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NEUROLOGICAL EFFECTS ON THE BRAIN WHILE VIEWING SPORTS MEDIA CONTENT

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SUSPENSE AND SURPRISE:
NEUROLOGICAL EFFECTS ON THE BRAIN WHILE VIEWING SPORTS MEDIA CONTENT

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Abstract

Studies focusing on EEG, neuromarketing, sports, and suspense and surprise have all been executed; however, there are no studies combining these aspects to focus on neurological effects based on suspense and surprise while viewing sports. **Purpose:** The main purpose of this study was to discern how sports fans are neurologically affected when watching video presentations of sporting events with varying suspenseful or surprising characteristics. **Methods:** 35 subjects were recruited to participate in the Electroencephalogram (EEG) portion of the study. After inclusion criteria was met, and preprocessing and processing of data was complete, 21 subject's data remained usable for analysis. Another 16 subjects participated in a Truth-of-Consensus portion of the study; this portion is where the subjects watched a random selection of videos and rated the videos using a Suspense and Surprise rating Scale created for this study. Each participant in the EEG portion of the study watched two videos from four different categories: High Suspense High Surprise (HH), High Suspense Low Surprise (HL), Low Suspense High Surprise (LH), Low Suspense Low Surprise (LL). Video category and wave frequency band were analyzed in pairs; ex: Theta HH or Alpha LH. **Results:** Whole brain electrocortical brain activation, prefrontal cortex electrocortical brain activation, and left and right hemispheres in the prefrontal cortex were all analyzed for differences due to varying levels of suspense and surprise within a video and found no statistically significant results. However, "rest of brain" compared to prefrontal cortex was analyzed for differences due to varying levels of suspense and surprise and found statistically significant results in all video category types and frequency waves, with the exception of one video type in Beta and all Gamma waves (no significant results reported from Gamma waves). "Rest of brain" vs prefrontal cortex showed theta (θ) HH ($p = 0.00$), HL ($p = 0.00$), LH ($p = 0.00$), LL ($p = 0.00$); alpha (α) HH ($p = 0.00$), HL ($p = 0.01$), LH ($p = 0.00$), LL (p=

0.00); beta (β) HH ($p= 0.03$), LH ($p= 0.03$), LL ($p= 0.02$). These results are significant in the direction of whole brain, which was not the hypothesized direction because a greater mean in the prefrontal cortex would indicate greater emotional response. However, the most notable finding is in the alpha differences in all four categories. Due to alpha's assumed role in decreased cortical activity, hemispheric activity levels are thought to actually decrease with an increase in alpha activity. This being stated, alpha having higher activity in the "rest of brain" portion lead to the assumption that alpha has lower activity levels in the prefrontal cortex, leading to greater alpha functions, including memory. **Conclusion:** The insignificant findings from the analysis are counterintuitive to the multiple hypotheses from this study. It was believed that videos of varying levels of suspense and surprise would create differences from baseline electrocortical brain activation. Several potential limitations including averaging data across the entire video, too small of a sample, and boredom due to a possible disinterest in certain videos leads to multiple suggestions for future research in the field of suspense and surprise in sports media.

CHAPTER 1: INTRODUCTION

“Andy, please step forward… the judges have decided that you are…” Such is the language that appears at the most pivotal moments of reality television programs.

Suspense and surprise are arguably what create the demand for more. Whether it be the suspense of finding out if your favorite contestant will be saved or eliminated, or the surprise of watching a title fight knockout in the first round. Suspense and surprise may create more fans, more anticipation, and more entertainment in any event. People crave non-instrumental information; readers and viewers always have and will likely continue to engulf themselves in books, shows, movies, and sports that are nonvital to everyday life (Ely, Frankel, & Kamenica, 2015). This may be considered the entertainment factor. No matter a person’s particular interests, finding a book, TV show, or team that will consume their lives for a number of hours per day or weeks can feel vital. In recent years, entertainment providers are facing stiffer competition in the entertainment market and it is becoming more difficult to grab the consumer’s attention, even more to keep that attention for a long period of time (Bizzozero, Flepp, & Franck, 2016). Therefore, understanding precisely what criteria and factors drive demand for entertainment is becoming more and more necessary (Bizzozero et al., 2016). A possible solution to this current problem is understanding and manipulating suspense and surprise within media content.

Suspense can be defined as “a state or feeling of excited or anxious uncertainty about what may happen,” and surprise can be defined as “an unexpected or astonishing event, fact, etc.” (Oxford University Press, 2019). The American Time Use Survey reveals that people in the United States use about one-fifth of their time awake consuming entertainment (Aguiar, Hurst, & Karabarbounis, 2013). To keep the consumers attention, suspense and surprise can be used as tools to make entertainment more exciting, possibly leading to longer and more engaged attention from the consumer. A way to extend the attention is by prolonging what the consumer is waiting for, better known as suspense. For years, “mystery novels, soap operas, sports events, and casinos all create value by revealing information over time in a manner that makes the experience more exciting” (Ely et al., 2015). There has been extensive research done to understand the perfect amount of suspense and surprise to incorporate into a novel or a film; certain directors and authors have this down to a science (Luttiken, 2006; Bryant, 1994; Yuan, 2018). Casinos are so popular because of the suspense and surprise factor, which is why people continue to gamble (Ely et al., 2015). Although research has been completed to systematically improve filmmaking, novel writing, and casino management, viewer attention in the sports industry has been relatively untouched by academic researchers.

Ever since about 2002 when neuroscience started to bleed into the marketing field, advertisers have been using what is known as neuromarketing to better understand consumer behavior (Morin, 2011). However, neuromarketing regarding athletic broadcasting has little to no academic literature. This leads to the question, “why have suspense and surprise not been researched more to better understand what the viewers want to see?” By exploiting increased public interest in athletic broadcasting, teams and sponsors could make more use of their investments and money spent.

To fully comprehend how suspense and surprise can create more impactful entertainment in sporting events, neuromarketing techniques can be adopted. Neuromarketing is a field of marketing that uses medical technologies such as the functional magnetic resonance imaging (fMRI) and the electroencephalography (EEG) to have a closer look into the conscious and subconscious minds of consumers (Morin, 2011). Neuromarketing is a rather new field with immense amounts of research emerging every day, however, the research being done in the sports industry is quite slim. Furthermore, how suspense and surprise in sports event viewing affects consumers brain activity is untouched territory in the neuromarketing field. This motivates why this area of study is important and clarifies how it can be used as a stepping stone for future research. A better understanding of sports consumers is vital for the sport marketing industry, as avid sport consumers are integral for the sport industry to maximize profits and market share (Iwasaki and Havitz, 2004). Once it is understood how suspense and surprise affect sports broadcast viewers brains, future studies can use this knowledge to see how suspense and surprise in broadcasts lead to changes in recognition and recall of advertisements. Emotional events, such as a suspenseful or surprising event, may be remembered differently than a neutral or ordinary event. An intense emotion generally leads to more accurate, detailed, and persistent memory (Christianson, 1992). With better understanding of cognitive effects on consumers watching a sports broadcast, advertisers and sponsors will be able to maximize the timing and placement of their brand images. This will lead to maximizing profit for sport organizations and maximizing entertainment value for consumers.

To make sure the previous statements are plausible, an EEG will be used in this study to help measure the effects of suspense and surprise on a viewer's brain while watching a sports broadcast. Explaining how one's conscious mind operates (i.e., "what were you thinking?") is a daunting task in and of itself but calling on a subject to explain what their subconscious mind was doing is, by definition, impossible. The EEG may allow for true readings of the conscious and subconscious brain activity through different wave frequencies; such as, theta, alpha, beta, and gamma waves. Using electrode sensors on a participant's head, the EEG can record even the slightest of changes in the brain activity. EEG in a carefully controlled experiment has been shown to be a valid measure of cognitive activity and particularly emotional responses (Garnter & Badbouj, 2014).

This study examined the neurological effects that suspense and surprise have on a consumer's different brain wave frequencies while viewing a sporting event or broadcast. Participants were asked to watch sports broadcast clips while wearing an EEG cap. The videos shown to the subjects were made up of four categories of varying levels of suspense and surprise. The categories are as follow: High Suspense and High Surprise (HH), High Suspense and Low Surprise (HL), Low Suspense and High Surprise (LH), and Low Suspense and Low Surprise (LL). Stories and videos can elicit powerful emotions, however, the neural process underlying emotions conveyed through suspense and surprise have not been previously investigated together (Lehne et al., 2015).

Purpose of the Study

The main purpose of this study is to discern how sports fans are neurologically affected when watching video presentations of a sporting events with varying suspenseful or surprising characteristics. To understand these effects an EEG was used to measure brain activation in specific parts of the brain, i.e. the prefrontal cortex and the whole brain. Different areas of the brain have different specialties and jobs, so pinpointing where the greatest power is generated can show which part of the brain is being affected. "Power is the amount of energy in a frequency band. This can be thought of as the loudness of a song" (iMotions, 2017). Different brain wave frequencies also have different attributes affiliated with them. Neural movements and changes in the brain can be measured with EEG and can even be seen in the raw, unfiltered data. However, these signals are mixture of all waveforms that all have specific cognitive and attentional states (iMotions, 2017). For this reason, theta, alpha, beta, and gamma frequency waves were analyzed individually to determine the underlying cognitive state in the participant while viewing the sports media content. Theta activity is correlated with the difficulty of cognitive tasks, alpha has multiple purposes correlating to sensory, motor, and memory functions, active thinking and active concentration are generally linked to higher levels of beta, and gamma band can be considered the black box of brain waves, as there is no set traits or characteristics attributed to gamma band and researchers are unclear what generates the gamma frequency and what the frequency reflects. For this study, prefrontal cortex activity was compared to whole brain activity. In terms of gross anatomy, the prefrontal cortex was the specific area looked at because it is thought that this area has a direct link to the amygdala (Purves et al., 2001). The amygdala is regarded to be the integrative center for emotions, which leads to this being an important center when looking at suspense and surprise (Wright, 2019).

Studies show the different ways in which suspense and surprise affect film and literature experiences for the viewer/reader. Suspense is thought to cause anticipation for what the audience is expecting to happen, however, anticipation appears to typically be more impactful than the actual event itself (Nomikos, Opton, & Averill, 1968). Suspense builds on basic aspects of human cognition such as processes of expectation, anticipation, and prediction (Lehne, Engel, Rohrmeier, Menninghaus, Jacobs, & Koelsch, 2015). Suspense can expand time and make people wait for what they want/fear. Alfred Hitchcock states that for this reason, suspense is money (Lutticken, 2006). A twist in a story can also keep a reader or viewer interested, which is why an occasional surprise can be impactful. Although these two emotions have been heavily researched in regard to film and literature, research on suspense and surprise in sports is not as common. This thesis helps fill the gap in this area of research.

The brain is always working, whether we are resting, active, or in this case, watching sports. This study reported on the difference in power output in the whole brain, the prefrontal cortex, the whole brain (minus prefrontal cortex) vs prefrontal cortex, and different hemispheres and focused on the four wave frequencies stated before (theta, alpha, beta, gamma) while watching sports. This leads to the following research questions and hypotheses:

RQ_1: *Does whole brain electrocortical activity vary due to level of suspense and surprise presented in the media content?*

> **H_1**: There will be a significant difference from baseline in whole brain activity while viewing a High Suspense and High Surprise video.
>
> **H_2**: There will be a significant difference from baseline in whole brain activity while viewing a High Suspense and Low Surprise video.
>
> **H_3**: There will be a significant difference from baseline in whole brain activity while viewing a Low Suspense and High Surprise video.
>
> **H_0**: There will be no significant difference from baseline in whole brain activity due to level of suspense and surprise presented in the media content.

RQ_2: *Does prefrontal cortex electrocortical activity vary due to level of suspense and surprise presented in the media content?*

> **H_4**: There will be a significant difference from baseline in prefrontal cortex brain activity while viewing a High Suspense and High Surprise video.
>
> **H_5**: There will be a significant difference from baseline in prefrontal cortex brain activity while viewing a High Suspense and Low Surprise video.

H_6: There will be a significant difference from baseline in prefrontal cortex brain activity while viewing a Low Suspense and High Surprise video.

H_0: There will be no significant difference from baseline in prefrontal cortex brain activity due to level of suspense and surprise presented in the media content.

RQ_3: *Does mean "rest of brain" electrocortical activity differ from mean prefrontal cortex electrocortical activity due to level of suspense and surprise presented in the media content?*

H_7: There will be a significant difference between "rest of brain" and prefrontal cortex brain activity while viewing a High Suspense and High Surprise video.

H_8: There will be a significant difference between "rest of brain" and prefrontal cortex brain activity while viewing a High Suspense and Low Surprise video.

H_9: There will be a significant difference between "rest of brain" and prefrontal cortex brain activity while viewing a Low Suspense and High Surprise video.

H_{10}: There will be a significant difference between "rest of brain" and prefrontal cortex brain activity while viewing a Low Suspense and Low Surprise video.

H_0: There will be no significant difference between "rest of brain" and prefrontal cortex activity due to level of suspense and surprise presented in the media content.

RQ$_4$: *Is there frontal EEG asymmetry in the prefrontal cortex due to level of suspense and surprise presented in the media content?*

> **H$_{11}$**: There will be a significant difference between the left hemisphere and the right hemisphere in the prefrontal cortex while viewing a High Suspense and High Surprise video.
>
> **H$_{12}$**: There will be a significant difference between the left hemisphere and the right hemisphere in the prefrontal cortex while viewing a High Suspense and Low Surprise video.
>
> **H$_{13}$**: There will be a significant difference between the left hemisphere and the right hemisphere in the prefrontal cortex while viewing a Low Suspense and High Surprise video.
>
> **H$_{14}$**: There will be a significant difference between the left hemisphere and the right hemisphere in the prefrontal cortex while viewing a Low Suspense and Low Surprise video.
>
> **H$_0$**: There will be no significant difference between the left hemisphere and the right hemisphere due to level of suspense and surprise presented in the media content.

The research questions and hypotheses that were formulated allowed for in depth analysis of whole brain electrocortical activity (**RQ$_1$**) and prefrontal cortex electrocortical activity (**RQ$_2$**); as well as comparison between the four category types to better understand differences in prefrontal and "rest of brain" activity (**RQ$_3$**). Lastly, research question 4 provides comparisons between the two hemispheres in the brain to better understand frontal asymmetry in the brain.

The research questions also allowed for flexibility of evaluation between wave frequencies while comparing the different category types. For clarification, during evaluation and comparison of video types Low Suspense and Low Surprise (LL) videos were categorized as the baseline power output. "Rest of Brain" in Research Question 3 refers to the whole brain minus the prefrontal cortex. This is conducted to compare between prefrontal cortex activity and the rest of the brain (not including the prefrontal cortex) to give a true comparison of the differences in the separate parts of the brain. For research questions 1 and 2, a significant difference between any of the three category types (HH, HL, or LH) and baseline (LL) in the direction of HH, HL, or LH would lead to greater understanding of which emotion, suspense or surprise or both, lead to greater brain activation in comparison to a video with no high levels of emotion. A significant difference in "rest of brain" vs prefrontal cortex (RQ3) would frame a potential difference in brain activation in different regions of the brain due to emotional cues of the videos. Possibly representing suspenseful or surprising tendencies in sports media lead to greater activation in a specific region of the brain. A significant difference in the left or right hemisphere of the brain (RQ4) would indicate if suspenseful or surprising tendencies in sports media lead to greater approach or withdrawal tendencies.

Limitations

The limitations of the following study were:

1. The participants were willing volunteers from the University of Oklahoma, Norman, and Oklahoma City area. Leading to this sample not being a true random sample.
2. Many sports clips were be shown. Some sports are not as popular, leading to possible disinterest in some clips.

3. Only a 32-electrode water-based EEG was used.
4. Some videos shown are popular and may have been seen by the viewer before.
5. Certain video audio is louder than others, leading to the possibility of a sudden shock when the video starts.

Delimitations

The delimitations for the following study were:

1. Population is individuals whom categorize themselves as sports fans.
2. People from the University of Oklahoma, Norman, and Oklahoma City area.
3. 32-electrode water-based EEG

Assumptions

1. Participants have never seen a majority of the videos being played.
2. If they have seen the video, it will not affect how they respond while watching.
3. Participants did not discuss the study content with other participants.
4. Participants had eyes on the screen and watched the videos while they were being played.
5. Participants stayed relatively still, as instructed, through the duration of the videos.

Definition of Terms

- Brain activation: How the fan's brain will react under the EEG
- Power Output: Amount of electrical energy being expressed in a frequency band
- Prefrontal Cortex: Front of the frontal lobe. Thought to be active during complex behaviors

- Limbic System/Amygdala: An area deep in the brain where emotions are thought to be expressed.
- Localization: The idea that specific areas of the brain have specific functions.
- Frontal Brain Asymmetry: Differences across the two hemispheres of the brain.
- Lateralization: The tendency for some cognitive functions or cognitive processes to be specialized to one side of the brain or the other.
- Electrocortical Activity: Pertaining to the electrical activity in the cerebral cortex
- Cerebral Cortex: Outermost layer of the brain responsible for higher brain processes; including sensation, voluntary muscle movements, thought, and memory.
- Whole Brain: For this study, whole brain is considered all 32 electrodes on the EEG.
- Rest of Brain: For this study, "rest of brain" is considered the whole brain minus the prefrontal cortex.

CHAPTER 2: LITERATURE REVIEW

Introduction

This paper discusses how, with the use of electroencephalography (EEG) while participants are viewing a sports broadcast, the factors of suspense and surprise affect the viewers brain. This research can be used as a stepping-stone for future research that may better predict how sports viewers are cognitively feeling while watching sports, potentially leading to optimized sponsorship and advertisement timing and placement within sports broadcasts. Understanding how suspense and surprise affects the recognition and recall for advertisements would be a breakthrough for sports advertisers.

This chapter dives into the foundational research done on the topic of suspense and surprise, neuromarketing, and relevant research pertaining to the use of EEG. The topic of suspense and surprise will be broken into subcategories focusing on how these two factors are used in literature, movie and TV productions, and then how these can tie into sports as well. The EEG portion will focus on neuroanatomy and why the EEG will be used for this study. As well as topics including frontal brain asymmetry and the different wave frequencies and the cognitive and attentional states they represent.

This literature review was conducted through the University of Oklahoma Library website. Advanced searches were done in order to have specific keyword combinations and inclusion criteria. Single keywords included: EEG, electroencephalography, Suspense, Surprise, Neuromarketing. Combinations of words included: EEG + Suspense, EEG + Surprise, EEG + Neuromarketing, EEG + Sports, EEG + Marketing, Uncertainty + Outcome, and Emotion +

Frequency. Many articles were found through other research and were then found using direct titles.

The next sections are divided up into literature regarding suspense and surprise, neuromarketing, and EEG measurement methods.

Suspense and Surprise

Literature

Suspense and surprise have been used for centuries to draw attention and keep the readers interest. Some researchers even argue that the bible is a prime example of how suspense and surprise have been used (Barber, 2015). For example, in a section of the 41st volume of the *Religious Studies Review,* Experiencing Irony in The First Gospel: Suspense, Surprise, and Curiosity, “Karl McDaniel utilizes the tools of literary criticism to argue that Matthew's narrative is shaped to elicit suspense, surprise, and curiosity from readers” (as cited in Barber, 2015, p.24). While explaining further, McDaniel says, “the announcement in 1:21 (‘he will save his people from their sins’) establishes the expectation that Jesus will receive a warm Jewish reception. As the narrative unfolds this seems increasingly unlikely, eliciting suspense” (as cited in Barber, 2015, p. 24). This unveils a suspenseful event that most likely caused great anxiety before the stories were better known.

However, in a more modern discussion of narrative, Yuan Yuan’s (2018) *Framing surprise, suspense, and curiosity: a cognitive approach to the emotional effects of narrative,* examines the three narrative defining interests of suspense, surprise, and curiosity. Yuan argues that, “the excessive weight put on emotions by the narratologists turns out to be rooted in their inadequate understanding of how emotions engender in our narrative experience” (Yuan, 2018,

p. 520). Basically, Yuan argues that some authors do not understand that allowing the reader's mind to wander and try to connect the dots on their own is what makes for suspense and surprise. A reader needs to be curious and anxious for what will happen next; a reader needs to think they know what is happening to build suspense and then if something is different, then the reader is surprised. In regard to this, Yuan states, "such results strongly testify to our claim that readers' emotional engagements with narrative must have as its basis their understanding of narrative" (Yuan, 2018, p. 520). The author is discussing how narrative matters and the reader just needs to have the basis of what is going on to fully comprehend the overall narrative. To extend this into sports viewing, we ask, does the narrative matter there similarly? As a thought experiment, we may consider two people watching a soccer match. If one viewer knows that this match is an important one, because of how it fits within a season long championship narrative for example, and the other does not know this narrative, do the viewers have the same experience? Clearly, there could be vastly different emotional reactions to the same media presentation.

Film

In Sven Lutticken's (2006) paper *Suspense and… surprise* he discusses how to perfect the act of suspense in movies, and filmmakers have explored actual acts of terror, such as 9/11 to understand the anticipation and feelings in those events. Some of the most agonizing anxiety a person or society can feel is during a war and wondering what will happen or after and act of terror and not understanding why. Obviously, this is an extreme context and is a far cry from live sports, however, the anticipation of a big game could have analogous effects on an individual's neurophysiology, which is why looking into how producers analyze these events could actually lead to improved marketing practices in sports. In an interview with Alfred Hitchcock (as cited in

Lutticken, 2006), the master of movie suspense, he goes on to tell a story to explain suspense and surprise:

> "We are having a very innocent little chat. Let us suppose that there is a bomb underneath this table between us. Nothing happens, and then all of a sudden, 'Boom!' There is an explosion. The public is surprised, but prior to this surprise, it has to be an absolutely ordinary scene, of no special consequence. Now, let us take a suspense situation. The bomb is underneath the table and the public knows it, probably because they have seen the anarchist place it there." (p.95-96)

So in a soccer match, if a player unexpectedly shoots from midfield and scores, that is like the random "boom" of the bomb no one was expecting. But if a team is keeping possession and getting a few chances on goal and the finally scores (boom), that is like the audience seeing the bomb and waiting for it to explode.

Hitchcock (as cited in Lutticken, 2006), goes on to explain how suspense is money, it stretches time, and how it allows the audience to identify with the people. Being more invested in a scene or sports play leads to greater viewer reaction (Lutticken, 2006).

Laboratory Studies

Nomikos, Opton, Averill, and Lazarus (1968) present their findings that the lead up and anticipation to an event or accident could be worse than the actual accident itself. This experiment had three harm anticipation videos. Two of which an accident came without warning (surprise) and one with a 20-30 second anticipation period with clues that the accident would occur. The results indicated that the long anticipation was more stressful than no anticipation (Nomikos et al, 1968). The most stressful reaction occurred during the anticipation period rather than during the actual accident. Multiple studies observe that anticipating a certain outcome is just as stressful as the actual situation itself. Shannon and Isbell (1963) mentioned how receiving a dental anesthetic injection resulted in no more increase in serum hydrocortisone than just anticipating the injection. Then another paper by Barber and Coules (1959) mentions a similar phenomenon in reference to anticipation if electric shock (as cited in Nomikos et al., 1968)

This leads to multiple questions tying this study into the world of sports: Could this phenomenon be similar to watching sports? In the final minutes of a close game, could the suspense of the game be more impactful than the actual outcome? Will surprising events show less of a reaction in the brain than the suspenseful events?

Sports

Looking into suspense and surprise outside of literature and film production leads to many of the same takeaways. In a study produced by Ely, Frankel, and Kamenica (2015) they define a period has more suspense if the variance of the next period's beliefs are greater than the previous. Basically, saying if the viewer has less idea what will happen next, the suspense is greater. For surprise, the authors state "a period has more surprise if the current belief is further from the last period's belief". Meaning, if what is currently happening is completely different than what just happened, the viewer will be more surprised (Ely et al., 2015). This paper formalizes the idea that nonvital information is entertainment and they analyze a way to maximize expected suspense and surprise in order to lead to maximum entertainment. The researchers suggest that entertainment is crucial in many industries; such as mystery novels, soap operas, sports, and casinos. This same study looks specifically into two tennis matches as a clarifying example; Djokovic versus Federer and Murray versus Nadal. The match between Federer and Djokovic had dramatic lead changes and important missed chances. Federer even had multiple match point opportunities but ended up going on to lose. In the other match, Nadal dominated the entire match from the beginning (Ely et al. 2015). This associates to a different research paper, *The Importance of Suspense and Surprise in Entertainment Demand: Evidence from Wimbledon* by Paolo Bizzozero, Raphael Flepp and Egon Franck (2016). This paper looks into the Wimbledon Championship, a setting that allows the authors to operationalize suspense and surprise by using audience beliefs of the "outcome of match and observe the demand for live entertainment using TV audience figures" (Bizzozero et al., 2016). The two papers compliment each other greatly when Bizzozero, Flepp, and Franck go on to say, "our match fixed effects estimates of 8,563 minute by-minute observations from 80 men's singles matches between 2009 and 2014 show that both suspense and surprise are drivers of media entertainment demand" (Bizzozero et al., 2016, p.1). The first paper (Ely et al. 2015) mentions how the match between Federer and Djokovic was way more exciting and theorizes the effects of this; the second paper (Bizzozero et al., 2016), puts that theory to the test and indicates why it is most likely the match between Federer and Djokovic had far greater viewership.

Ely et al. (2015) also discuss how sports fans enjoy the shifting emotions during a game. This is similar to playing blackjack at a casino. Participants seem to love the excitement of the ups and downs while playing at a casino (Ely et al., 2015). Sports fans may similarly prefer a suspenseful game over watching their favorite team win easily every time. Part of the fun of gambling or rooting for a team is the suspense and surprise. Typically, when rooting for two unfamiliar teams, the viewer roots for the underdog. This is because the surprise is greater when the underdog wins (Ely et al., 2015). This connects with the Uncertainty of Outcome Hypothesis which says that, "sports fans value contests with uncertain outcomes" (Eckard, 2017, p. 299). In a study done on PGA Tour television ratings, Gooding and Stephenson (2017) conclude that a major influence on TV ratings for the PGA Tour was that another golfer was within 5 strokes of the leader. This represents golf viewer's want for a close match and uncertainty of outcome for who will win. Another research article by Tim Pawlowski (2013) indicates that over 70% of fans cared about competitive balance in the German Bundesliga. When a game has a larger margin of victory, this has a negative and significant impact on how fans feel about their team; indicating that fans prefer closer games (Paul, Wachsman, & Weinbach, 2011). The Uncertainty of Outcome Hypothesis supports that suspense and surprise are drivers of entertainment.

Paul, Wachsman, and Weinback (2011) go on to discuss that different sports have very different distribution paths when it comes to the outcome. Therefore, a study in this area should address these variations when considering underlying suspense and surprise constructs. Soccer, for example, is unlikely to have anything consequential happen in any given minute. As time passes, whichever team is leading becomes more likely to win. There is a small chance that a team scores, however, this makes that goal extremely important. Leading to soccer being a very suspenseful game. But in basketball, both teams score a lot every minute and each possession a team could become slightly more likely or less likely to win depending if they score. So no single possession will have a incredibly large effect on beliefs of the outcome. This makes basketball more surprising (Ely et al., 2015).

One study done by Bryant, Rockwell, and Owens (1994) titled *Buzzer beaters and barn burners: The effects on enjoyment of watching the game go "down to the wire"* has similar methodology to this proposed study. In Bryant's research a high school football game was professionally recorded and edited with play-by-play commentary to portray a suspenseful version and a non-suspenseful version. The results yielded that viewing a more suspenseful version made the game more exciting, less boring, more enjoyable, and less dull. Viewers of the more suspenseful version were also more anxious, cared more if the team they liked won, and cared more for the winning team than did the people that watched the non-suspenseful version (Bryant et al., 1994).

Circling back to Bizzozero, Flepp and Franck's study, they explain why using an EEG on consumers will lead to possible breakthroughs in sports marketing and sponsorship. The authors state that, "although it is intuitive that suspense and surprise matter in the context of entertainment, empirical tests are difficult to design because people's beliefs and their enjoyment are hard to observe" (Bizzozero, Flepp, & Franck, 2016). It is hard to capture a viewer's true emotions while watching a game, however, if these emotions can be better understood, sports marketing and sponsorship could make greater use of time and money.

Neuromarketing

In the paper, *Neuromarketing: The New Science of Consumer Behavior* by Christophe Morin, he states that "neuromarketing is an emerging field that bridges the study of consumer behavior with neuroscience" (Morin, 2011). For decades advertisers have tried to understand what consumers are truly thinking. With the help of the EEG, this is now a feasible task. Sometimes conscious thoughts are hard to explain, and subconscious thoughts are impossible to understand. However, with neuroscience and EEG, it is possible to dive deeper into a consumer's brain to better understand conscious and even subconscious thoughts. This is the reasoning for this preliminary project; to understand if suspense and surprise have any effect on a consumer watching a sports broadcast. Understanding how these emotions affect a viewer can lead to better marketing and broadcasting practices.

According to Rumpf and Breuer (2017), positive consumer reactions to marketing techniques is an important driver in business success. Rumpf and Breuer continue on to say how traditional marketing techniques are very limited in regard to insights into consumer perceptions and intentions. Therefore, neuroscientific techniques can attribute to a greater understanding of the consumer's "black box" (Rumpf and Breuer 2017). Rumpf and Breuer (2017) acknowledge that EEG studies allow researchers with the opportunity to further understand consumers. Typically, EEG technology has been used to study the non-conscious consumer reaction while viewing advertisements (Rumpf and Breuer 2017).

In a study produced by Schmidt, Patnaik, and Kensinger (2011), the researchers conducted a study using neuromarketing techniques to better understand if emotion enhances memory accuracy. The researchers hypothesize that, "items are remembered in a spatial and temporal context, so [they] examined whether an item's valence (positive, negative) or arousal (high, low) would influence its ability to be remembered with those contextual details" (Schmidt, Patnaik, & Kensinger, 2011). Across two experiments, one to look at high-arousal items and one for low-arousal items, the high-arousal items were remembered with greater spatial and temporal context that low-arousal items. Also, positive items were remembered or recalled more often than negative items (Schmidt et al., 2011). These findings lead to the proposition that while viewing a sport broadcast the more memorable games (and associated brands) are the suspenseful games where the viewer's favorite teams is on the favorable side. Memory versus emotion is a large aspect of neuromarketing; whether it be in sports or general advertisements, marketers are beginning to use these techniques to better understand when and where to advertise.

Electroencephalography (EEG)

This section of review will focus on the background literature related to the neuroanatomy of the brain and literature pertaining to which parts of the brain could be targeted for EEG data gathering in this study. Further review on frontal brain asymmetry along with different functions and characteristics of frequency waves will conclude the section. To begin, a short introduction to the EEG and why this technology is used for this experiment will be discussed. In the EEG Pocket Guide by the Biometric Research Platform, iMotions, they explain "everything you need to know about electroencephalography to boost your insights into brain activity" (iMotions, 2017). No matter whether you are asleep or awake, preparing for work or taking a leisurely stroll around a park, as you think, dream, see and sense, your brain is always active (iMotions, 2017). Even while watching a sport, when we think we are merely relaxing, our mind is fully active and comprehending everything. The brain controls behavioral processing without you even noticing. This is what the EEG will be used for; to understand those deeper emotions that even the study participant might be unaware of as they are viewing the sports broadcasts. The EEG is capable of detecting cortical responses in experimental settings (Rumpf and Breuer 2017). The EEG has a high temporal resolution and can capture even the slightest of changes in the cognitive process. This high temporal resolution is important in order to gather when the viewer began to feel suspense occur. However, since surprise happens at a certain moment, the high temporal resolution will allow the capture of real time changes. It is human nature to make predictions about what will happen next and people can encode regularities and detect violations in what should happen next. According to a study produced by Garrido, Teng, Taylor, Rowe, and Mattingley (2016) neuronal responses to unpredictable events carry a unique prediction error signature and can be reflected in recordings.

Neuroanatomy

In terms of neuroanatomy; behavior and emotion are thought to originate deep in the brain, more specifically in the Limbic System (Wright, 2019). The Limbic System is often referred to as the emotional brain and includes the thalamus, hypothalamus and amygdala; however, the amygdala will be of focus here. According to Anthony Wright, an author for the Neuroscience Online Textbook, the Amygdala is the integrative center for emotions, emotional behavior, and motivation (Wright, 2019). Wright continues on to discuss how the central nucleus of the amygdala produces conscious perception of emotion mainly through the prefrontal cortex (Wright, 2019). The amygdala is so deep in the brain that it is impossible to get true readings of emotions. However, there is a primary pathway connecting the amygdala and the prefrontal cortex; leading to the prefrontal cortex being the best way to get accurate readings of emotions (Wright, 2019). The prefrontal cortex EEG reading can be used as an estimate of generated emotions.

Further support for focusing on the amygdala and the prefrontal cortex can be found in *The Anatomy of the Amygdala* in the textbook *Neuroscience* edited by Purves, Augustine, and Fitzpatrick (2001). These authors state that, "the prefrontal cortical connections of the amygdala give it access to more cognitive neocortical circuits, which integrate the emotional significance of sensory stimuli and guide complex behavior" (Purves at el., 2001). The authors go on to discuss how the amygdala and the prefrontal cortex partake in a triangular circuit linking the two together and this complex interaction leads to direct connection between the amygdala and the prefrontal cortex (Purves at el, 2001). The connection between the amygdala and the prefrontal cortex supports using the prefrontal cortex as the focus for data collection in this study.

For this research, the entire prefrontal cortex power was compared to whole brain power. The methodology section will discuss in greater detail how the experiment took place, however, for further justification of why whole prefrontal cortex power was taken instead of localized parts, an article by Wilson, Gaffan, Browning, and Baxter (2010) will be used. The authors mention how all regions in the prefrontal cortex (PFC) are heavily interconnected and "the localization of function in the PFC is neither straightforward nor consistent" (Wilson, Gaffan, Browning, & Baxter, 2010) This is why this study will take the power of the entire prefrontal cortex. The PFC is heavily interconnected with all divisions, however, the localization of exactly what the subdivisions do is difficult to understand.

The authors also discuss how different demands on memory processing could be linked with activation of different dorsal/ventral levels within the prefrontal cortex. Memory processing is important for recall and recognition. The prefrontal cortex being important for memory processing makes this study, as a stepping stone for future studies, essential in greater understanding of recognition and recall for sports advertisements.

Frequency Waves

The exceedingly complex patterns and traits of the billions of neurons in a person's brain make up a mixture of several underlying wave frequencies. These wave frequencies reflect unique affective and cognitive states. The individual factors of the wave frequencies vary ever so slightly, which is why research classifies them in ranges, better known as frequency bands. The ranges for the frequency bands are defined as theta: 4.0 – 7.9 Hz, alpha: 8.0 -12.9 Hz, beta: 13.0 – 29.9 Hz, gamma: 30.0 – 50.0 Hz (Park, Oh, Jeong, & Sohn, 2013).

Theta: Brain waves between the frequency range of 4.0 – 7.9 Hz are categorized as theta band (Schomer, & Da Silva, 2012). Consistently, studies show that frontal theta activity is correlated with the difficulty of cognitive tasks. For example, theta band is active during focused attention and information acquiring, processing and understanding, and while remembering material. Theta frequency becomes more prevalent during increased difficulty of the task at hand. For this reason, theta band is often times connected with brain processes underlying memory and workload (Klimesch, 1996; O'Keefe,& Burgess, 1999; Klimesch, Schack, & Sauseng, 2005).

Alpha: Brain waves between the frequency range of 8.0 – 12.9 Hz are categorized as alpha band (Schomer, & Da Silva, 2012). Alpha has multiple purposes correlating to sensory, motor, and memory functions. Alpha levels tend to be increased at times of relaxation and eyes closed. On the contrary, alpha can be observed at lower or suppressed levels during physical or mental activity with eyes open. Alpha suppression can be monitored during times of intense focused attention to a particular stimulus; in this case, sports media (Pfurtscheller, & Aranibar, 1977).

Beta: Brain waves between the frequency range of 13.0 – 29.9 Hz are categorized as beta band (Schomer, & Da Silva, 2012). Active thinking and active concentration are generally linked to higher levels of beta. Beta typically gets stronger when we execute bodily movements; however, our brain mimics the movements we see performed by others (Zhang et al., 2008). This is important while the participant for the current study watched the sports media; the subject was not physically moving, however, was watching multiple videos of athletes performing physical movements.

Gamma: Brain waves between the frequency range of 30.0 – 50.0 Hz are categorized as gamma band (Schomer, & Da Silva, 2012). Currently, gamma band can be considered the black box of brain waves, as there is no set traits or characteristics attributed to gamma band and researchers are unclear what generates the gamma frequency and what the frequency reflects. There are researchers arguing that gamma is a binding frequency of various sensory impressions, attributing it with an attentional process. For this study, any gamma frequency found would be in consistent with these researchers' arguments. Other researchers argue that gamma band does not reflect cognitive processing at all and is more affiliated with neural process such as eye-movements (iMotions, 2017). Nevertheless, little is known about how gamma waves may differ in suspenseful/surprising sport viewing conditions.

Frontal Brain Asymmetry

Frontal brain asymmetry can be defined as the differences across hemispheres of the brain linked to emotional processing (Coan & Allen, 2003). Many studies over the last few decades have come to the conclusion that frontal asymmetry is related to approach and withdrawal tendencies. Greater left hemispheric activation is attributed to greater approach feelings, while greater right dominance is related to greater withdrawal tendencies. These traits are also attributable to positive and negative stimuli; greater left hemispheric activation corresponds to positive stimuli, greater right dominance corresponds to greater negative stimuli (Davidson & Fox,1982; Ahern & Schwartz, 1985; Davidson, 1992; Davidson, 1998). Harmon-Jones (2003) links left asymmetry to greater feelings of approach and right asymmetry with greater tendencies to withdrawal, however, does not connect these two with positive and negative feedback. When viewings sports, this correlation is more representative. During a suspenseful game, certain people will be more likely to "approach" and want to watch the game, while others could "withdraw" and not want to watch. This feeling does not correlate with positive and negative, at least in the moments leading up to the event. This example can be backed by Wheeler (1993) whom describes frontal asymmetry as, not to be a casual factor in emotional reactivity, but rather it appears to create vulnerability or a predisposition to react.

Lee, Cho, Lasko, Kim, and Kwon (2020) were, as to the extent of this study's knowledge, the first to relate frontal asymmetry back to sports. They connected sports involvement back to spectator response, however, their research and findings regarding spectators is greatly related to this current study. Findings in their literature associated brain activity during emotional arousal and motivation to effects of goal-directed behavior (Lee et al., 2020). For instance, there is obvious and distinct brain activation when a person is looking at a stimulus they consider interesting, and more attention leads to more brain activity (Zaichkowsky, 2012). As mentioned before, more brain activation leads to greater and more detailed memory and recognition and recall.

Frontal asymmetry is more commonly known as alpha asymmetry because it can be seen in the alpha band. Hall (2000) emphasizes the previous point regarding activity in the brain. Hall (2000) iterates how activity in the alpha band is a reflection of activation; greater alpha activity is related to less activation, while less alpha activity is linked to greater activation. Before this study took place, Ray and Cole (1985) unveiled that beta activity reflects emotional processes, while alpha is linked to attentional demands. Focused attentional and emotions based on the stimuli are considered a state of emotion. Frontal asymmetry can be a measure of state related variation to a particular stimulus, not correlated to a specific person's emotional traits as previous studies inferred (Coan, Allen, & McKnight, 2006).

Summary

Suspense and surprise have long been used in the entertainment industry. These two constructs have been manipulated in order to keep the audience's attention and keep them coming back for more. Suspense and surprise elicit emotional responses that are both conscious and subconscious. However, in the world of sports, the experimental manipulation of suspense and surprise are rather scarce. Attention to a stimulus, ie. sports, has been documented to affect frequency waves to show that greater attention leads to greater activity. Greater activity in the brain leads to better and more accurate and descriptive memory. This accurate memory is a way to test sports viewers on sponsorship and marketing stimuli recall and recognition. Since extensive research involving neurological effects while viewing sports media has yet to be researched, and marketing manipulation in order to capitalize on audience attention is important; then further investigation in this topic should be done to give insight to unanswered questions in this field. Electroencephalography and neuromarketing methods could be the key in unlocking this potential.

CHAPTER 3: METHODOLOGY

Introduction

As mentioned, the purpose of this study is to better understand how sports fans are neurologically affected when watching a game or video that has suspenseful or surprising tendencies. There is substantial literature that explores suspense and surprise in regard to film and written literature, however, EEG measurements when referring to suspense and surprise are very limited. EEG was used as a method for analyzing different areas of cortical activation during sports broadcast viewing due to its high temporal resolution relative to other brain imaging technologies, such as MRI or PET scanners. With this high time precision, this technology was able to measure brain activity during the entire process of showing different sports clips and was, therefore, be able to differentiate brain activity between and within videos. A final reasoning behind the use of the EEG is that this technology is capable of detecting behavior and emotion even though they are subtle (iMotions, 2017). Specifically, whether or not watching a more or less suspenseful or surprising broadcasts give rise to differences in power within the prefrontal cortex relative to the rest of the brain.

This chapter will discuss the study population/sample, instrumentation and measurement protocols, the overall research design, data collection procedures, and data management and analysis. All recruitment and data collection protocols were reviewed and approved by the University of Oklahoma Institutional Review Board for the protection of human subject in research.

Sample

The overall population that this study examined is sports fans. This ranges from casual fans, such as those that only watch highlights or when convenient, to the most diehard fans that watch every sport and every game. The sampling procedure for this study was a non-random convenience sample design. Volunteer participants were self-identified sports fans in the University of Oklahoma community in Norman, Oklahoma; as well as residents of the Oklahoma City, Oklahoma metropolitan area. Participants were at least 18 years of age. A sample size of 35 volunteers was tested for the EEG portion of the study. The a priori sample size was determined using the power analysis software, G*Power (Version 3.1.9.2). This sample size was calculated by using a repeated-measures within F-Test with the following parameters: effect size equaling 0.25 (moderate level), alpha level at 0.05, power at 0.95, and a specification that there were four groups and four conditions. With these being imputed into G*Power, the target sample size is 35 volunteers. The expectation was to recruit up to 50 participants to account for exclusions, no-show participants, and voluntary withdrawals, however data collection was also truncated due to COVID-19 precautions. Data preprocessing through manual rejection of artifact and rejection based on independent components through ICLabel (greater than 15 components removed meant the subject was rejected) rejected 14 participants (See Appendix 1. Cleaned EEG Data; Appendix 2. ICLabel;). This led to a final analysis of 21 subjects.

The recruitment process was based on volunteer solicitation via flyer advertisements, email messaging, and word of mouth. Recruitment flyers were posted around high traffic areas of a large university campus to ensure more people are aware of the study. This process asked for individuals who identify themselves as a sports fan to participate in a study. The screening process for this experiment included being able to read instructions in English and understand the

English language audio of the videos, along with a signature agreeing to the experimental methods as they are outlined in the informed consent document. Finally, subjects needed to be able to transport themselves to and from the laboratory for the time of their scheduled visit. This was a voluntary and convenience sample since the study accepted any person willing and able to participate meeting those criteria. Convenience and voluntary sampling are the simplest forms of non-probability sampling because the study relies on participants wanting to join the study and who are in a convenient location to be tested. Internal validity is priority for experiments. By this study being a volunteer basis, it makes it possible to eliminate alternative explanations to findings; e.g., if an individual is forced to participate, findings could be different due to external factors.

In this study, the participants viewed a random sample of videos that were preselected for their suspense and surprise characteristics. The videos were classified into 4 categories of videos: High Suspense and High Surprise, High Suspense and Low Surprise, Low Suspense and High Surprise, and Low Suspense and Low Surprise. These video categories are the independent variables in this study. Each participant was shown two videos in each category, for a total of eight videos being shown. The sample of videos were selected by the primary investigator for this study based on the criteria of the four categories. The video run-times were between one minute and six minutes. A total of eight videos per category were chosen and two per category were shown to each participant. To determine the two videos that were shown, in each category separately each video is given a number from 1-8 and a random number generator selected the videos in each category that the unique participant watched. This process randomized the videos shown, leading to a more valid identification of the suspense and surprise effects, and reduce the threat of any confounding influence of any one particular film and/or ordering effects.

Instrumentation/Measurement Protocols

All measurements were analyzed, pre-processed, and processed from EEG recordings and cleaned via MathWorks MatLab R2018b. The EEG electrode net was placed on the subjects' head with sensors placed in accordance to the EEG International 10-20 System (Appendix 4. 10/20). The international 10/20 system is a recognized system to describe electrode placement on the scalp. This system is based on the relationship between the electrode location and the area of the cerebral cortex. Due to this system, it can be seen in Appendix 4 where the CZ is located on the net and where it would be placed on the scalp (CZ is known as the main reference electrode). All subjects recorded impedances below 50Kohms. All outcome measurements that were analyzed were in microvolts^2/Hz; these outcomes are the independent variables. Continuous measurement of EEG via 32 electrode EEG cap (HydroCel Geodesic Sensor Net) began four minutes prior to the showing of the first video and ended once the final video was shown. Videos being shown to the participants were imbedded into a Microsoft PowerPoint presentation to allow for seamless transitions between videos. Once the participant was comfortably set up with the EEG cap on, the recording of the EEG began, and a running clock started. Timestamp markers placed during the videos were used in order to keep track of all events that took place during the experiment. The first 4 minutes of the experiment was a resting period. Markers were places for "eyes closed" and "eyes open". The participant sat with their eyes closed for a total of two minutes and eyes open for a total of two minutes for the initial resting period. After the second "eyes open" marker, the first video began. Once any video began, the video type (HH, HL, LH, LL) was tracked as a timestamp. When the video ended, "stop" was marked to indicate the end of the video. Once the video ended. The participant was again asked to close their eyes and "eyes closed" was marked as a timestamp. Following the minute of eyes closed, the participant was asked to open their eyes, and "eyes open" was then recorded as a timestamp. This two-minute process was conducted between each video. While videos were being shown, if the video was a High Surprise clip, an "event" marker was placed in order to determine when the surprising event took place.

Emotional and neurological processes are fast and can occur within tens to hundreds of milliseconds, but the events triggering these processes can last between milliseconds to a few seconds. However, much like a high-speed camera, the EEG captures the neurophysiological changes due to the high time resolution of the technology (iMotion, 2017). With the documented times and events of the videos and time locked fluctuations in the EEG outputs, this allowed for timestamps and event markers to be read and analyzed.

System Technical Details

A 32-electrode water-based EEG was used on every subject. A sampling rate of 1,000Hz was used, with low filter at .5 and high filter at 120. This instrument allows for measurements of the regions we are interested in regarding how they were affected due to suspense and surprise. The subject watched the videos in a private room, with natural office lighting turned off, via a 15-inch HP computer. The primary investigator started, stopped, and tracked EEG data in a separate, attached room via a 32-inch Apple computer. To ensure precise data quality throughout testing, 2 impedance checks were conducted. One after video 3, the second after video 6. These impedance checks ensured the EEG electrodes continued to have proper signal.

Stimuli Classification

Prior to any EEG data collection. 16 non-EEG participants were involved in a Truth by Consensus rating of the videos that were shown to the EEG participants. The volunteers watched

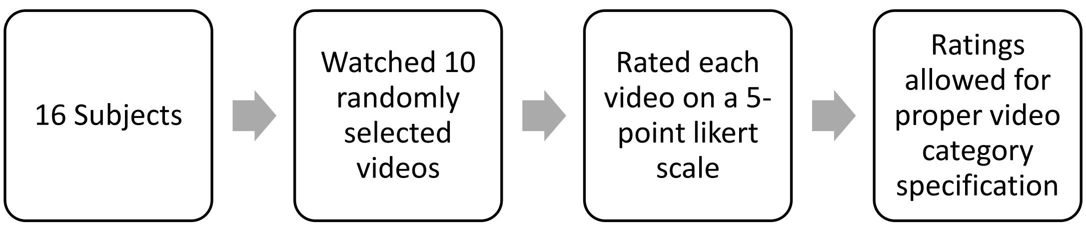
10 videos, a random selection from each category, and rated, on a 1-5 scale, how suspenseful and surprising the video was based on an 8-question questionnaire. This allowed for analysis to determine if the videos were selected to be in the correct categories, and a correlational analysis of whether more suspenseful/surprising videos caused greater power outputs. This questionnaire was created fully by the primary investigator for the purposes of this study. To ensure the questions were effective for their stated aims, a face validity review was conducted with 3 experts in the fields of kinesiology, sport marketing, and neurophysiology.

The Truth by Consensus model simply takes statements to be true based on the fact that the majority of people generally agree upon it. If a majority of the volunteers whom watch a video for this study agree that it fits in the category it is assigned to, the consensus will be that the video can be shown in the EEG portion of the study. All videos included in this study showed consensus classification into their respective categories

Research Design

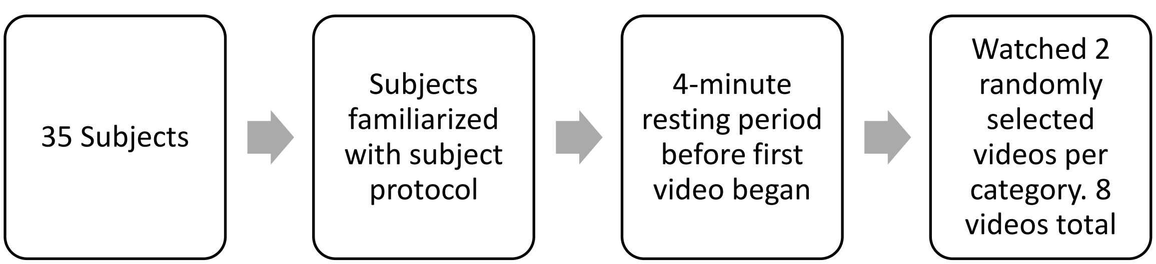
This study is a quasi-experimental design which implements the use of an EEG in order to have more accurate observation of neurophysiological changes in the brain. This study consisted of three stages; a Truth by Consensus method of rating the videos, one screening questionnaire and email, and one laboratory testing session with each participant. The total time of the Truth by Consensus rating was approximately sixty minutes and the testing visit was approximately ninety minutes. No participants overlapped between the Truth by consensus section and the EEG laboratory session. In the video categories, there were four categories and 8 videos per category. For this study, the independent variables are the four video category types and the dependent variables are the measurement outcomes (microvolts^2/Hz).

For the Truth of Consensus ranking procedure, a consent form was signed, then the 16 non-EEG participants were asked to watch a total of 10 videos from the four categories. After viewing each video, the volunteer ranked the videos on a scale of 1-5 based on how suspenseful and surprising the video was. Once the data had been collected, the data provided details whether the videos were correctly assigned to a category or needed to be taken out of the study due to not fitting the category criteria. Once each video had been examined and adjusted into the proper categories, the overall stimuli presentations were prepared for the EEG laboratory participant testing.



EEG participants were first acquainted with the study procedures, then seated in front of a computer screen in a quiet testing room. Once seated and the consent form signed and the study procedure had been explained, the EEG cap placement began. The primary investigator was the experimenter placing the cap on the participant’s head, while an authorized assistant helped. The procedure for cap application began with a statement informing the subject about the process: “I will be placing a 32-electrode water-based EEG cap on your head. This will not hurt and cannot read your thoughts. The cap has been sitting in a mixture of water, a mild soap, and potassium chloride. Please keep your eyes closed until instructed to open them.” Once the cap had been placed and adjusted so the participant was comfortable, the primary investigator, once more, explained how many videos would be shown and explained the impedance checks (indicating to the participant that twice throughout the session, extra water would be placed under the electrodes to ensure proper measures), asked for any questions, and finally started the EEG recording and began with the 4 minute resting period.

Following the 4 minute resting period, the first video began playing on the computer screen in front of the participant. The eight videos shown were in random order with no indication to what category the clip belonged to. Right before the videos began to play, there was an informative PowerPoint slide about the upcoming video. This was to set the tone of the video, so the subject had some context for the video. The subject was given about 30 seconds to read the short informative slide. Videos had audio, so the participant was able to hear the action from the event along with what the commentators have to say. The audio was included because hearing the crowd and the commentators can increase or decrease the level of suspense and surprise, making the broadcast feel more lifelike.



Internal and External Validity Threats

Internal Threats

Interaction effects of selection bias and experimental treatment may have occurred due to participants being recruited based on convenience. Suspense and surprise might have poor readings on an EEG due to boredom and mind-wandering or the volunteer is not comfortable in the testing environment. A longer video or a video of a sport the subject is not interested in could lead to the participant becoming bored and not paying close attention to the screen.

External Threats

Due to non-random sampling the selection of subjects is an internal threat to validity. Many subjects are students at the University of Oklahoma, leading to the subjects not being fully representative of the overall population. Generalizability is, again, a threat to validity due to the sample being made up of sports fans. Therefore, cannot be generalized to a broader market.

Minimization of Threats

Instrumentation is always a possible threat to internal validity, however, no adjustments or changes to the measurement tools will be made during the study. All subjects used the same set of EEG caps, stimuli presentation hardware, and laboratory setting. This eliminated some threats to instrumentation validity. The study consisted of one meeting for each participant, so the internal threat of experimental mortality was minimal due to this. Only subjects with complete sessions were included in the analysis. All participants whom volunteered fully finished their laboratory session, indicating no subjects withdrew during the testing process.

Data Collection Procedures

Data collection approval was obtained through the Institutional Review Board (IRB) at the University of Oklahoma Norman Campus on January 16, 2020. The primary investigator conducted all subject testing and data collection procedures.

The data collected from participant included EEG frequencies (continuous), and questionnaire responses (discrete). The EEG participants filled out the same 8-question questionnaire for the last video they watched, as the non-EEG participants used in the Truth-by-Consensus method.

A checklist was established for subject screening and testing and is included in the appendix. All paperwork signed by the participant, including the agreement of the methods and procedure sheet and instructions sheet, are in the appendix. The rating scale that the 20 volunteers used prior to the EEG testing is included in appendix 9

Data Management and Analysis

Once data collection was finished, all data was imputed into the Statistical Package for Social Sciences (SPSS Version 24) and MathWorks MatLab (Update 2) and were cleaned and prepared for analysis. Analysis of EEG determined which regions of the brain were activated during different states or mental tasks, which helps with localization to determine which part of the brain is functioning while, in this case, watching a sports broadcast (Ibanez, 2015). Measurements taken from the EEG recordings are averaged data over the entire length of the video. Both videos in each of the four video types that the subject watched were averaged together as well; this allowed for an analysis for the video category as a whole, instead of on an individual video basis. Due to manual processing and coded processing, many artifacts, including, subject movement, eye movement, muscle movement blinks, and heartbeat were all filtered from the raw data. The usable data was then averaged together. This data was used for analysis. The values from the signal processing are non-normalized raw microvolts.

Statistical Tests and Appropriateness

Each of the four research questions have multiple hypotheses along with it. For research question 1 and 2, since the analysis was based on comparing the differences across multiple measurements on individual subjects and across the different film-type groups, a repeated measure within F-Test was used for testing hypotheses 1-6. Research Question 3 and 4 use a paired sample t-test to understand differences between the levels of suspense and surprise in "rest of brain" and prefrontal cortex, as well as differences across hemispheres of the brain. Bonferroni corrected post hoc comparisons were conducted to compare film types and pairwise differences. Frequency bands were used in accordance with video type to allow for further conclusions of how suspense and surprise affected the sports viewer's brain. Signal processing was used in order to gather the specific frequency bands. More specifically, Fourier Transform was conducted in order to decompose the overall brain wave to gather and analyze the individual frequency waves. The values from the signal processing are non-normalized raw microvolts.

Conclusion

This is a quasi-experimental design, using EEG frequencies along with a Truth by Consensus rating scale. Subjects were volunteers from the University of Oklahoma, Norman, and Oklahoma City areas that consider themselves sports fans. Recruitment was based on a volunteer basis using word-of-mouth, and mass email. This study aimed to examine if there were any differences in brain activity while watching a sports broadcast due to suspense and surprise.

Further in-depth frequency band analysis based on the categories of video helped expand upon possible conclusions of the data.

CHAPTER 4: RESULTS

The results section will consist of a description of the subject characteristics and the Truth-of-consensus findings, followed by the analysis and results for each individual research question, as well as extra analysis conducted to provide further detail. Subject characteristics include descriptive statistics for the subjects whom were included in both the Truth-of-Consensus portion of the study and the EEG experiment portion. Frequency results portray the analysis of EEG activity (power) in just the EEG experiment portion of the study. All EEG activity is measured in units of Microvolts^2.

Subject Characteristics

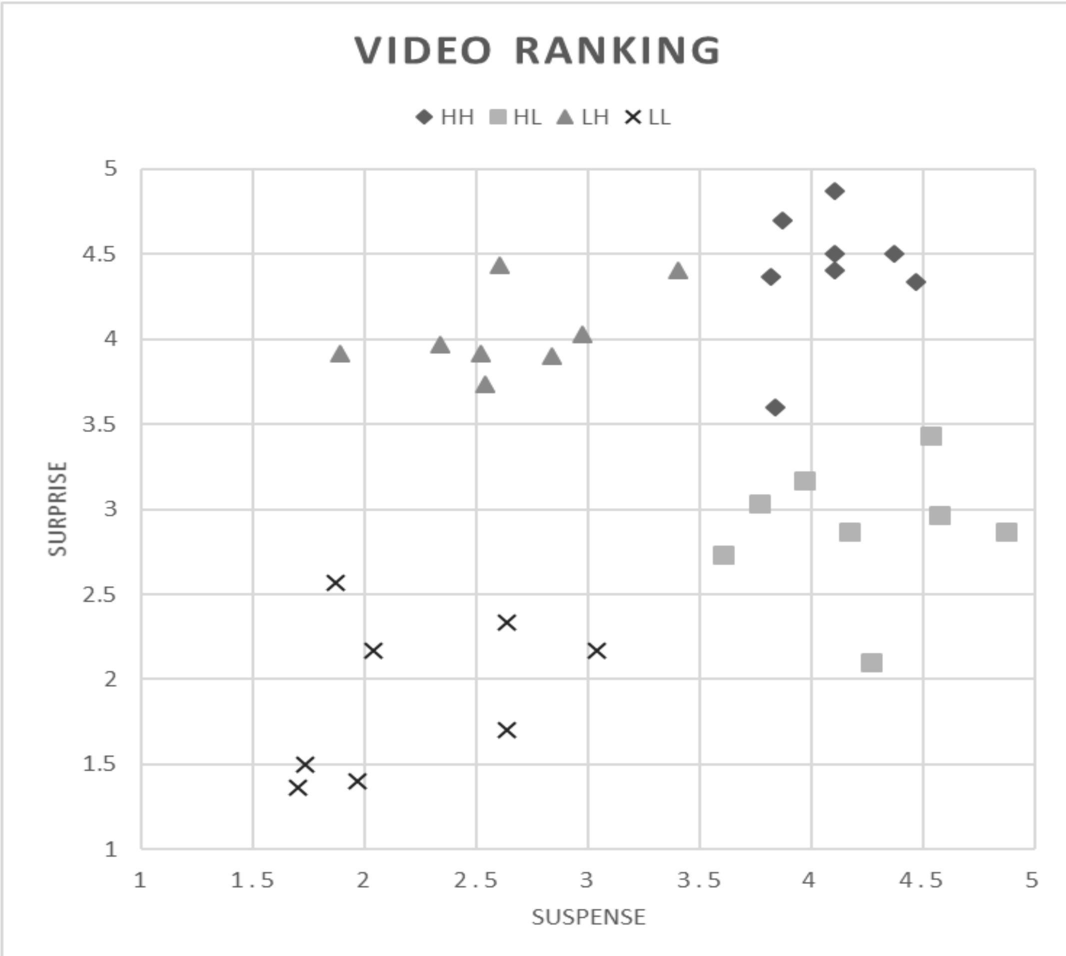
For the Truth-of-Consensus portion of the study, 16 participants voluntarily took part in watching a random selection of videos in order to give a, in literal terms, consensus of what rating is true for each video. The average age of the 16 participants was 24. 6 years old, and the sex differences were 8 males/8 females.

For the EEG experiment portion of the study 35 subjects volunteered to have an EEG cap placed on their head while they watched 8 different sport videos. The average age for the 35 subjects whom were involved in the study was 22.7 years and the sex differences were 24 males/11 females. However, after data preprocessing and processing, only 21 subjects were included in the data analysis. Out of these 21 subjects, 12 were male and 9 were female; the average age slightly dropped to 21.8 years. There were no overlap in participants in the two sections (truth by consensus and EEG experiment).

Truth-of-Consensus Findings

The Truth-of-Consensus portion of the study was to ensure that all videos chosen by the primary investigator were properly placed in its correct category. If a video did not meet the qualifications to be in the selected group, the video would have been erased from the study. Sixteen people participated in this portion of the test, each watching 10 videos. All 32 videos selected and placed in a category by the primary investigator were confirmed to be in the correct category by consensus of the group or participants. The scale used was on a 5-point likert scale; to be classified as “High” for a category, the average of everyone’s rankings needed to be above 3.5, and to be categorized as “low”, the average of everyone’s rankings needed to be below 3.5. For example, a video in the category Low High needed a suspense ranking of below 3.5 and a surprise ranking of above 3.5. Figure one shows how the videos fit into each category.

Figure 1: Video Rank Scatter Plot



Descriptive statistics

Table 1: Table Overview, represents the mean and standard deviations of frequency and video category outcomes across multiple different tables that are discussed in this chapter. Table 2 represents whole brain data, table 3 represents prefrontal cortex data, table 4 holds "rest of brain" vs prefrontal cortex data (however, in this table, prefrontal cortex is not shown twice), and table 5 portrays asymmetry between the left and the right hemispheres in the brain. Table 5 is broken into two parts in Table 1 to represent the two hemisphere's data. The reason for this table

is for a single table to hold all mean and standard deviation data in order to make referencing and comparing numbers in a specific grouping easier for the reader.

Table 1: Table Overview

	HH	HL	LH	LL
Whole Brain	Mean ± Standard Deviation			
Theta	0.67 ± 0.22	0.63 ± 0.20	0.67 ± 0.26	0.66 ± 0.22
Alpha	0.59 ± 0.44	0.64 ± 0.51	0.62 ± 0.51	0.61 ± 0.43
Beta	0.16 ± 0.07	0.16 ± 0.08	0.16 ± 0.09	0.17 ± 0.09
Gamma	0.05 ± 0.02	0.05 ± 0.02	0.05 ± 0.02	0.05 ± 0.03
Prefrontal Cortex				
Theta	0.51 ± 0.22	0.50 ± 0.21	0.53 ± 0.26	0.54 ± 0.24
Alpha	0.40 ± 0.24	0.48 ± 0.36	0.44 ± 0.33	0.45 ± 0.32
Beta	0.14 ± 0.08	0.15 ± 0.09	0.14 ± 0.09	0.14 ± 0.10
Gamma	0.05 ± 0.03	0.05 ± 0.03	0.04 ± 0.03	0.04 ± 0.03
"Rest of Brain"				
Theta	0.69 ± 0.22	0.65 ± 0.21	0.69 ± 0.27	0.68 ± 0.22
Alpha	0.62 ± 0.47	0.67 ± 0.54	0.64 ± 0.53	0.64 ± 0.45
Beta	0.16 ± 0.07	0.16 ± 0.08	0.16 ± 0.08	0.17 ± 0.09
Gamma	0.05 ± 0.02	0.05 ± 0.03	0.05 ± 0.02	0.05 ± 0.03
Asymmetry Left				
Theta	0.50 ± 0.25	0.40 ± 0.25	0.13 ± 0.09	0.04 ± 0.04
Alpha	0.50 ± 0.26	0.50 ± 0.09	0.14 ± 0.09	0.05 ± 0.04
Beta	0.53 ± 0.31	0.40 ± 0.31	0.13 ± 0.09	0.04 ± 0.03
Gamma	0.56 ± 0.30	0.43 ± 0.30	0.13 ± 0.09	0.03 ± 0.03
Asymmetry Right				
Theta	0.50 ± 0.21	0.39 ± 0.27	0.14 ± 0.09	0.05 ± 0.04
Alpha	0.47 ± 0.21	0.45 ± 0.12	0.15 ± 0.12	0.04 ± 0.03
Beta	0.50 ± 0.24	0.43 ± 0.36	0.14 ± 0.10	0.04 ± 0.04
Gamma	0.50 ± 0.22	0.43 ± 0.34	0.14 ± 0.11	0.04 ±0.04

- Measures in microvolts^2

RQ1: Whole Brain Electrocortical Activity

For Research Question 1, "*Does whole brain electrocortical activity vary due to level of suspense and surprise presented in the media content?",* a repeated measures ANOVA was conducted. A repeated measures ANOVA was conducted after a test of normality resulted in more than half of the measures being normally distributed according to the Shapiro-Wilk test. In this study, whole brain measurements are all 32 electrodes on the EEG. The results of this test can be seen in Table 2. To answer RQ1 and test hypothesis 1, 2, and 3, data was categorized into the four category types along with the four frequency bands being tested (Theta Ɵ, Alpha α, Beta β, and Gamma γ). To measure whether there is a difference between videos, we had to look within frequency bands. Meaning, analysis was conducted with each frequency band against each category type. In Table 2, it can be seen that the frequency bands are on the far left, then moving inward to the suspense and surprise categorization allows for the comparison to baseline. Baseline is considered the Low Low category; this is because for this individual study, we wanted to understand activity in the brain while watching sports, hence why baseline is still while watching sports and not while resting. Low Low videos still show the mean theta frequency plus/minus the standard deviation, just to represent differences within the same video type. Analyzing baseline (Low Low) to the three other category types (High High, High Low, and Low High) allows for proper examination of the 3 research questions. The hypotheses (1, 2, and 3) that correlate with RQ1 are described below.

Hypothesis 1: "There will be a significant difference from baseline in whole brain activity while viewing a High Suspense and High Surprise video." To analyze whether there is a significant difference in whole brain electrocortical activity between baseline and High High videos, each frequency band was used to compare the video types. Using Table 2 as a guide, it can be seen that theta(θ) Low Low compared to theta(θ) High High was not significant (p = 1.00), alpha(α) Low Low compared to alpha(α) High High was not significant (p = 1.00), beta (β) Low Low compared to beta (β) High High was not significant (p = 1.00), and finally, gamma (γ) Low Low compared to gamma (γ) High High was not significant (p = 1.00). Although, significance level is most likely not exactly 1.00, this could be due to a statistical software program, the data is almost perfectly described by the other category, indicating we reject Hypothesis 1, accept Null Hypothesis 1, and conclude there is no significant difference between baseline and the High High video category in whole brain activity.

Hypothesis 2: "There will be a significant difference from baseline in whole brain activity while viewing a High Suspense and Low Surprise video." To analyze whether there is a significant difference in whole brain electrocortical activity between baseline and High Low videos, each frequency band was used to compare the video types. Using Table 2 as a guide, it can be seen that theta(θ) Low Low compared to theta(θ) High Low was not significant (p = 0.51), alpha(α) Low Low compared to alpha(α) High Low was not significant (p = 1.00), beta (β) Low Low compared to beta (β) High Low was not significant (p = 1.00), and finally, gamma (γ) Low Low compared to gamma (γ) High Low was not significant (p = 1.00). Although, significance level is most likely not exactly 1.00, this could be due to a statistical software program, the data is almost perfectly described by the other category, indicating we reject Hypothesis 2, accept Null Hypothesis 1, and conclude there is no significant difference between baseline and the High Low video category in whole brain activity.

Hypothesis 3: "There will be a significant difference from baseline in whole brain activity while viewing a High Suspense and Low Surprise video." To analyze whether there is a significant difference in whole brain electrocortical activity between baseline and Low High videos, each frequency band was used to compare the video types. Using Table 2 as a guide, it can be seen that theta(θ) Low Low compared to theta(θ) Low High was not significant (p = 0.51), alpha(α) Low Low compared to alpha(α) Low High was not significant (p = 1.00), beta (β) Low Low compared to beta (β) Low High was not significant (*p* = 1.00), and finally, gamma (γ) Low Low compared to gamma (γ)Low High was not significant (*p* = 1.00). Although, significance level is most likely not exactly 1.00, this could be due to a statistical software program, the data is almost perfectly described by the other category, indicating we reject Hypothesis 3, accept Null Hypothesis 1, and conclude there is no significant difference between baseline and the Low High video category in whole brain activity.

Table 2: Whole Brain ANOVA

Brain wave	**Suspense**	**Surprise**	**Microvolt² (μV^2)**	**Mean Difference**	**Std. Error**	***p* value**
Theta (Ѳ) (F= 203.68 P = <0.00)	Low Low	High High	0.67 ± 0.22	-0.01	0.03	1.00
		High Low	0.63 ± 0.20	0.03	0.02	0.51
		Low High	0.67 ± 0.26	-0.01	0.03	1.00
		Low Low	0.66 ± 0.22			
Alpha (α) (F= 38.53 P = <0.00)	Low Low	High High	0.59 ± 0.44	0.02	0.05	1.00
		High Low	0.64 ± 0.51	-0.03	0.03	1.00
		Low High	0.62 ± 0.51	-0.01	0.04	1.00
		Low Low	0.61 ± 0.43			
Beta (β) (F= 87.78 P = <0.00)	Low Low	High High	0.16 ± 0.07	0.00	0.01	1.00
		High Low	0.16 ± 0.08	0.00	0.01	1.00
		Low High	0.16 ± 0.09	0.00	0.00	1.00
		Low Low	0.17 ± 0.09			
Gamma (γ) (F=121.20 P = <0.00)	Low Low	High High	0.05 ± 0.02	0.00	0.00	1.00
		High Low	0.05 ± 0.02	0.00	0.00	1.00
		Low High	0.05 ± 0.02	0.00	0.00	1.00
		Low Low	0.05 ± 0.03			

RQ2: Prefrontal Cortex Electrocortical Activity

For Research Question 2, "*Does prefrontal cortex electrocortical activity vary due to level of suspense and surprise presented in the media content?",* a repeated measures ANOVA was conducted. A repeated measures ANOVA was conducted after a test of normality resulted in some measures being normally distributed according to the Shapiro-Wilk test. Although, the results of the Shapiro-Wilk test indicated many non-normally distributed factors, a repeated measures ANOVA was still conducted. This, potentially, led to limitations in the data. Prefrontal cortex is considered, according to the 10/20 system, electrodes F3, F4, F7, and F8 (see Appendix 4). The results of this test can be seen in Table 3. Similar to RQ1, to answer RQ2 and test hypothesis 4, 5, and 6, data was categorized into the four category types along with the four frequency bands being tested (Theta ϴ, Alpha α, Beta β, and Gamma γ). For this reason, Table 3, is set up just like Table 2. However, RQ2 analyzes prefrontal cortex electrocortical activity, rather than whole brain. The hypotheses (4, 5, and 6) that correlate with RQ2 are described below.

Hypothesis 4: "There will be a significant difference from baseline in prefrontal cortex brain activity while viewing a High Suspense and High Surprise video." To analyze whether there is a significant difference in prefrontal cortex electrocortical activity between baseline and High High videos, each frequency band was used to compare the video types. Using Table 3 as a guide, it can be seen that theta(θ) Low Low compared to theta(θ) High High was not significant (p = 1.00), alpha(α) Low Low compared to alpha(α) High High was not significant (p = 0.22), beta (β) Low Low compared to beta (β) High High was not significant (p = 1.00), and finally, gamma (γ) Low Low compared to gamma (γ) High High was not significant (p = 1.00). Although, significance level is most likely not exactly 1.00, this could be due to a statistical software program, the data is almost perfectly described by the other category, indicating we reject Hypothesis 4, accept Null Hypothesis 2, and conclude there is no significant difference between baseline and the High High video category in prefrontal cortex brain activity.

Hypothesis 5: "There will be a significant difference from baseline in prefrontal cortex brain activity while viewing a High Suspense and Low Surprise video." To analyze whether there is a significant difference in prefrontal cortex electrocortical activity between baseline and High Low videos, each frequency band was used to compare the video types. Using Table 3 as a guide, it can be seen that theta(θ) Low Low compared to theta(θ) High Low was not significant ($p = 0.83$), alpha(α) Low Low compared to alpha(α) High Low was not significant ($p = 1.00$), beta (β) Low Low compared to beta (β) High Low was not significant ($p = 1.00$), and finally, gamma (γ) Low Low compared to gamma (γ) High Low was not significant ($p = 1.00$). Although, significance level is most likely not exactly 1.00, this could be due to a statistical software program, the data is almost perfectly described by the other category, indicating we reject Hypothesis 5, accept Null Hypothesis 2, and conclude there is no significant difference between baseline and the High Low video category in prefrontal cortex brain activity.

Hypothesis 6: "There will be a significant difference from baseline in prefrontal cortex brain activity while viewing a Low Suspense and High Surprise video." To analyze whether there is a significant difference in prefrontal cortex electrocortical activity between baseline and Low High videos, each frequency band was used to compare the video types. Using Table 3 as a guide, it can be seen that theta(θ) Low Low compared to theta(θ) Low High was not significant ($p = 1.00$), alpha(α) Low Low compared to alpha(α) Low High was not significant ($p = 1.00$), beta (β) Low Low compared to beta (β) Low High was not significant ($p = 1.00$), and finally, gamma (γ) Low Low compared to gamma (γ) Low High was not significant (p = 1.00). Although, significance level is most likely not exactly 1.00, this could be due to a statistical software program, the data is almost perfectly described by the other category, indicating we reject Hypothesis 6, accept Null Hypothesis 2, and conclude there is no significant difference between baseline and the High Low video category in prefrontal cortex brain activity.

Table 3: Prefrontal Cortex ANOVA

Brain wave	**Suspense Surprise**		**Microvolt² (μV^2)**	**Mean Difference**	**Std. Error**	***p* value**
Theta (ϴ) (F= 117.62 P = <0.00)	Low Low	High High	0.51 ± 0.22	0.03	0.02	1.00
		High Low	0.50 ± 0.21	0.04	0.03	0.83
		Low High	0.53 ± 0.26	0.01	0.03	1.00
		Low Low	0.54 ± 0.24			
Alpha (α) (F= 45.68 P = <0.00)	Low Low	High High	0.40 ± 0.24	0.05	0.02	0.22
		High Low	0.48 ± 0.36	-0.03	0.03	1.00
		Low High	0.44 ± 0.33	0.02	0.03	1.00
		Low Low	0.45 ± 0.32			
Beta (β) (F= 55.26 P = <0.00)	Low Low	High High	0.14 ± 0.08	0.00	0.01	1.00
		High Low	0.15 ± 0.09	-0.01	0.01	1.00
		Low High	0.14 ± 0.09	0.01	0.01	1.00
		Low Low	0.14 ± 0.10			
Gamma (γ) (F= 54.49 P = <0.00)	Low Low	High High	0.05 ± 0.03	0.00	0.01	1.00
		High Low	0.05 ± 0.03	-0.01	0.00	1.00
		Low High	0.04 ± 0.03	0.00	0.00	1.00
		Low Low	0.04 ± 0.03			

RQ3: “Rest of Brain” vs Prefrontal Cortex

For Research Question 3, “*Does mean “rest of brain” electrocortical activity differ from mean prefrontal cortex electrocortical activity due to level of suspense and surprise presented in the media content?*” a paired sample t-test was conducted. According to the Shapiro-Wilk test, data was normally distributed. “Rest of brain”, for this study, are all electrodes on the EEG net minus prefrontal cortex (electrodes F3, F4, F7, and F8). The paired sample test matched up frequency wave and video category pairs in “rest of brain” and prefrontal cortex. For example, “rest of brain” HH theta(θ) would be paired with prefrontal cortex HH theta(θ), “rest of brain” HH alpha(α) would be paired with prefrontal cortex HH alpha(α), and this is done for each frequency wave and category type. Table 4 is set up similar to Tables 2 and 3, the main difference is Table 4 gives the mean Micrvolt squared for both “rest of brain” and for prefrontal cortex and that Table 4 is not comparing all video types to baseline (Low Low). This allows visual reference for the mean difference. Research question 3 aimed to show the differences in electrocortical brain activity between prefrontal cortex and the rest of the brain. The hypotheses (7, 8, and 9) that correlate with RQ3 are described below.

Hypothesis 7: “There will be a significant difference between “rest of brain” and prefrontal cortex brain activity while viewing a High Suspense and High Surprise video.” To analyze whether there is a significant difference between “rest of brain” and prefrontal cortex electrocortical activity, each frequency band and video type were used to compare the matching pairs. Using Table 4 as a guide, it can be seen that theta(θ) High High was significant (p = <0.01), alpha(α) High High was significant (p = <0.01), beta (β) High High was significant (p =

0.03), and finally, gamma (γ) High High was not significant (p = 0.33). Three frequency bands were significant, theta(θ), alpha(α), and beta (β)were all below the alpha level of .05, indicating we reject Null Hypothesis 3, and accept Hypothesis 7, and conclude there is significant difference between “rest of brain” and prefrontal cortex brain activity while viewing sports media with suspense and surprise level of High High.

Hypothesis 8: “There will be a significant difference between “rest of brain” and prefrontal cortex brain activity while viewing a High Suspense and Low Surprise video.” To analyze whether there is a significant difference between “rest of brain” and prefrontal cortex electrocortical activity, each frequency band and video type were used to compare the matching pairs. Using Table 4 as a guide, it can be seen that theta(θ) High Low was significant (p = <0.01), alpha(α) High Low was significant (p = <0.01), beta (β) High Low was not significant (p = 0.41), and finally, gamma (γ) High Low was not significant (p = 0.60). Two frequency bands were significant, theta(θ) and alpha(α)were both below the alpha level of .05, indicating we reject Null Hypothesis 3, and accept Hypothesis 8, and conclude there is significant difference between “rest of brain” and prefrontal cortex brain activity while viewing sports media with suspense and surprise level of High Low.

Hypothesis 9: “There will be a significant difference between “rest of brain” and prefrontal cortex brain activity while viewing a Low Suspense and High Surprise video.” To analyze whether there is a significant difference between “rest of brain” and prefrontal cortex electrocortical activity, each frequency band and video type were used to compare the matching pairs. Using Table 4 as a guide, it can be seen that theta(θ) Low High was significant (p = <0.01), alpha(α) Low High was not significant (p = <0.01), beta (β) Low High was significant (p

= 0.03), and finally, gamma (γ) Low High was significant ($p = 0.43$). Although, not every frequency band is significant, theta(θ), alpha(α), and beta (β) were all below the alpha level of .05, indicating we reject Null Hypothesis 3, and accept Hypothesis 9, and conclude there is significant difference between "rest of brain" and prefrontal cortex brain activity while viewing sports media with suspense and surprise level of Low High.

Hypothesis 10: "There will be a significant difference between "rest of brain" and prefrontal cortex brain activity while viewing a Low Suspense and Low Surprise video." To analyze whether there is a significant difference between "rest of brain" and prefrontal cortex electrocortical activity, each frequency band and video type were used to compare the matching pairs. Using Table 4 as a guide, it can be seen that theta(θ) Low Low was not significant ($p = <0.01$), alpha(α) Low Low was not significant ($p = <0.01$), beta (β) Low Low was not significant ($p = 0.02$), and finally, gamma (γ) Low Low was not significant ($p = 0.28$). Theta(θ), alpha(α), and beta (β) were, again, significant below the alpha level of 0.05, indicating we reject Null Hypothesis 3, and accept Hypothesis 10, and conclude there is significant difference between "rest of brain" and prefrontal cortex brain activity while viewing sports media with suspense and surprise level of Low Low.

Table 4: “Rest of Brain” vs Prefrontal Cortex Paired T-Test

Brain wave	Suspense Surprise	Mean "Rest of Brain" (μV^2)	Mean Prefrontal Cortex (μV^2)	Mean Difference	*p* value
Theta (ϴ)	High High	0.69 ± 0.22	0.51 ± 0.22	0.19	0.00
	High Low	0.65 ± 0.21	0.50 ± 0.21	0.15	0.00
	Low High	0.69 ± 0.27	0.53 ± 0.26	0.16	0.00
	Low Low	0.68 ± 0.22	0.54 ± 0.24	0.14	0.00
Alpha (α)	High High	0.62 ± 0.47	0.40 ± 0.24	0.22	0.00
	High Low	0.67 ± 0.54	0.48 ± 0.36	0.19	0.01
	Low High	0.64 ± 0.53	0.44 ± 0.33	0.20	0.00
	Low Low	0.64 ± 0.45	0.45 ± 0.32	0.19	0.00
Beta (β)	High High	0.16 ± 0.07	0.14 ± 0.08	0.02	0.03
	High Low	0.16 ± 0.08	0.15 ± 0.09	0.01	0.41
	Low High	0.16 ± 0.08	0.14 ± 0.09	0.02	0.03
	Low Low	0.17 ± 0.09	0.14 ± 0.10	0.03	0.02
Gamma (γ)	High High	0.05 ± 0.02	0.05 ± 0.03	0.00	0.33
	High Low	0.05 ± 0.03	0.05 ± 0.03	0.00	0.60
	Low High	0.05 ± 0.02	0.04 ± 0.03	0.01	0.43
	Low Low	0.05 ± 0.03	0.04 ± 0.03	0.01	0.28

RQ4: Frontal Asymmetry

For Research Question 4, “*Is there frontal EEG asymmetry in the prefrontal cortex due to level of suspense and surprise presented in the media content?”* a paired sample t-test was conducted. According to the Shapiro-Wilk test, data was normally distributed. For this study, left brain is considered electrodes F3 and F7, and right brain is electrodes F4 and F8 (see appendix 4). The paired sample test matched up frequency wave and video category pairs in the left and the right hemispheres of the prefrontal cortex. For example, left HH theta(θ) would be paired with right HH theta(θ), left HH alpha(α) would be paired with right HH alpha(α), and this is done for each frequency wave and category type. Table 5 is set up the exact same as Table 4 besides the mean difference scores are now according to RQ4.

Hypothesis 11: "There will be a significant difference between the left hemisphere and the right hemisphere in the prefrontal cortex while viewing a High Suspense and High Surprise video." To analyze whether there is a significant difference between the left and right hemispheres in the prefrontal cortex, each frequency band and video type were used to compare the matching pairs. Using Table 5 as a guide, it can be seen that theta(θ) High High was not significant (p = 0.94), alpha(α) High High was not significant (p = 0.46), beta (β) High High was not significant (p = 0.47), and finally, gamma (γ) High High was not significant (p = 0.19). Not a single frequency band is significant below the alpha level of .05, indicating we accept Null Hypothesis 4, and reject Hypothesis 11, and conclude there is no significant difference between left and right hemisphere activity in the prefrontal cortex while viewing sports media with suspense and surprise level of High High.

Hypothesis 12: "There will be a significant difference between the left hemisphere and the right hemisphere in the prefrontal cortex while viewing a High Suspense and Low Surprise video." To analyze whether there is a significant difference between the left and right hemispheres in the prefrontal cortex, each frequency band and video type were used to compare the matching pairs. Using Table 5 as a guide, it can be seen that theta(θ) High Low was not significant (*p* = 0.61), alpha(α) High Low was not significant (*p* = 0.27), beta (β) High Low was not significant (*p* = 0.25), and finally, gamma (γ) High Low was not significant (*p* = 0.90). Not a single frequency band is significant below the alpha level of 0.05, indicating we accept Null Hypothesis 4, and reject Hypothesis 12, and conclude there is no significant difference between left and right hemisphere activity in the prefrontal cortex while viewing sports media with suspense and surprise level of High Low.

Hypothesis 13: "There will be a significant difference between the left hemisphere and the right hemisphere in the prefrontal cortex while viewing a Low Suspense and High Surprise video." To analyze whether there is a significant difference between the left and right hemispheres in the prefrontal cortex, each frequency band and video type were used to compare the matching pairs. Using Table 5 as a guide, it can be seen that theta(θ) Low High was not significant (*p* = 0.54), alpha(α) Low High was not significant (*p* = 0.78), beta (β) Low High was not significant (*p* = 0.19), and finally, gamma (γ) Low High was not significant (*p* = 0.44). Not a single frequency band is significant below the alpha level of .05, indicating we accept Null Hypothesis 4, and reject Hypothesis 13, and conclude there is no significant difference between left and right hemisphere activity in the prefrontal cortex while viewing sports media with suspense and surprise level of Low High.

Hypothesis 14: "There will be a significant difference between the left hemisphere and the right hemisphere in the prefrontal cortex while viewing a Low Suspense and Low Surprise video." To analyze whether there is a significant difference between the left and right hemispheres in the prefrontal cortex, each frequency band and video type were used to compare the matching pairs. Using Table 5 as a guide, it can be seen that theta(θ) Low Low was not significant (p = 0.89), alpha(α) Low Low was not significant (p = 0.96), beta (β) Low Low was not significant (p = 0.51), and finally, gamma (γ) Low Low was not significant (p = 0.43). Not a single frequency band is significant below the alpha level of .05, indicating we accept Null Hypothesis 4, and reject Hypothesis 14, and conclude there is no significant difference between left and right hemisphere activity in the prefrontal cortex while viewing sports media with suspense and surprise level of Low Low.

Table 5: Frontal EEG Asymmetry Paired Sample T-Test

Brain wave	**Suspense Surprise**	**Mean Left Prefrontal Cortex (μV^2)**	**Mean Right Prefrontal Cortex (μV^2)**	**Mean Difference**	***p* value**
Theta (Θ)	High High	0.50 ± 0.25	0.50 ± 0.21	0.00	0.94
	High Low	0.40 ± 0.25	0.39 ± 0.27	0.01	0.61
	Low High	0.13 ± 0.09	0.14 ± 0.09	-0.01	0.53
	Low Low	0.04 ± 0.04	0.05 ± 0.04	0.00	0.89
Alpha (α)	High High	0.50 ± 0.26	0.47 ± 0.21	0.03	0.46
	High Low	0.50 ± 0.09	0.45 ± 0.12	0.05	0.27
	Low High	0.14 ± 0.09	0.15 ± 0.12	-0.01	0.78
	Low Low	0.05 ± 0.04	0.04 ± 0.03	0.00	0.96
Beta (β)	High High	0.53 ± 0.31	0.50 ± 0.24	0.03	0.47
	High Low	0.40 ± 0.31	0.43 ± 0.36	-0.03	0.25
	Low High	0.13 ± 0.09	0.14 ± 0.10	-0.02	0.19
	Low Low	0.04 ± 0.03	0.04 ± 0.04	-0.01	0.51
Gamma (γ)	High High	0.56 ± 0.30	0.50 ± 0.22	0.05	0.19
	High Low	0.43 ± 0.30	0.43 ± 0.34	0.00	0.90
	Low High	0.13 ± 0.09	0.14 ± 0.11	-0.01	0.44
	Low Low	0.03 ± 0.03	0.04 ±v0.04	0.00	0.43

Other Findings

One last result, although not a part of a research question, that was conducted and analyzed was the rankings from the Truth-of-Consensus scale against each pair of category videos that the participant watched. This result is very similar to RQ1, in that we are analyzing whole brain affects against video categories. However, for this analysis, a continuous measure is used in place of the categorical data, as well as a correlation being ran instead of an ANOVA. Instead of comparing Theta, Alpha, Beta, and Gamma power output scores to the categorical video identities (HH, HL, LH, LL), a correlation was conducted against the true score of the participants videos to the wave frequency output scores. To find the "true score", the videos in each category that an individual watched were averaged with the TOC scale scores; an average was taken for both HH, both HL, both LH, and both LL videos the participant watched. For example, if participant 1 watched videos 2 and 4 (every video had a number assigned), the videos suspense and surprise scores would be averaged, so this participant would have a TOC score for suspense of, hypothetically, 4.3, and a hypothetical surprise score of 3.98. These scores were then correlated against the frequency wave scores. Table 6 shows the results.

Table 6: Truth-of-Consensus vs Whole Brain Correlation

Brain wave		**Correlation**	***p* value**
Theta (Θ)	**Suspense**	-0.02	0.82
	Surprise	-0.02	0.61
Alpha (α)	**Suspense**	0.00	1.00
	Surprise	-0.04	0.71
Beta (β)	**Suspense**	-0.05	0.65
	Surprise	-0.07	0.53

Gamma (γ)	**Suspense**	0.01	0.90
	Surprise	0.00	0.98

As can be seen from the correlation table, there was not a significant p value score below 0.05. This indicates that comparing the specific TOC scores to whole brain wave frequencies did not cause any video type to show higher electrocortical brain activation than any other category. A continuous score of the TOC results and the categorical comparison from RQ1 were both shown to be insignificant when viewing changes in brain activity due to level of suspense and surprise.

CHAPTER 5: DISCUSSION AND CONCLUSION

The purpose of this study was to apply EEG to sports media content viewing to determine if there were significant differences in different parts of the brain depending on the level of suspense and surprise being shown. There were multiple research questions and hypotheses to go along with each research question. It was hypothesized that, when compared to baseline (Low Low) videos, there would be a significant difference of increased brain activation in each category depending on the level of suspense and surprise; this hypothesis was implemented for both whole brain and prefrontal cortex. Due to findings from Purves et al. (2001), arguing that the prefrontal cortex is the direct link to the amygdala, and findings from Wright (2019) stating that the amygdala is regarded to be the integrative center for emotions, it was hypothesized that prefrontal cortex and "rest of brain" cortical activity would differ from each other while watching sports media content of varying leveling of suspense and surprise. Lastly, frontal asymmetry being defined as the differences across hemispheres of the brain linked with emotional processing led to the final research questions and hypotheses that there would be a significant difference between left and right hemisphere due to the varying levels of suspense and surprise (Coan & Allen, 2003).

This chapter discusses the findings on the prevalence of varying levels of suspense and surprise regarding whole brain and prefrontal cortex, findings of prefrontal cortex compared to the rest of the brain, findings about frontal brain asymmetry differences, limitations of the study, and future research. This chapter is outlined as follows: Research Question 1 (whole brain), Research Question 2 (prefrontal cortex), Research Question 3 (rest of brain vs prefrontal cortex), Research Question 4 (frontal asymmetry), limitations, and, finally, future research.

RQ1: Whole Brain Electrocortical Activity

Whole brain electrocortical activity was a fundamental research question for this study for multiple reasons. The Uncertainty of Outcome Hypothesis tells us that viewers prefer to watch something when the outcome is not obvious (Paul, Wachsman, & Weinbach, 2011; Pawlowski, 2013, Eckard, 2017; Gooding & Stephenson, 2017). Neuromarketing makes it clear that there is obvious and distinct brain activation when a person is looking at a stimulus they consider interesting, and more attention leads to more brain activity (Zaichkowsky, 2012). These reasons lead to a research question assuming that whole brain activity should be affected while watching media content with varying levels of suspense and surprise.

As can be seen from the works of Schomer and Da Silva (2012) where they describe the frequency wave functions, the four frequency waves tested in this study all have unique characteristics; some relating to emotion more than others. However, for this reason, the wave frequencies were compared to the varying level of suspense and surprise in order to have a more in depth look into what the true differences in brain activity caused via suspense and surprise could be.

As seen from Table 2 and the results corresponding, Theta (Θ), Alpha (α), Beta (β), and Gamma (γ) were used to compare the four video categories of High Suspense and High Surprise, High Suspense and Low Surprise, Low Suspense and High Surprise, and Low Suspense and Low Surprise. Low Suspense and Low Surprise videos were used as baseline for comparison because these videos were tested to show that there was very little, to no, suspense or surprise in the videos; meaning that this could be considered baseline, or regular, sports viewing.

The results show that there is no significant difference between LL videos types compared to HH, HL, or LH for any of the four frequency waves. All video comparisons have a significance value of 1.00 (besides Theta HH) indicating that there was absolutely no detected difference in electrocortical brain activity between video types. A significance of 1.00 means that the values are absolutely perfect to one another, although this is not the case, the values were so similar that the SPSS data software showed no difference. Theta LL compared to Theta HH was the only whole brain comparison that was not at a significance of 1.00; however, the score was still not close to the goal alpha level of .05. Hypothesis 1, 2, and 3 all hypothesized there would be a difference in whole brain electrocortical activity due to varying levels of suspense and surprise. The results might not match theoretical expectations for multiple reasons and limitations. One major limitation causing insignificant findings could be how the data was averaged. Since data was averaged throughout the entire video and also averaged between the two videos in the same category, this could have led to muted effects which may not be identified in this study, e.g. small sample size leading to potential Type II errors. This is discussed in more length below in the limitations section.

RQ2: Prefrontal Cortex Electrocortical Activity

Prefrontal cortex is another important element to this study. The prefrontal cortex is thought to be the area, most accessible to EEG, that produces the best and most accurate data of emotions (Wright, 2019). For this reason, prefrontal cortex plays a vital role when processing the information and emotions while watching a suspenseful or surprising event. The prefrontal cortex is made up of many regions, all with unique characteristics and duties, including the orbito-frontal cortex that receives inputs and computes emotional appraisal, the ventro-medial prefrontal cortex that is closely associated with evaluations of emotion, the ventro-lateral region that supports response and selection, and the dorso-lateral region involved in working memory and cognitive control (Grimshaw & Carmel, 2014). Studies often split up these regions to dive deeper into what a specific region does; however, all regions are heavily connected and they are not as straightforward as previously stated and are not always consistent (Wilson, Gaffan, Browning, & Baxter, 2010). For this reason, the prefrontal cortex for this study was analyzed as a whole.

Similar to Table 2, Table 3 shows the corresponding results to RQ2. Theta (ϴ), Alpha (α), Beta (β), and Gamma (γ) were used to compare the four video categories of High Suspense and High Surprise, High Suspense and Low Surprise, Low Suspense and High Surprise, and Low Suspense and Low Surprise. Low Suspense and Low Surprise videos were used as baseline for comparison because these videos were tested to show that there was very little, to no, suspense or surprise in the videos; meaning that this could be considered baseline, or regular, sports viewing.

The results show that there is no significance between LL videos types compared to HH, HL, or LH for any of the four frequency waves. All video comparisons have a significance value of 1.00 (besides Theta HL and Alpha HH) indicating that there was no difference in electrocortical brain activity between video types. A significance of 1.00 means that the values are absolutely perfect to one another, although this is not the case, the values were so similar that the SPSS data software showed no difference. Theta LL compared to Theta HL and Alpha LL compared to Alpha HH were the only prefrontal cortex cortical brain activity comparisons that were not at a significance of 1.00; however, the scores were still not close to the goal alpha level of .05. Hypothesis 4, 5, and 6 all hypothesized there would be a difference in electrocortical prefrontal cortex brain activity due to varying levels of suspense and surprise. The results might not match theoretical expectations for the same reasons seen in RQ1.

RQ3: "Rest of Brain" vs Prefrontal Cortex

Following Research Questions 1 for whole brain activity and Research Question 2 for prefrontal cortex activity, it only makes sense to compare differences between whole brain and prefrontal cortex. However, to make this a true score, the prefrontal cortex region of the whole brain should not be analyzed against prefrontal cortex since that is the area being compared to. Since the prefrontal cortex is, obviously, part of the whole brain, when comparing whole brain to prefrontal cortex, numbers could be skewed. For this reason, prefrontal cortex is compared against "rest of brain". "Rest of brain", as just explained, is the whole brain minus the prefrontal cortex.

Table 4 portrays the paired t-test ran comparing mean differences in "rest of brain" and prefrontal cortex electrocortical activity. For this analysis frequency wave and video category "rest of brain" items were matched with their prefrontal cortex counterpart. For example, "rest of brain" Beta LH was matched with prefrontal cortex Beta LH; this pairing was done for every frequency and video type.

The results for the paired sample t-test between "rest of brain" and prefrontal cortex shows many significant differences, especially in the HH, HL, and LH video categories. The significance level is in the direction of "rest of brain", indicating that a significance level of $p<0.01$ means "rest of brain" activity is higher than prefrontal cortex brain activity. The significant results being in the direction of whole brain are counterintuitive. As stated before, the prefrontal cortex is thought to be the best connection for emotion (Wright, 2019), making the results odd that whole brain is more active while watching videos.

The results indicate that for Theta ϴ and Alpha α the video categories HH, HL, LH and LL were all statistically significant towards "rest of brain". While for Beta β, only HH, LH, and LL were significant, but still towards "rest of brain". Gamma γ did not have a single statistically significant value. Although, for the statistically significant values, these significances are not promising due to being significant towards "rest of brain", there are some important takeaways.

Not a single Gamma γ statistic that was significant, indicating that there was no electrocortical activity difference in "rest of brain" and prefrontal cortex. Gamma, as previously stated, is often referred to as the black box because no researcher has fully comprehended what the frequency wave does. With no significances in this study, it can add to the literature that Gamma waves are not statistically different when viewing sports videos with varying levels of suspense and surprise. However, the most notable finding is in the alpha differences in all four categories. Alpha activity in the prefrontal cortex is assumed to signify cortical inhibition or the involuntary restraint of cortical activity (Uusberg, Uibo, Kreegipuu, & Allik, 2013). Due to alpha's assumed role in decreased cortical activity, hemispheric activity levels are thought to actually decrease with an increase in alpha activity (Grimshaw et al., 2014). This being stated, alpha having higher activity in the "rest of brain" portion lead to the assumption that alpha has lower activity levels in the prefrontal cortex, leading to greater alpha functions, including memory. Which, not to be forgotten, this study has a purpose of better understanding how sports viewers are cognitively feeling while watching sports, potentially leading to optimized sponsorship and advertisement timing and placement within sports broadcasts. With a significance showing that alpha function could be increased while watching videos with both high suspense and high surprise characteristics and high suspense and low surprise characteristics, this is significant for advertisements to understand there could be better memory functions (one of the characteristics of increased alpha function).

RQ4: Frontal Asymmetry

Frontal brain asymmetry can be defined as the differences across hemispheres of the brain linked to emotional processing (Coan & Allen, 2003). Many studies over the last few decades have concluded that frontal asymmetry is related to approach and withdrawal tendencies. Greater left hemispheric activation is attributed to greater approach feelings, while greater right hemispheric activation is related to greater withdrawal tendencies. These traits are also attributable to positive and negative stimuli; greater left asymmetry corresponds to positive stimuli, greater right dominance corresponds to greater negative stimuli (Davidson & Fox,1982; Ahern & Schwartz, 1985; Davidson, 1992; Davidson, 1998). These differences could be attributed to watching sports. During a very suspenseful game, certain fans might withdraw themselves from the event and would rather close their eyes and not watch a dramatic ending; while other fans could approach a suspenseful ending (correlating back to the uncertainty of outcome hypothesis).

Research Question 4 investigates asymmetry and the differences between left hemisphere and the right hemisphere to better understand how sports fan approach or withdraw from media content. As seen from the results displayed in Table 5, there were no significant differences in electrocortical activity between the left and the right hemisphere.

A plausible hypothesis to why there are no significant differences in the left and the right hemisphere in frequency and video types could be that, although the videos were suspenseful/surprising, there was no connection to the teams in the videos or games that were being shown. Although, there was an information slide before the video was shown to demonstrate the meaning of the video, that might not be enough for the subject to feel connected to the stimuli. For instance, there is obvious and distinct brain activation when a person is looking at a stimulus they consider interesting, and more attention leads to more brain activity (Zaichkowsky, 2012). If the subject indicated their favorite teams, then only videos of said team were shown, there could be an argument made to attest to stronger differences in approach and withdraw. Future studies could test this hypothesis by only testing, for example, football fans and only showing football videos.

Limitations

One of the major limitations in the study was the small sample size. While the a priori sample size calculation suggested that 35 subjects would be sufficient, a reduced portion of those tested actually provided usable data after processing and filtering. In addition to not meeting this target of 35 subjects of complete usable data to identify moderate effect sizes, it is also possible that the true impacts might have actually been smaller than anticipated, and viewing may have had more subtle impacts on brain activity, i.e. small or very small effects. For example, a simple Cohen's D effect size calculation for a pairwise comparison of HH v. LL conditions for prefrontal cortex brain alpha waves (arguably a comparison with one of the greatest expected contrasts), yielded an effect size of only approximately 0.18. This would fall just below small effects (typically 0.2), and would require (all other parameters equal) a sample size of close to 100 participants in order to identify any population differences with the same level of confidence (statistical power). The small observed effects may also be ultimately related to the averaging of the measurements throughout the video viewings and across the two videos of each type, as mentioned previously. Future researchers should aim to therefore take the following measures in order of priority, 1) analyze data on a single video level, 2) more precisely measure a distinct time point that reflects onset of a suspenseful/surprise condition, and/or 3) collect more data in order to be able to reliably distinguish the signal of interest (impacts of viewing) from and noise of the measurements, i.e. avoid Type II errors.

A limitation in regard to signal processing results is how non-normalized raw microvolts were used. Possible normalization of the data, percentage changes in the data instead of overall data, or an orthogonal procedure to scale the measurements to an individual basis. For this study, the results were not directed towards an individual participant basis. An overall average was used for analysis.

Another large limitation of this study was the time duration after surprising events. For surprising events, for many videos, the event would occur towards the end of the video, then within about a minute, usually after showing replays of the event a few times, the video would end. The time duration did not allow for us to get a minimum of 20, 1s EPOCHs for a few of our subjects; which is the minimum number of seconds needed for reliable data (Gudmundsson, Runarsson, Sigurdsson, Eiriksdottir, & Johnsen, 2007). This did not affect the analysis of any research questions; however, it could have been more useful for understanding how just surprise affected the subjects.

Another limitation dealing with the surprise portion of the videos was the processing afterwards. Many times, when a surprising event would occur, the subject would involuntarily react; whether that be an actual movement or just internal reaction. This reaction would cause the EEG brain waves to become extremely dense and move across multiple wave frequencies. When processing the data, items such as these extremely dense regions, have to be cut from analysis.

Because of the nature of surprising events, the shock factor leads to greater reaction than can be analyzed. This caused some important reactions and data to be cut from analysis.

A limitation that was previously mentioned was not having subjects express their favorite teams/sports. Having videos tailored to a specific fan group could lead to greater connection, possibly leading to statistically significant asymmetry differences. Context matters, especially for the suspense element of the study. However, to portray true suspense, much longer video clips would need to be shown. For this reason, contextual descriptions were provided before videos to give background knowledge on the video; whether that be information to allude to greater suspense because the game is crucial for a team or information downplaying an event to surprise the viewer. Contextual descriptions before the videos played could have been a suboptimal option. Future researchers may consider using prolonged video clips and/or more informed participants to analyze the effects suspense and surprise elements induce.

As previously mentioned, research questions 1 and 2 had many independent factors that were not normally distributed. For both research questions, however, a repeated measures ANOVA was still conducted. Assumptions were violated and a non-parametric test could have been more appropriate. This limitation could have led to different significance in the results.

Recommendations for Future Research

This study was a relatively exploratory study in the field of neuroscience and neuromarketing in regard to using EEG to measure differences in varying levels of suspense and surprise; therefore, future research can use this paper as an initial guide. Although this study did not find statistical differences in the research questions being analyzed, apart from differences in alpha electrocortical brain activity between “rest of brain” and prefrontal cortex; the fundamental research can still be seen as important to build upon. Understanding how sport viewers are reacting neurologically can be an innovative way to better use sponsorship and advertisements.

For future studies, as mentioned previously, I would suggest focusing on specific target populations. This study focused on all sports fans; from leisure fans to diehard fans. Future studies could focus on a variety of different groups but should intend to select a single group to analyze. Whether that be only leisure fans or only diehard fans or selecting one sport to focus on. For example, a researcher could only focus on football fans, or to be more specific, only diehard football fans. If a team were to back a study, a focus could be on fans of a certain team. These results could potentially affect whole brain, prefrontal cortex, differences in the two, and hemispheric differences. With a greater fandom, researchers could see a change in attention and pleasure from watching their favorite sport or team, leading to greater attention, which as mentioned before, would lead to greater brain activation, therefore leading to greater recognition and recall.

A recommendation for methodology: future studies using a similar format should not do randomly selected videos. Find a set of 2-4 videos with suspense and surprise ratings that perfectly fit into the categories and use just those videos. Some problems in this study were that, although all videos fit in the proper category, some videos were rated higher/lower than others in the same category.

This study and this research topic was meant to be an initial dive into the field of suspense and surprise being implemented to better understand sports viewers. There is immense room to expand and build upon this preliminary glimpse into the analyzation of EEG being used to examine suspense and surprise in sports media content.

Conclusion

This study's main purpose was to examine the neurological effects on a sport viewer's different brain wave frequencies while viewing a sporting event or broadcast with varying levels of suspense and surprise. Studies focusing on EEG, neuromarketing, sports, and suspense and surprise have all been executed; however, there are no studies combining these aspects to focus on neurological effects based on suspense and surprise while viewing sports. This study was meant to be a stepping-stone project for a better understanding of sports consumers. This knowledge could, indeed, be vital for the sport marketing industry, as avid sport consumers are integral for the sport industry to maximize profits and share (Iwasaki and Havitz, 2004).

In order to analyze the neurological effects on the brain that varying levels of suspense and surprise induce and better comprehend how these findings could relate back to neuromarketing in the sports industry, an EEG was utilized and frequency waves were analyzed along with four video categories (HH, HL, LH, and LL). Analysis was focused on whole brain, prefrontal cortex, "rest of brain" vs prefrontal cortex, and frontal asymmetry. It was hypothesized that for whole brain and prefrontal cortex there would be a significant difference between baseline (LL video type) electrocortical activity when compared to all three other video types. When comparing "rest of brain" to the prefrontal cortex, it was hypothesized that there would be a significant difference between the two factors in all four video categories. And finally, it was hypothesized that there would be a significant difference in all 4 video categories when comparing electrocortical activity between the left and right hemispheres in the prefrontal cortex.

Analysis of differences in whole brain led to findings of no significant differences among any of the video categories for any of the frequency waves. This indicates that there are no apparent whole brain significant differences in brain activity when viewing a rather boring sports broadcast compared to a suspenseful or surprising broadcast. Similarly, analysis of prefrontal cortex discovered no apparent significant differences among any video type compared to the baseline.

Prefrontal cortex and the rest of the brain were compared against one another, demonstrating many significant differences. However, these significant differences were counterintuitive as they were significant in the direction of whole brain. A significance in activity for prefrontal cortex would have shown greater levels of suspense and surprise led to greater levels of emotion. One finding, however, that does hold some meaning behind it was when analyzing alpha. Although alpha was statistically significant with greater mean activity towards whole brain, this, in effect, indicates that prefrontal cortex was more active due to alpha's assumed role in decreased cortical activity (Grimshaw et al., 2014). This being stated, alpha having higher activity in the "rest of brain" portion lead to the assumption that alpha has lower activity levels (truly meaning higher activation) in the prefrontal cortex, leading to greater alpha functions, including memory.

Finally, investigation of asymmetry and the differences between left hemisphere and the right hemisphere to better understand how sports fan approach or withdraw from media content was conducted. Again, there were no statistically significant differences between the left and the right hemisphere. As stated before, a greater activity in the left hemisphere deals with "approach" and greater activity in the right hemisphere indicates "withdrawal". No significant difference between the two hemispheres specifies that the sports fans in the study did not necessarily have greater approach or withdraw tendencies based on the varying levels of suspense and surprise.

The reason for subjects not showing strong approach and withdrawal tendencies depending on the varying levels of suspense and surprise could be attributed to the viewers not having a strong connection with the videos. For future research, identifying fans of a more specific market, whether that be a single sport or a single team, could lead to greater connection and interest in the videos. This greater interest could lead to greater left and right hemispheric differences; as well as possible differences in whole brain and prefrontal cortex differences.

Suspense and Surprise: Neurological Effects on the Brain While Viewing Sports Media Content was an exploratory research study hoping to bring light to an otherwise looked over topic in the field of sports, neuromarketing, and neuroscience. There is a vast amount of research that can be conducted to better understand how varying levels of emotional cues in sports effect a viewer's brain and this study is meant to set that future research into action.

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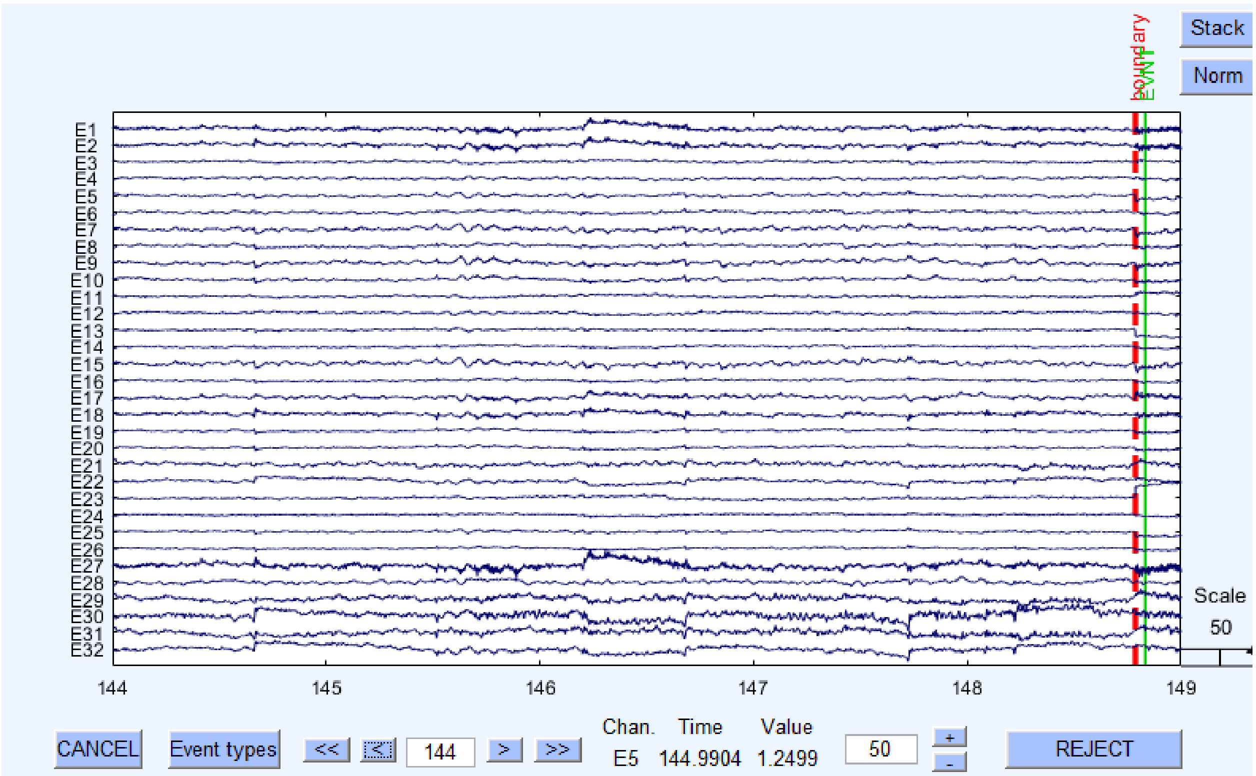
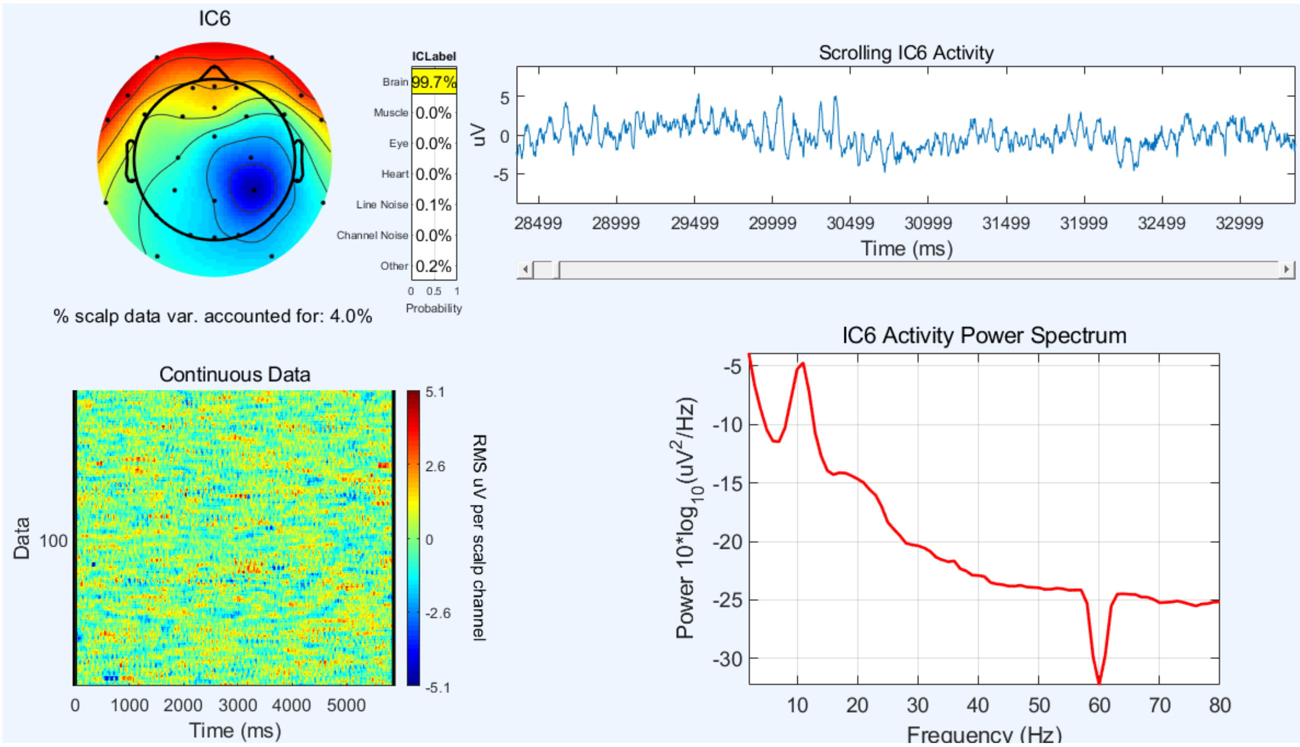
Appendix

1. Cleaned EEG Data

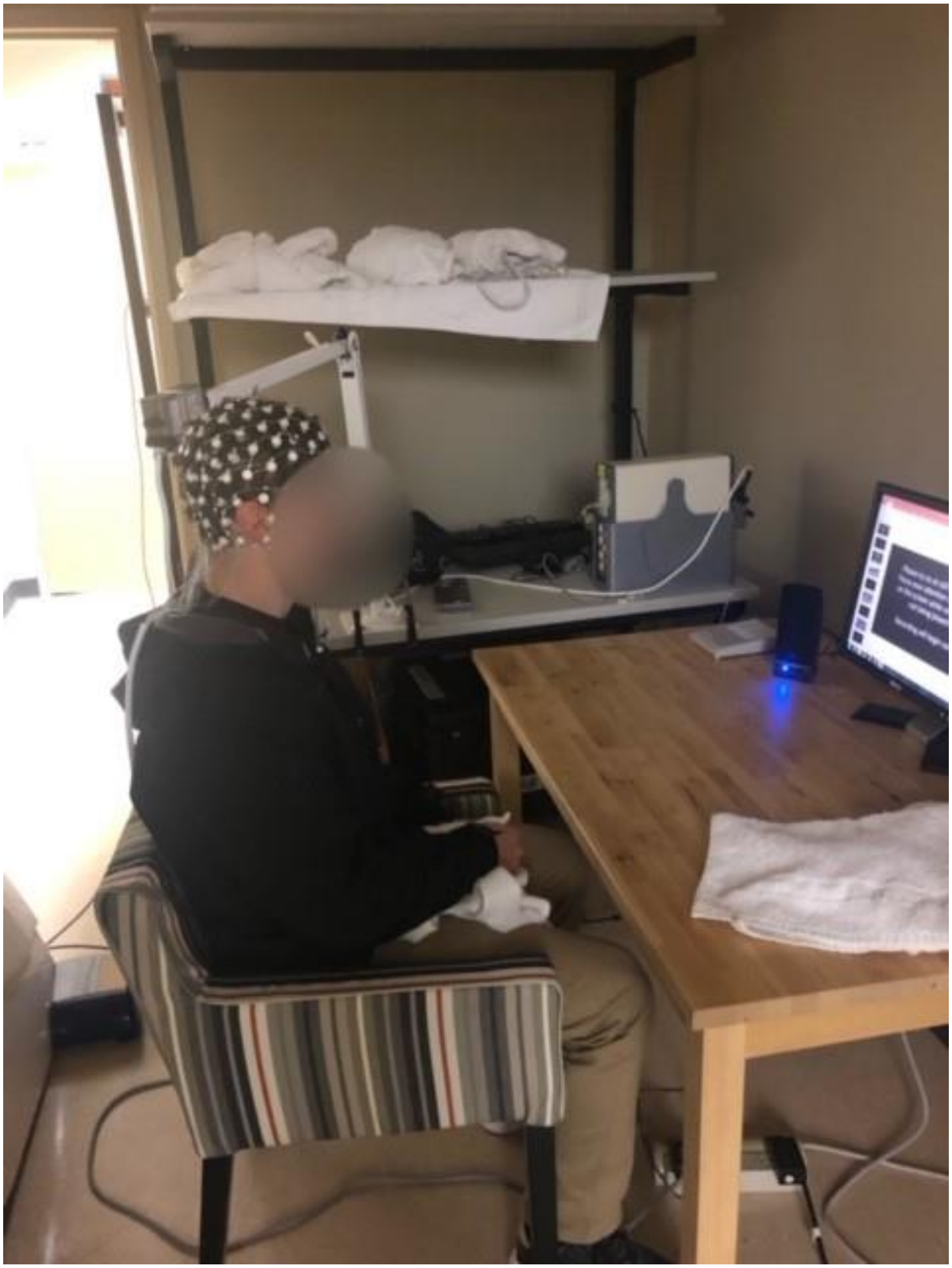


2. ICLabel

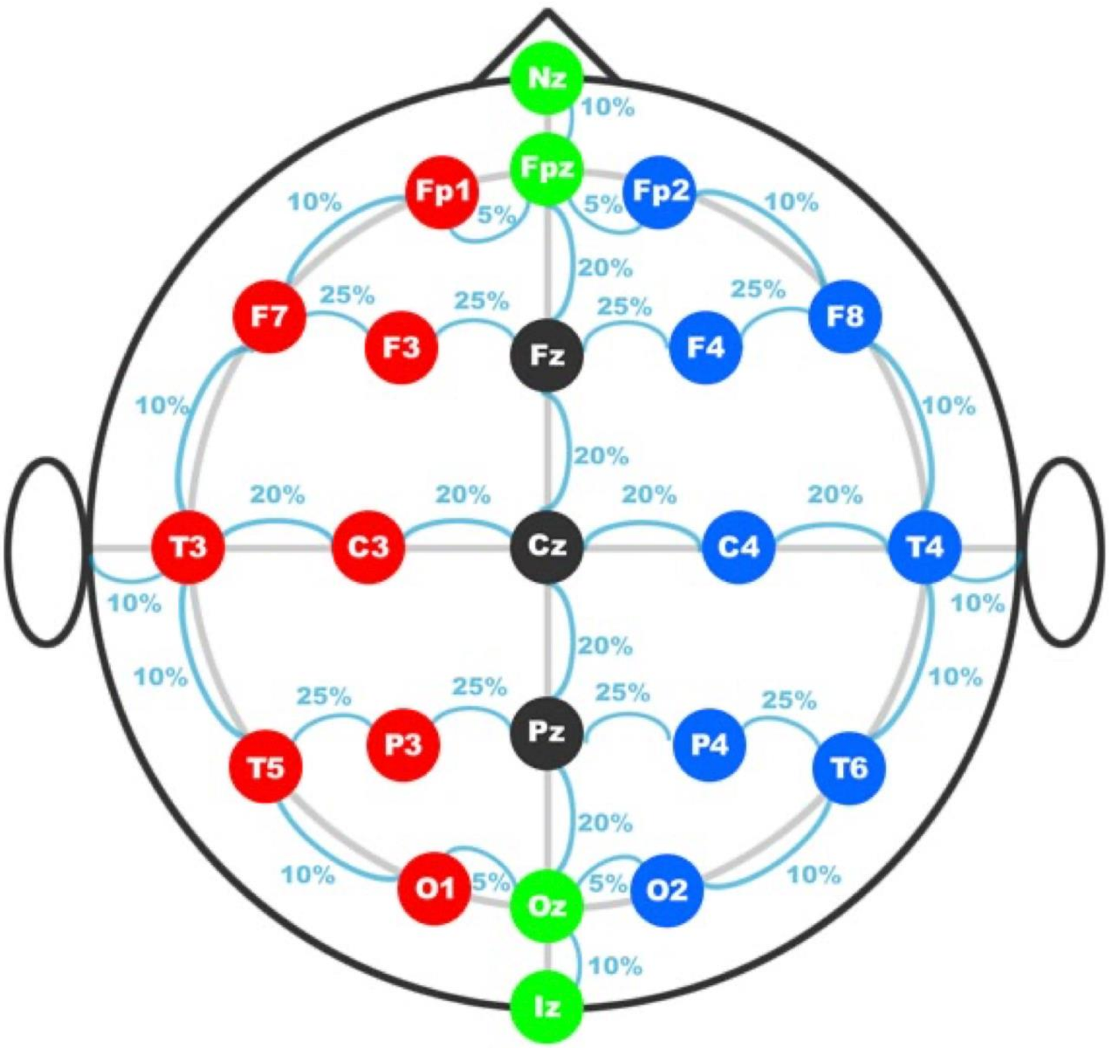

IC6
ICLabel
Brain 99.7%
Muscle 0.0%
Eye 0.0%
Heart 0.0%
Line Noise 0.1%
Channel Noise 0.0%
Other 0.2%
0 0.5 1
Probability
% scalp data var. accounted for: 4.0%
Scrolling IC6 Activity
uV
5
0
-5
28499 28999 29499 29999 30499 30999 31499 31999 32499 32999
Time (ms)
Continuous Data
Data
100
5.1
2.6
0
-2.6
-5.1
RMS uV per scalp channel
0 1000 2000 3000 4000 5000
Time (ms)
IC6 Activity Power Spectrum
Power 10*log10(uV2/Hz)
-5
-10
-15
-20
-25
-30
10 20 30 40 50 60 70 80
Frequency (Hz)

3. Subject Set Up (front)

4. Subject Set Up (side)



5. EEG International 10-20 System



http://chgd.umich.edu/wp-content/uploads/2014/06/10-20_system_positioning.pdf

6. IRB Approval Letter

The UNIVERSITY of OKLAHOMA

Institutional Review Board for the Protection of Human Subjects

Approval of Initial Submission – Expedited Review – AP01

Date: January 16, 2020

IRB#: 11594

Principal Investigator: Daniel J Larson

Approval Date: 01/16/2020

Status Report Due: 12/31/2020

Study Title: SUSPENSE AND SURPRISE: NEUROLOGICAL EFFECTS ON THE BRAIN WHILE VIEWING SPORTS MEDIA CONTENT.

Expedited Category: 7

Collection/Use of PHI: No

On behalf of the Institutional Review Board (IRB), I have reviewed and granted expedited approval of the above-referenced research study. To view the documents approved for this submission, open this study from the *My Studies* option, go to *Submission History*, go to *Completed Submissions* tab and then click the *Details* icon.

Requirements under the Common Rule have changed. The above-referenced research meets one or more of the circumstances for which continuing review is not required. However, as Principal Investigator of this research, you will be required to submit an annual status report to the IRB.

As principal investigator of this research study, you are responsible to:

- Conduct the research study in a manner consistent with the requirements of the IRB and federal regulations 45 CFR 46.
- Obtain informed consent and research privacy authorization using the currently approved, stamped forms and retain all original, signed forms, if applicable.
- Request approval from the IRB prior to implementing any/all modifications.
- Promptly report to the IRB any harm experienced by a participant that is both unanticipated and related per IRB policy.
- Maintain accurate and complete study records for evaluation by the HRPP Quality Improvement Program and, if applicable, inspection by regulatory agencies and/or the study sponsor.
- **Submit an annual status report to the IRB to provide the study/recruitment status and report all harms and deviations that may have occurred.**
- **Submit a final closure report at the completion of the project.**

If you have questions about this notification or using iRIS, contact the IRB @ 405-325-8110 or irb@ou.edu.

Cordially,

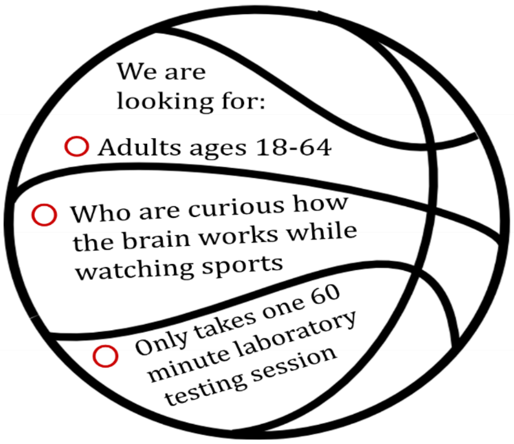
Lara Mayeux

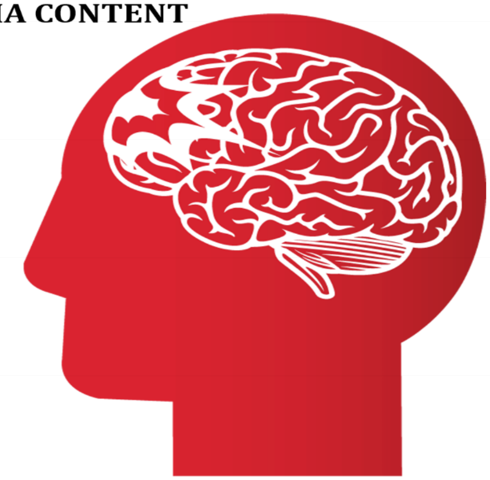
Lara Mayeux, Ph.D.

7. Recruitment Flyer

PARTICIPATE IN A SPORTS STUDY

NEUROLOGICAL EFFECTS ON THE BRAIN WHILE VIEWING SPORTS MEDIA CONTENT





If interested, please go to the following link or scan the QR Code:
https://ousurvey.qualtrics.com/jfe/form/SV_3R6NUBM5IreOWep

COLLEGE OF ARTS AND SCIENCES
DEPARTMENT OF HEALTH AND EXERCISE SCIENCE
The UNIVERSITY of OKLAHOMA

For more information, questions, concerns, or complaints about the research, contact me by email at twrichardson@ou.edu

The University of Oklahoma is an equal opportunity institution.

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8. Consent Form

Signed Consent to Participate in Research

Would you like to be involved in research at the University of Oklahoma?

I am Travis Richardson, a Sports Data Analytics Master's student from the Health and Exercise Science Department and I invite you to participate in my research project entitled NEUROLOGICAL EFFECTS ON THE BRAIN WHILE VIEWING SPORTS MEDIA CONTENT. This research is being conducted at the University of Oklahoma in the Visual Neuroscience Laboratory. You were selected as a possible participant because you meet the inclusion criteria; meaning you are a self-identified sports fan and are a resident of Oklahoma. You must be at least 18 years of age to participate in this study.

Please read this document and contact me to ask any questions that you may have BEFORE agreeing to take part in my research.

What is the purpose of this research? The purpose of this research is to assess brain activity while viewing a sports broadcast/video.

How many participants will be in this research? About 35 people, aged 18 and up, who meet the inclusion criteria.

What will I be asked to do?

If you agree to be in this research, you will be asked to attend 1 visit. The visit consists of completing paperwork (this agreement form). You will also be familiarized with the equipment, procedures, and measurements used in this study. Following familiarization, you will be seated in front of a computer monitor and an EEG cap will be placed on your head. There will be a five-minute period to get baseline measurements. The first video will begin shortly after. You will be asked to sit relatively still while watching the videos.You will watch eight, 2-8 minute clips. Before, during, and after the test, we will have a cap on your head which will measure continuous brain activity.

How long will this take?

Your participation will take about 1 hour per visit. A total of 1 hour of your time.

What are the risks and/or benefits if I participate?

There are no safety risks involved in this study. However, your safety is the upmost importance, so you will be closely monitored during testing in case of an emergency. There is no medical benefit for participating in this research study.

What do I do if I am injured?

If you are injured during your participation, report this to a researcher or the principal investigator, Daniel Larson, immediately. Dr. Larson can be reached at (352) 262-7601 (cell). Emergency medical treatment is available. However, you or your insurance company will be expected to pay the usual charge from this treatment. The University of Oklahoma Norman Campus has set aside no funds to compensate you in the event of injury.

Will I be compensated for participating?

You will not be reimbursed for your time and participation in this research.

Who will see my information?

In research reports, there will be no information that will make it possible to identify you. Research records with identifiable information will be stored securely in locked file cabinets and research computers, and only approved researchers and the OU Institutional Review Board will have access to the records. You will be assigned a subject identification number, so your identifiable information will be kept confidential. You have the right to access the research data that has been collected about you as a part of this research. However, you may not have access to this information until the entire research has completely finished and you consent to this temporary restriction.

Do I have to participate?

No. If you do not participate, you will not be penalized or lose benefits or services unrelated to the research. If you decide to participate, you don’t have to answer any question and can stop participating at any time.

What will happen to my data in the future?

After removing all identifiers, we might share your data with other researchers or use it in future research without obtaining additional consent from you.

Will I be contacted again?

The researcher might like to contact you to gather additional data or recruit you into new research. I give my permission for the researcher to contact me in the future.

___Yes ___ No

Who do I contact with questions, concerns or complaints?

If you have questions, concerns or complaints about the research or have experienced a research-related injury, contact me at twrichardson@ou.edu or on my cell at (502)264-1223, or you may contact the principal investigator Daniel Larson at larsondj@ou.edu, or on his cell at (352) 262-

7601. You can also contact the University of Oklahoma – Norman Campus Institutional Review Board (OU-NC IRB) at 405-325-8110 or irb@ou.edu if you have questions about your rights as a research participant, concerns, or complaints about the research and wish to talk to someone other than the researcher(s) or if you cannot reach the researcher(s).

You will be given a copy of this document for your records. By providing information to the researcher(s), I am agreeing to participate in this research.

Participant Signature	Print Name	Date
Signature of Researcher	Print Name	Date
Signature of Witness (if applicable)	Print Name	Date

9. Truth-of-Consensus Scale

Participant ID _______________

SUSPENSE AND SURPRISE:
NEUROLOGICAL EFFECTS ON THE BRAIN WHILE VIEWING SPORTS MEDIA CONTENT

Questionnaire

All statements will be answered on a 1-5 scale.

1 – Strongly Disagree 2 – Disagree 3 – Neutral 4 – Agree 5 – Strongly Agree

1. I was surprised by the events that occurred in the video

1 2 3 4 5

2. I was expecting the video to end the way it did

1 2 3 4 5

3. The video was suspenseful

1 2 3 4 5

4. The video made me feel anxious to what would happen next

1 2 3 4 5

5. The video ended in a different way than I was prepared for

1 2 3 4 5

6. Throughout the video I found myself wanting to know what happened at the end

1 2 3 4 5

7. The video ended differently than I was expecting

1 2 3 4 5

8. I was not interested in how the video would end

1 2 3 4 5