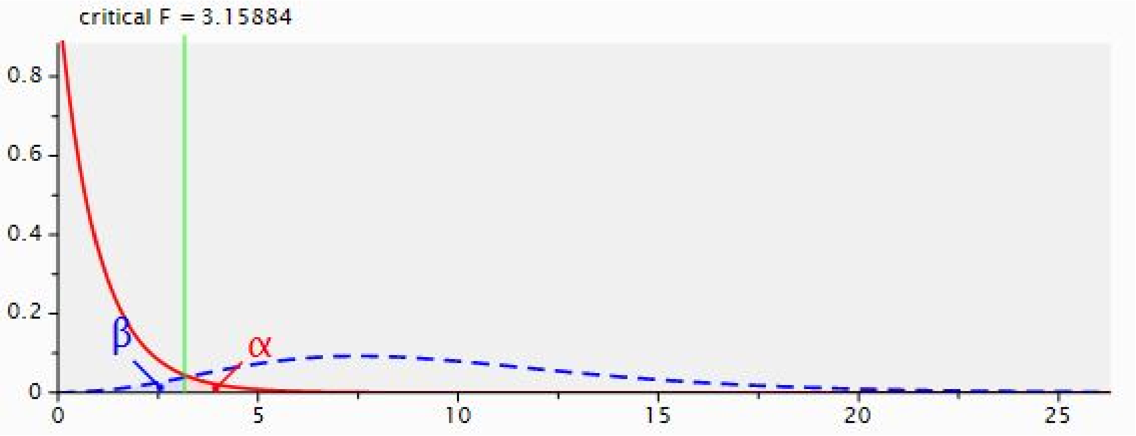
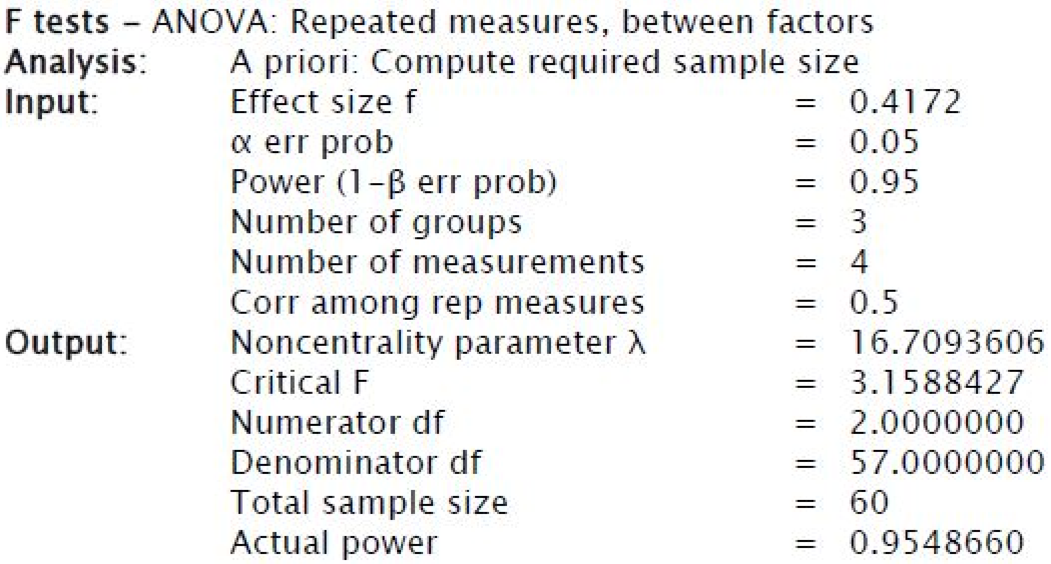
[3] The sample size converter provided by DeCoster (2012) uses formulas from Cohen (1988) and Rosenthal (1994).

Below are the resulting data from the G*Power software printout.



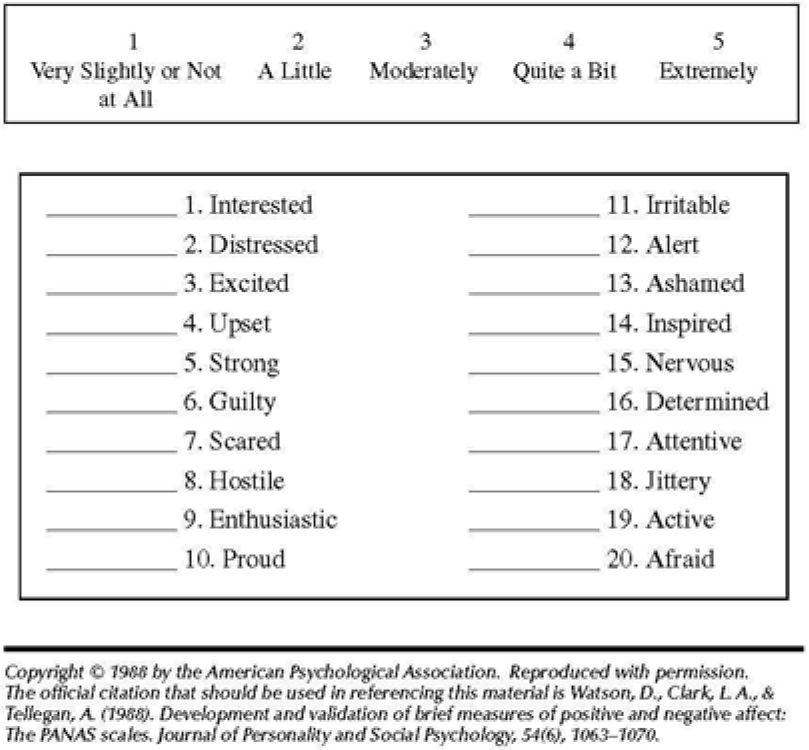


```
F tests – ANOVA: Repeated measures, between factors
Analysis:     A priori: Compute required sample size
Input:        Effect size f                        =   0.4172
              α err prob                           =   0.05
              Power (1–β err prob)                 =   0.95
              Number of groups                     =   3
              Number of measurements               =   4
              Corr among rep measures              =   0.5
Output:       Noncentrality parameter λ            =   16.7093606
              Critical F                           =   3.1588427
              Numerator df                         =   2.0000000
              Denominator df                       =   57.0000000
              Total sample size                    =   60
              Actual power                         =   0.9548660
```

Participants that have used the following drugs within the past 24 hours will be rescheduled for another testing session.

1. Cold/Flu Medicine including, but not limited to:
    - Robitussin, Mucinex, Dayquil, Nyquil, Sudafed, Afrin, Delsym, etc.
2. Stimulants including Caffeine (in excess)
3. Alcohol (to the point of intoxication)
4. Cardiac Medication including, but not limited to:
    - Including Rivaroxban, Dabigatran, Apixaban, Heparin, Warfarin, Beta blockers, etc.
5. Illegal drugs.

This scale consists of a number of words that describe different feelings and emotions. Read each item and then list the number from the scale below next to each word. **Indicate to what extent you feel this way, right now, that is, at the current moment.**



| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Very Slightly or Not at All | A Little | Moderately | Quite a Bit | Extremely |

__________ 1. Interested
__________ 2. Distressed
__________ 3. Excited
__________ 4. Upset
__________ 5. Strong
__________ 6. Guilty
__________ 7. Scared
__________ 8. Hostile
__________ 9. Enthusiastic
__________ 10. Proud
__________ 11. Irritable
__________ 12. Alert
__________ 13. Ashamed
__________ 14. Inspired
__________ 15. Nervous
__________ 16. Determined
__________ 17. Attentive
__________ 18. Jittery
__________ 19. Active
__________ 20. Afraid

*The official citation that should be used in referencing this material is Watson, D., Clark, L. A., & Tellegan, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. Journal of Personality and Social Psychology, 54(6), 1063–1070.*

On the following number line, draw a vertical line indicating your current level of stress.

*Figure 4*.
A histogram illustrating the data distribution of the HF-HRV data measured during the baseline condition. Note participant 17's location on the far right.

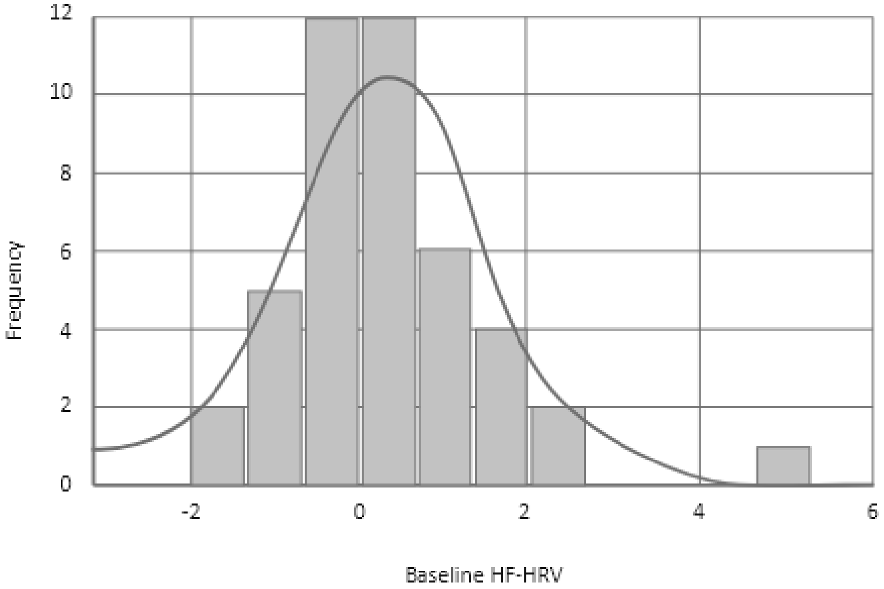


*Figure 5*.
A Box Plot illustrating the data distribution of the HF-HRV data measured during the baseline condition. This figure shows that participant 17 is an outlier.

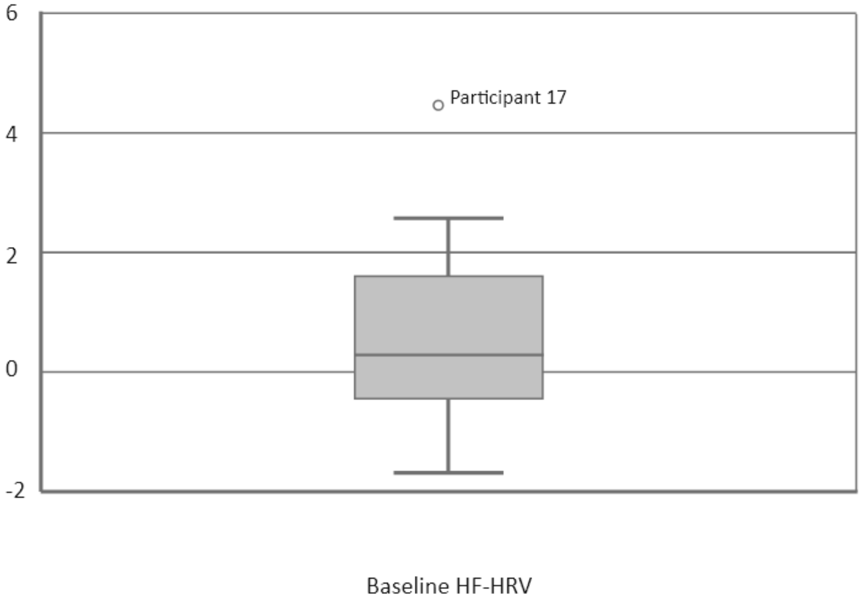
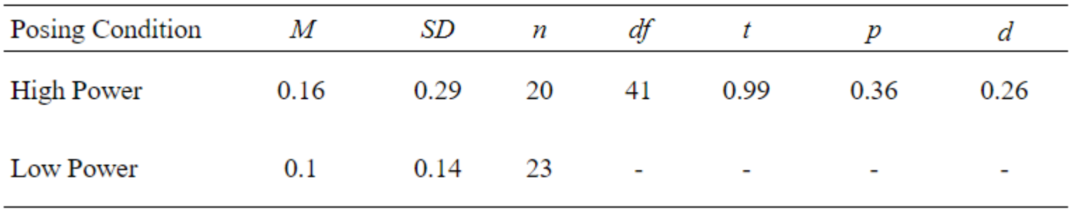


Table 1.

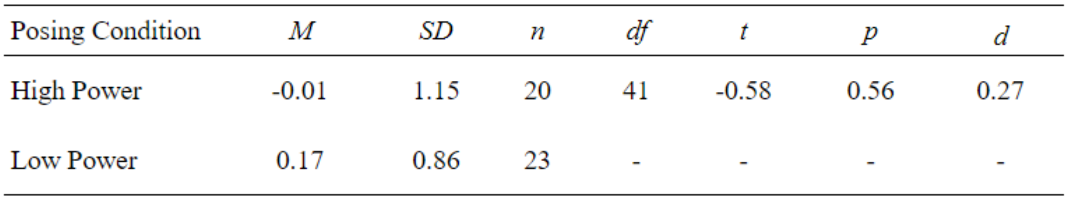
*Results of a t-test comparing EDA Scores for the High and Low Power Posing groups during posing conditions (testing Hypothesis 1: Stress Reactivity).*



| Posing Condition | *M* | *SD* | *n* | *df* | *t* | *p* | *d* |
|---|---|---|---|---|---|---|---|
| High Power | 0.16 | 0.29 | 20 | 41 | 0.99 | 0.36 | 0.26 |
| Low Power | 0.1 | 0.14 | 23 | - | - | - | - |

Table 2.

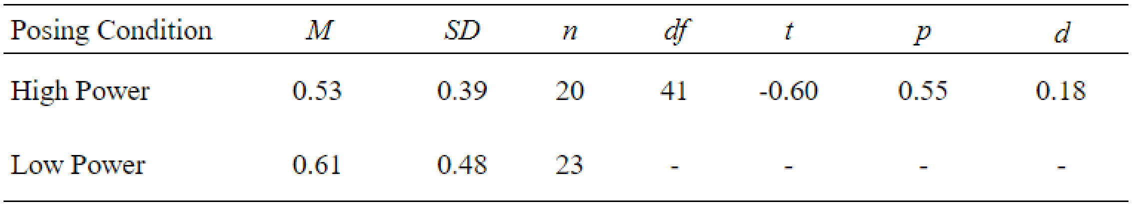
*Results of a t-test comparing HF-HRV Scores for the High and Low Power Posing groups during posing conditions (testing Hypothesis 1: Stress Reactivity).*



| Posing Condition | *M* | *SD* | *n* | *df* | *t* | *p* | *d* |
|---|---|---|---|---|---|---|---|
| High Power | -0.01 | 1.15 | 20 | 41 | -0.58 | 0.56 | 0.27 |
| Low Power | 0.17 | 0.86 | 23 | - | - | - | - |

Table 3.

*Results of a t-test comparing EDA Scores for the High and Low Power Posing groups during CWT (testing Hypothesis 1: Stress Reactivity).*



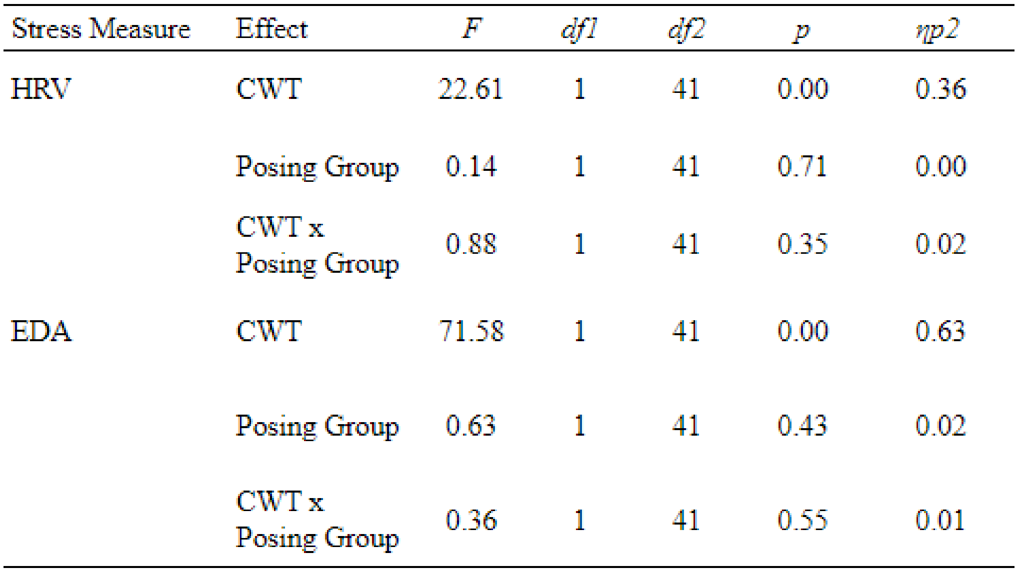
| Posing Condition | *M* | *SD* | *n* | *df* | *t* | *p* | *d* |
|---|---|---|---|---|---|---|---|
| High Power | 0.53 | 0.39 | 20 | 41 | -0.60 | 0.55 | 0.18 |
| Low Power | 0.61 | 0.48 | 23 | - | - | - | - |

Table 4.
*Results of a t-test comparing HF-HRV Scores for the High and Low Power Posing groups during CWT (testing Hypothesis 1: Stress Reactivity).*

| Posing Condition | *M* | *SD* | *n* | *df* | *t* | *p* | *d* |
|---|---|---|---|---|---|---|---|
| High Power | 0.52 | 0.89 | 20 | 41 | -0.94 | 0.35 | 0.28 |
| Low Power | 0.77 | 0.88 | 23 | - | - | - | - |

Table 5.

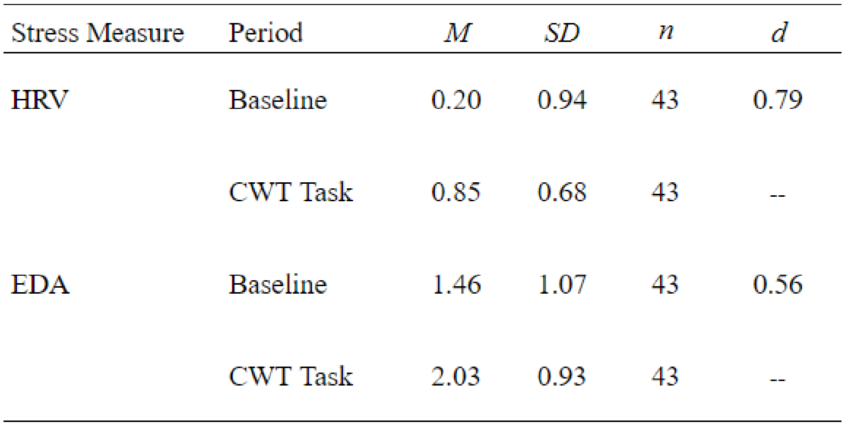
*Results of a Two-Way Mixed ANOVA which tested for main effects and interaction effects of CWT exposure on stress measures for posing groups (testing Hypothesis 1: Stress Reactivity).*



| Stress Measure | Effect | *F* | *df1* | *df2* | *p* | *ηp2* |
|---|---|---|---|---|---|---|
| HRV | CWT | 22.61 | 1 | 41 | 0.00 | 0.36 |
| | Posing Group | 0.14 | 1 | 41 | 0.71 | 0.00 |
| | CWT x Posing Group | 0.88 | 1 | 41 | 0.35 | 0.02 |
| EDA | CWT | 71.58 | 1 | 41 | 0.00 | 0.63 |
| | Posing Group | 0.63 | 1 | 41 | 0.43 | 0.02 |
| | CWT x Posing Group | 0.36 | 1 | 41 | 0.55 | 0.01 |

Table 6.

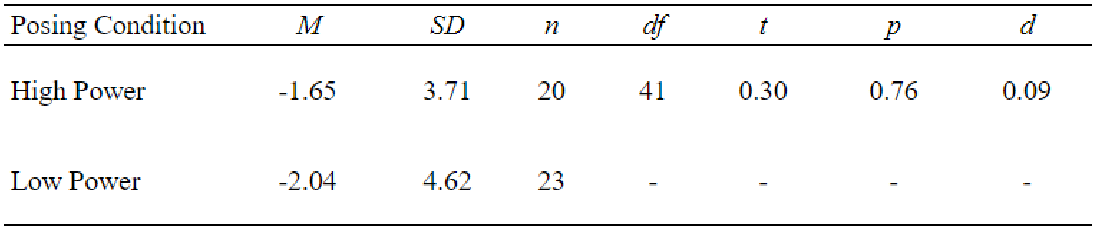
*Descriptive statistics for EDA and HRV stress responses during the baseline period and during the CWT (testing Hypothesis 1: Stress Reactivity).*



| Stress Measure | Period | *M* | *SD* | *n* | *d* |
|---|---|---|---|---|---|
| HRV | Baseline | 0.20 | 0.94 | 43 | 0.79 |
| | CWT Task | 0.85 | 0.68 | 43 | -- |
| EDA | Baseline | 1.46 | 1.07 | 43 | 0.56 |
| | CWT Task | 2.03 | 0.93 | 43 | -- |

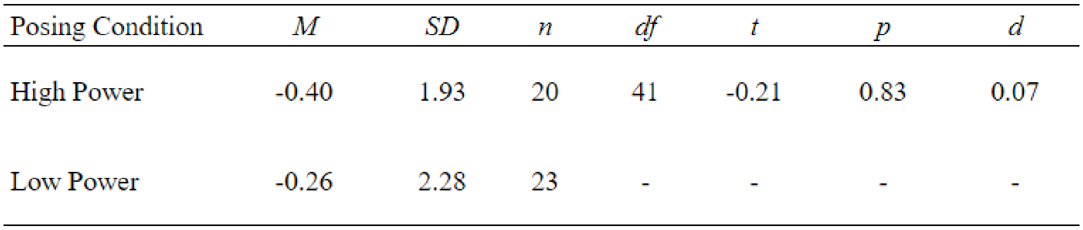
Table 7.

*Results of a t-test comparing changes in Positive Affect Scores for the High and Low Power Posing groups (testing Hypothesis 1: Stress Reactivity).*



| Posing Condition | *M* | *SD* | *n* | *df* | *t* | *p* | *d* |
|---|---|---|---|---|---|---|---|
| High Power | -1.65 | 3.71 | 20 | 41 | 0.30 | 0.76 | 0.09 |
| Low Power | -2.04 | 4.62 | 23 | - | - | - | - |

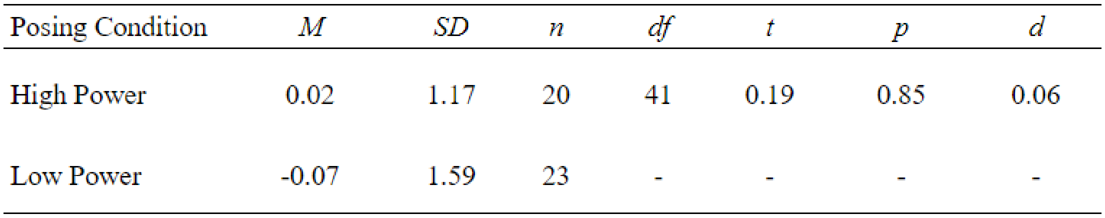
Table 8.
*Results of a t-test comparing changes in Negative Affect Scores for the High and Low Power Posing groups (testing Hypothesis 1: Stress Reactivity).*



| Posing Condition | *M* | *SD* | *n* | *df* | *t* | *p* | *d* |
|---|---|---|---|---|---|---|---|
| High Power | -0.40 | 1.93 | 20 | 41 | -0.21 | 0.83 | 0.07 |
| Low Power | -0.26 | 2.28 | 23 | - | - | - | - |

Table 9.

*Results of a t-test comparing changes in Line Rating Scores for the High and Low Power Posing groups (testing Hypothesis 1: Stress Reactivity).*



| Posing Condition | *M* | *SD* | *n* | *df* | *t* | *p* | *d* |
|---|---|---|---|---|---|---|---|
| High Power | 0.02 | 1.17 | 20 | 41 | 0.19 | 0.85 | 0.06 |
| Low Power | -0.07 | 1.59 | 23 | - | - | - | - |

Table 10.

*Results of a Two-Way Mixed ANOVA which tested for main effects of exposure to power posing and power posing group on mood (Positive Affect & Negative Affect; testing Hypothesis 1: Stress Reactivity).*

| Mood Measure | Effect | *F* | *df1* | *df2* | *p* | *ηp2* |
|---|---|---|---|---|---|---|
| Positive Affect | Power Posing | 8.16 | 1 | 41 | 0.00 | 0.36 |
| | Power Posing Group | 2.83 | 1 | 41 | 0.10 | 0.07 |
| | Power Posing x Posing Group | 0.88 | 1 | 41 | 0.35 | 0.02 |
| Negative Affect | Power Posing | 71.58 | 1 | 41 | 0.00 | 0.63 |
| | Power Posing Group | 0.05 | 1 | 41 | 0.82 | 0.0 |
| | Power Posing x Posing Group | 0.36 | 1 | 41 | 0.55 | 0.01 |

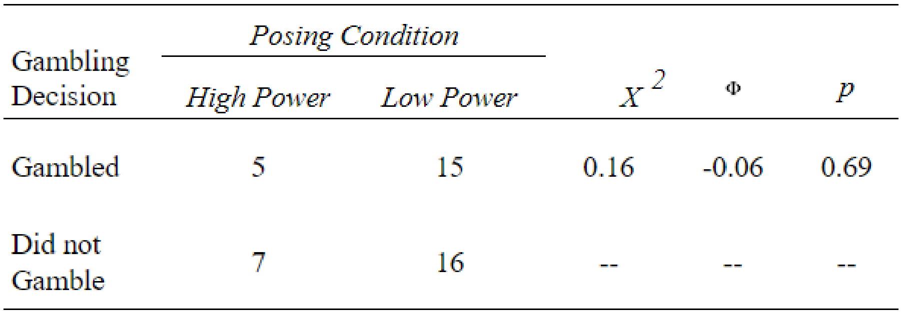
Table 11.

*Descriptive statistics for self-reported mood (positive and negative affect) during the baseline period and after power posing (testing Hypothesis 1: Stress Reactivity).*

| Mood Measure | Period | *M* | *SD* | *n* | *d* |
|---|---|---|---|---|---|
| Positive Affect | Baseline | 27.70 | 5.60 | 43 | 0.30 |
| | After Posing | 25.84 | 6.90 | 43 | -- |
| Negative Affect | Baseline | 13.37 | 3.20 | 43 | 0.10 |
| | After Posing | 13.05 | 2.90 | 43 | -- |

Table 12.

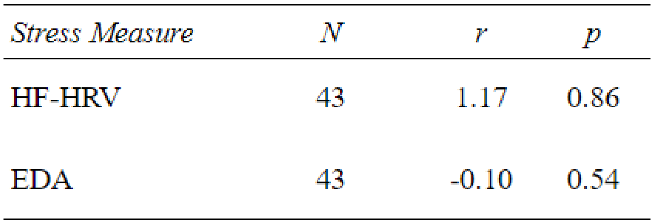
*Results of a chi-square test of independence comparing differences in gambling decision between posing groups (testing Hypothesis 2: Risk Tolerance).*



| Gambling Decision | *Posing Condition* | | | | |
|---|---|---|---|---|---|
| | *High Power* | *Low Power* | $X^2$ | Φ | *p* |
| Gambled | 5 | 15 | 0.16 | -0.06 | 0.69 |
| Did not Gamble | 7 | 16 | -- | -- | -- |

Table 13.

*Results of a correlational analysis to determine whether task performance and stress responses were correlated. (testing Hypothesis 3: Task Performance).*



| *Stress Measure* | *N* | *r* | *p* |
|---|---|---|---|
| HF-HRV | 43 | 1.17 | 0.86 |
| EDA | 43 | -0.10 | 0.54 |

Table 14.
*Results of a t-test comparing error rates for High and Low Power Posing groups during CWT (testing Hypothesis 3: Task Performance).*

| Posing Condition | *M* | *SD* | *n* | *df* | *t* | *p* | *d* |
|---|---|---|---|---|---|---|---|
| High Power | 4.2 | 4.0 | 20 | 41 | -0.86 | 0.39 | 0.27 |
| Low Power | 5.48 | 5.5 | 23 | - | - | - | - |