ABSTRACT
PLAYING A RIGGED GAME: INEQUALITY’S EFFECT ON ACUTE STRESS RESPONSES

Income and wealth inequality have been consistently increasing around the world. High inequality corresponds with high rates of various health and social problems. Some researchers implicate chronic stress induced by inequality as the primary mechanism for these effects. It was the goal of the present experiment to investigate the physiological effects of inequality. We hypothesized that experiencing inequality in a short competitive computer game would produce physiological stress responses especially in participants who competed with a disadvantage. Participants (n = 96) were assigned to one of four groups and played a memory game against a confederate opponent to earn “money” to spend in our lab market. The four groups depended on the difficulty of the problems and the fairness of the game. We evaluated four physiological measures: cortisol samples, facial corrugator muscle EMG, heart rate variability (HRV), and skin conductance levels (SCL). The result found that the disadvantaged group with high difficulty problems showed the highest corrugator levels and the lowest SCL, indicating increased stress. Cortisol levels were the highest in unequal groups compared to the equal groups and this was supported by similar HRV results. The results of this experiment showed that experiencing inequality even for a short time elicited several autonomic stress responses even if the participant benefitted from the inequality.

Rhanda Theresa Gardea Rylant
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PLAYING A RIGGED GAME: INEQUALITY’S EFFECT ON
ACUTE STRESS RESPONSES

by
Rhanda Theresa Gardea Rylant

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APPROVED

For the Department of Psychology:

We, the undersigned, certify that the thesis of the following student meets the required standards of scholarship, format, and style of the university and the student's graduate degree program for the awarding of the master's degree.

Rhanda Theresa Gardea Rylant
Thesis Author

Martin Shapiro (Chair) Psychology

Lorin Lachs Psychology

Paul Price Psychology

For the University Graduate Committee:

Dean, Division of Graduate Studies
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF FIGURES</td>
<td>vi</td>
</tr>
<tr>
<td>CHAPTER 1: INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>CHAPTER 2: LITERATURE REVIEW</td>
<td>3</td>
</tr>
<tr>
<td>CHAPTER 3: METHODS</td>
<td>11</td>
</tr>
<tr>
<td>The Game</td>
<td>14</td>
</tr>
<tr>
<td>CHAPTER 4: RESULTS</td>
<td>16</td>
</tr>
<tr>
<td>Survey Measures</td>
<td>16</td>
</tr>
<tr>
<td>Within-Game Physiological Measures</td>
<td>19</td>
</tr>
<tr>
<td>Post-Game Physiological Analyses</td>
<td>21</td>
</tr>
<tr>
<td>CHAPTER 5: DISCUSSION</td>
<td>25</td>
</tr>
<tr>
<td>Summary</td>
<td>25</td>
</tr>
<tr>
<td>Limitations and Confounds</td>
<td>29</td>
</tr>
<tr>
<td>Future Directions</td>
<td>30</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>33</td>
</tr>
<tr>
<td>APPENDICES</td>
<td>38</td>
</tr>
<tr>
<td>APPENDIX A: SHORT STRESS STATE QUESTIONNAIRE</td>
<td>39</td>
</tr>
<tr>
<td>APPENDIX B: FIELD POLL</td>
<td>41</td>
</tr>
<tr>
<td>APPENDIX C: DESCRIPTIVE COMBINED IDEOLOGIES SCALE</td>
<td>43</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Figure 1</td>
<td>Step-by-step events of a trial</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Post/pre survey scores</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Fairness ratings</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Facial EMG scores by group averaged over 10 blocks</td>
</tr>
<tr>
<td>Figure 5</td>
<td>SCL scores by group averaged over 10 blocks</td>
</tr>
<tr>
<td>Figure 6</td>
<td>Post/pre cortisol scores</td>
</tr>
<tr>
<td>Figure 7</td>
<td>HRV x fairness effect</td>
</tr>
</tbody>
</table>
CHAPTER 1: INTRODUCTION

Economic inequality, also known as income inequality, can be conceptualized as the wealth gap between the rich and the poor of a country and this gap has been increasing around the world (Solt, 2008). Psychologists, along with economists and sociologists, list a number of concerns when discussing the consequences of rising economic inequality. Those living in countries with high levels of inequality experience physical and psychological illnesses that ultimately make it difficult, if not impossible, to reverse the poverty they find themselves in. Overall, countries with higher levels of inequality experience corresponding rates of negative consequences such as mental illness, crime, and teenage pregnancy, along with various other health issues (Burns, Tomita, & Kapadia, 2014; Wilkinson & Pickett, 2009). Some researchers implicate stress induced by inequality as the primary mechanism for these effects (Pickett & Wilkinson, 2010). Chronic stress has been established as a source of physical and psychological health concerns, including lowered immune system response, hippocampal damage, and various other health problems (Dickerson & Kemeny, 2004; Lupien et al., 1998). These issues in turn put a great deal of stress on the people who experience them in addition to putting a large strain on already minimal financial resources.

While inequality affects individuals in different ways, inequality is often a product of social engineering in a situation in which the playing field is uneven, with some people receiving advantages and some receiving disadvantages. Sociologists and economists have laid the foundation for research in this area. However, the majority of the studies examining inequality and its negative effects are correlational and have not yet been able to cite inequality-induced
stress as the cause of health issues (Pickett & Wilkinson, 2010; Torre & Myrskyla, 2014). The present study attempted to simulate economic inequality in a contrived setting in order to investigate the possible link between inequality and physiological stress responses.
CHAPTER 2: LITERATURE REVIEW

Inequality is traditionally assessed using the Gini index. The Gini index, developed by Corrado Gini in the early 20th century, is a mathematical equation developed to measure the size of inequality in developed nations (Lerman & Yitzhaki, 1984). The equation, which examines wealth distribution in a country, is one of the most widely used scales in economics, sociology, and more recently, psychology, to determine an individual country’s income inequality rating. The index uses a country’s gross domestic product (GDP) and income data to generate an equation based on the Lorenz curve, which uses cumulative income received and number of recipients (Lambert & Aronson, 1993). The Gini coefficient is the amount of area between the line of equality and the Lorenz curve. If income is perfectly distributed, the result is a straight line. As a result, it is possible for a country to have perfect equality (a score of 0), perfect inequality (a score of 1), or any percentage of inequality in between (Lambert & Aronson, 1993). Inequality has been rising—not only in the United States but around the world—and researchers have been working to determine whether or not it has any ill effects on the societies in which it is the highest. One of the most extensive areas of research concerns the effects of a country’s high inequality on the health of its citizens.

Overall, there is a negative correlation between inequality and general health and a positive correlation between inequality and premature mortality (Kondo et al., 2009). This effect is seen regardless of demographic variables such as socioeconomic status or age. As the Gini coefficient increases by 0.5, premature mortality increases by 8%. Research conducted using data from other countries suggest that around the world, higher rates of inequality mean lower
rates of health. Torre and Myrskyla (2014) examined inequality’s relationship with health using data from 21 countries over 30 years with income inequality assessed by the Gini index. The results showed a negative correlation between income inequality and the general health of the population. The results also showed a positive correlation between income inequality and premature mortality for elderly females. The research suggests that inequality has health effects on people of all ages.

These effects are seen in the health choices people make at young ages as well as their health outcomes at older ages. Li and Guindon (2013) examined the correlation between youth smoking and inequality by using the Global Youth Tobacco Survey to assess tobacco and cigarette consumption among youth. The results showed a significant positive correlation between inequality and youth smoking rates. A 10% increase in GDP predicted an approximate 2% increase in the chance of a young person being a smoker. The results were the same when income distribution was examined. As income distribution inequality increased, so did the number of youth smokers. Inequality has also been correlated with illicit drug overdose (Galea et al., 2003). Neighborhoods in cities with the highest levels of income inequality saw the highest numbers of drug overdoses. Researchers suggest that this relationship is due to a lack of investment in these neighborhoods. As a result, these neighborhoods see fewer resources spent on safety, healthcare, and education, which contributes to fewer people getting the health assistance they need, thus raising the probability of suffering from the lethal consequences of prolonged drug use. This suggests that inequality is linked with health choices, and therefore, health outcomes, even at young ages.

Muckenhuber, Burkert, Grosschadl, and Freidl (2014) examined the correlation between inequality and health in 23 countries by measuring
psychological stress and number of sick days taken from work. The results showed a positive correlation between income inequality and number of days taken for sick leave. They also showed that psychological demands were more strongly related to the days taken for sickness leave when the income inequality levels were higher. This suggests that those who work in countries in which there is higher inequality experience higher levels of on-the-job stress which leads to a decline in physical health. Mental health is correlated with physical health and a decline in one tends to predict a decline in the other. This is very important for workers who are subjected to high levels of stress in their jobs. Stress acquired while working is only one mechanism that contributes to a decline in health. Those who are in lower socioeconomic statuses in unequal countries also describe experiencing other negative feelings stemming from their environment that ultimately exacerbate stress and the resulting health issues.

While most of the research done in this area has been correlational, there has been some attempt to begin studying effects of inequality experimentally that has focused on the subjective experiences of those in lower socioeconomic brackets. Kraus, Piff, and Keltner (2009) examined how sense of control varies between members of lower or higher socioeconomic statuses. It has been hypothesized that those with higher SES feel as though they have control over their lives and those lower in SES attribute their situations to more contextual, environmental influences. The researchers manipulated the participants’ subjective SES by having them compare themselves to those above them or lower than themselves on the SES ladder. The level of SES of the participant predicted whether or not he or she would endorse more contextual explanations for inequality (Kraus, Piff, & Keltner, 2009). Those who feel like they are higher in SES are more likely to explain their situation in terms of their own abilities and
actions. Ultimately, this suggests that lower subjective SES is correlated with a sense of a lack of control in one’s life and affects their behavior.

Similar research suggests that how participants view their SES can change how they act in particular situations. Those high in SES are more prone to act unethically and have more positive attitudes toward greed and are less likely to support charity programs. Those lower in SES have been shown to be less tolerant of greed, more willing to give to charity, and more prone to act prosocially (Piff, Kraus, Cote, Cheng, & Keltner, 2010; Piff, Stancato, Cote, Mendoza-Denton, & Keltner, 2012). These differing attitudes toward particular actions or attributes may illustrate in part what keeps those in poverty from rising in SES or how those who are affluent maintain their wealth. If certain values are taught from one generation to the next, it is unlikely that those experiencing either wealth or poverty would be influenced to change the attitudes that could result in a change in their financial situations. This also lends support to the hypothesis that environmental influences make a difference in how a person copes with his or her financial situation—in particular, how difficult it would be to advance in SES. This would contribute to chronic stress and negative feelings associated with being judged by others.

There are social, cultural, and internal mediators that all contribute to a very complex sense of shame that heightens stress response. Jo (2013) examined the psychological effects of social judgment. The widespread beliefs that those in poverty are irresponsible, lacking skills, lazy, and as a result somehow deserve their situation only serves to shame those experiencing financial hardship. When those in poverty feel as though nothing they do can help their situation, they tend to stay stuck in the cycle of poverty. Social judgment along with stress and general negative affect caused by poverty contributes to this cycle and prevents
people from being able to work themselves out of it (Haushofer & Fehr, 2014).
Layte (2011) referenced these various aspects as the mediating links between mental health and inequality. Those lower in SES consistently face status anxiety by interacting with others from higher SES. As a result, they experience social anxiety and other negative feelings that cause psychological stress and result in a physiological stress response—in particular, the secretion of cortisol into the body.

There are several documented physiological responses to stress. Cortisol is a hormone produced by the adrenal glands and is released in response to both acute and chronic stress. It is regulated by the hypothalamic-pituitary-adrenal axis and is released when a person is subjected to physical or psychological stress. While the release of small amounts of cortisol is an important regulatory response to acute stress, prolonged stress leading to a consistent release of cortisol into the bloodstream has documented negative effects on the rest of the body. Chronic exposure to cortisol can lead to various problems with many physiological systems. Over long periods of time, cortisol suppresses the immune system and damages hippocampal neurons (Dickerson & Kemeny, 2004; Lupien et al., 1998). Children in poor families tend to suffer from chronic stress and chronic cortisol exposure. The cumulative cortisol response developmentally delays the children on cognitive measures and has long-term effects on the body’s regulation of stress and cortisol (Blair, Berry, Mills-Koonce, & Granger, 2013). This suggests that the effects of stress begin at an early age and possibly continue to negatively affect the individual into their adulthood.

Dickerson and Kemeny (2004) conducted a meta-analysis on stress induction and physiological response in order to determine which situations elicit the highest levels of physiological stress response as measured by levels of
cortisol. They analyzed several models of stress induction including the social self-preservation theory, social-evaluative threat theory, and uncontrollability theory. Overall, the researchers determined that situations in which there was a social evaluative component were those that elicited the highest levels of cortisol. As a result, the researchers suggest that people are inclined to preserve their “public” selves and putting that self in jeopardy through social judgment arouses the hypothalamic-pituitary-adrenal (HPA) axis and results in the release of cortisol. Those who find themselves in poverty are consistently in a position in which they are being negatively socially evaluated by others. Negative social evaluation consistently produces a physiological stress response (Dickerson, Mycek, & Zaldivar, 2008). In a study in which participants were asked to give a speech under various conditions, the condition in which the participants were negatively evaluated by a confederate significantly elicited the cortisol response compared to the non-judgment conditions. Those in poverty report facing negative social evaluation in their everyday lives (Jo, 2013). It is possible that this would lead to a chronic stress response including a long-term release of cortisol—compromising health in the long run and contributing to corresponding mental and physical illnesses.

While cortisol is the most widely used measurement of stress, there are others that can be utilized to measure acute stress. These measures include facial electromyography (facial EMG), skin conductance levels (SCL), and electrocardiography (ECG). In addition to reflecting levels of stress, these can also be used to determine an individual’s affect. Facial EMG, specifically the activation of the corrugator muscle, has been used to indicate negative emotion—particularly that of disgust (Huang & Hu, 2009; Rana, 1993). Additionally, SCL can be used to measure emotional response due to acute
arousal (Jacobs et al., 1994), but has been found to correlate with getting feedback of accuracy in our lab.

In addition, heart rate variability has been used to reflect physiological arousal linked to stress (Hjortskov et al., 2004). HRV refers generally to the difference in time between heart beats as controlled by two branches of the autonomic nervous system (ANS) (Akselrod et al., 1981). The sympathetic branch is linked to elevated physiological arousal with the vagal (parasympathetic) branch indicating lower arousal (Pomeranz et al., 1985). Research indicates that these systems work to maintain cardiovascular homeostasis and reflect HRV control in the short term (Pomeranz et al., 1985). The vagal component of variability is thought to represent parasympathetic activity that is linked to low arousal and low stress and the sympathetic component is linked to high arousal and high stress. Hjortskov et al. (2005), for example, found higher sympathetic/vagal scores in individuals solving a difficult rather than an easy computer problem. The BIOPAC ECG apparatus can analyze this variability and categorizes the results in terms of two components of the HRV: sympathetic (S) and vagal (V). Thus, the sympathetic (S) score divided by the vagal (V) score indicates an overall level of arousal and reflects the stress that the subject experiences.

There is an extensive link between mental and physical health and inequality and while these correlations exist, there is little experimental evidence to determine causality or specific moderators of the effects or if they are due explicitly to economic inequality. In addition, the studies that attempted to investigate inequality did not measure stress response or physiological response to the inequality the participants experienced. The present experiment investigated well-established attitudinal and physiological correlates to stress
while participants played an economic game in which they experienced inequality or fair play against a confederate opponent.
CHAPTER 3: METHODS

Participants
Ninety-six participants with an equal number of men and women were selected from the California State University, Fresno introductory psychology subject pool and various psychology courses. Ages ranged from 18-25 years and all participants received class credit for participating.

Experimental Design
Each participant played a delayed match-to-sample task (DMTS) against a confederate (the “opponent”). The confederate was needed to create a sense of competition and social judgment and was a research assistant from the present lab who played as though he or she was another participant. Participant cortisol levels were recorded before and directly after gameplay while heart rate (ECG), skin conductance level (SCL), and facial electromyography (EMG) were recorded during gameplay. The study used a between-subjects 2x2 design with participants randomly assigned to either a fair version of the task with either low or high difficulty or an unfair version with low or high difficulty. The participant and the opponent each took turns solving a DMTS problem with each being able to see the other’s problems as well as their respective feedback. The participants were randomly assigned to one of the following groups:

Unfair-Hard (UH): The participant was given difficult problems to solve while the opponent received easy problems.

Unfair-Easy (UE): The participant was given easy problems to solve while the opponent received difficult problems.
Fair-Hard (FH): The participant and the opponent were given equally difficult problems to solve. The participant received the same problem set as in the Unfair-Hard condition.

Fair-Easy (FE): The participant and the opponent were given equally easy problems to solve. The participant received the same problem set as in the Unfair-Easy condition.

E-Prime, the computer application used for the DMTS game, was programmed so that the participant’s and opponent’s answers to the problems did not influence the final overall relative standing of each player. In Unfair-Hard, the game concluded with an overall score ratio of 40:60 in favor of the opponent; in Unfair-Easy, the overall score ratio was 60:40 in favor of the participant, and in Fair-Hard and Fair-Easy the overall score ratio was 50:50 (a tie).

The study additionally utilized surveys, a confidence measure during game play, and physiological measures in order to gauge physiological and behavioral response to stress. The pre-survey included the Short Stress State Questionnaire (SSSQ) (Helton & Näswall, 2015) Appendix A describes the questions used in the pre-survey. The post-surveys included the SSSQ, Field Poll, and Descriptive Combined Ideologies Scale (DCIS) (Helton & Näswall, 2015; Zimmerman, & Reyna, 2013). Appendices B and C describe the questions asked in the Field Poll and DCIS, respectively.

Procedure

The participants were asked to refrain from ingesting caffeine or eating for an hour before the study and the study was only run between the hours of 12 p.m. and 5 p.m. due to diurnal fluctuations in cortisol (Kirschbaum &
The participant entered the lab and was asked to take a small sip of water 10 minutes prior to giving the first saliva sample. During this time both the participant and the opponent read and signed the informed consent form and completed the SSSQ pre-survey. After they completed these tasks, the confederate was asked to sit and wait quietly until the game began. Once the required 10 minutes had elapsed, the researcher instructed the participant to hold a small sterilized cotton swab under his or her tongue for 2.5 minutes to collect the first salivary cortisol sample. After the time elapsed, the participant placed the cotton swab into a vial that was frozen and sent to the commercial laboratory Salimetrics for analysis after the study was completed. Each vial was marked with the participant number and whether it was a pre or post sample. Following the collection of the sample, the researcher attached the BIOPAC electrodes to the participant. The EMG electrodes were attached to the participant’s right corrugator muscle after the area had been cleansed with an alcohol pad and slightly abraded with a sponge. The ECG electrodes were placed under the right clavicle and inside of the left ankle after those areas have been cleansed with an alcohol pad. The SCL electrodes were placed on the palmar side of the middle and index fingers on the non-dominant hand after those fingers had been cleansed with an alcohol pad. After these steps were concluded the researcher explained the steps of the game. The researcher also informed the participant and opponent that each problem they answered correctly would earn them $10 of fake money they could use in our lab market at the end of the game. The researcher then instructed the participant and opponent to begin the game. Figure 1 shows a diagram of a single trial in the game.
**The Game**

![Game Diagram](image)

**Figure 1. Step-by-step events of a trial**

*Note:* This figure shows the events of each trial the participant played. It began with the sample flashing once on the screen and was then replaced by the four targets to which the participant must have matched the sample. The participant makes his or her choice and was then asked to rate how confident he or she is in the choice on a scale from 1-9 with 1 indicating no confidence in the choice to 9 indicating full confidence in the choice. This screen was followed by a feedback screen that told the participant if they got the problem right or wrong. This feedback screen was immediately followed by a screen that showed the players’ standings relative to each other.

The participant and opponent sat opposite each other facing their computer screens. The participant played the first trial, the opponent played the next trial, and so on, with each player able to see their opponent’s trial and feedback as well as his or her own. Each trial was a delayed match-to-sample task and consisted of a problem, a confidence rating, feedback, and a comparison of the players’ performances relative to each other. At the beginning of the trial, a picture flashed quickly on the screen (.02 sec in the easy condition and .01 sec in the hard condition). This was followed by a 1-second blank screen and then four pictures of varying similarity were displayed. The object was for the player to match which picture was the one that originally flashed on the screen (the “sample”). After the player attempted to match the correct target to the sample, he or she was asked to rate his or her confidence for that trial. The confidence rating was a Likert-like 1-9 scale with a score of 1 indicating no confidence that the choice was correct and a score of 9 indicating full confidence in the choice. The players were encouraged to use any number on the scale they felt most
accurately described their confidence. After the confidence rating, the player received feedback of success or failure. A success resulted in 10 “dollars” being added to the player’s score while a failure resulted in the score remaining the same. After this feedback, the game displayed the players’ relative scores as well as which player was winning and which was losing. This screen was followed by the next player’s turn. There were 160 of these trials (each participant solved 80) with breaks lasting 30 seconds occurring approximately every 12 minutes.

After the game ended, the participant was asked to give another salivary cortisol sample using the same procedure as with the first sample while the confederate filled out the post-surveys. The opponent was given the “money” he or she earned during the game and was escorted to the market where he or she spent the money while the participant filled out the post-surveys. The market was stocked with snacks, pens, pencils, and a raffle for gift cards. After the participant finished the surveys, the researcher removed the participant’s BIOPAC electrodes and gave the participant his or her money earned and escorted him or her to the market.
CHAPTER 4: RESULTS

Overall the study examined stress responses due to inequality using self-reported stress measures as well as physiological measures. This study primarily sought to investigate whether there was a difference between the groups, an effect of fairness, or an effect of difficulty. Each of these will be discussed in terms of survey measures, trial-by-trial within-game physiological measures (EMG and SCL), measurement at the beginning, middle and end of the game (HRV) and cortisol analysis at the beginning and end of the game. All results are considered significant at an alpha level of $p = .05$.

Survey Measures

Short Stress State Questionnaire

The participants completed pre and post surveys using the SSSQ (see Appendix A). We averaged scores for questions 1-10 for each participant on their pre and post tests and divided their post score by their pre score. Figure 2 shows the post survey scores divided by pre survey scores averaged across each group, with increased values indicating increased stress. A repeated measures ANOVA was run with groups as the between subjects factor and pre/post scores as the within subjects factor. There was an overall pre/post effect $F(1,85) = 29.57, p < 0.00$, indicating that overall they reported greater stress. While there was no overall group effect ($F < 1$), there was a pre/post by group interaction $F(3,85) = 3.49, p = 0.019$ indicating that there was a difference in how groups changed during the experiment. A Fisher’s least significant difference (LSD) post-hoc test was conducted on the pre/post ratios to determine how the groups differed. Group Unfair-Hard differed from group Unfair-Easy ($M = 0.18, SD = 0.085$) and
group Fair-Easy ($M = .229$, $SD = 0.086$), but did not differ from group Fair-Hard. None of the other groups differed from each other.

![Graph](image)

**Figure 2.** Post/pre survey scores  
*Note:* In this figure, UH represents group Unfair-Hard, UE represents group Unfair-Easy, FH represents group Fair-Hard, and FE represents group Fair-Easy. The solid bars represent a difficult game while striped bars represent an easy game. Black indicates an unfair game while gray indicates a fair game. The pre and post survey scores were averaged for each participant for questions 1-10 and the averaged post scores were divided by the averaged pre scores. Figure 1 shows these post divided by pre scores averaged across each group with higher numbers indicating higher stress. Error bars were calculated as one standard error.

**Fairness Ratings**

At the end of the game, participants were asked to rate on a Likert scale how fair they believed the game to be after they had played it. A rating of “1” indicated that the game was completely unfair and a rating of “7” indicated that the game was completely fair. Figure 3 shows these scores averaged across groups. Unfair-Hard rated the game as less fair than the other groups. A one-way ANOVA determined that there was an overall group effect, $F(3,89) = 4.79, p$
= 0.004. 003. A LSD post-hot analysis found that Unfair-Hard differed from Unfair-Easy ($M = -1.10, SD = 0.45$), Fair-Hard ($M = -1.26, SD = 0.458$) and Fair-Easy ($M = -1.68, SD = 0.453$), but none of the other groups differed from each other. This suggests that, as expected, Unfair-Hard noticed the game was unfair and rated it accordingly. What is also interesting is that although Unfair-Easy played an equally unfair game as Unfair-Hard, they did not recognize that they were playing in an unfair game. That is, winning led them to see the game as fair.

Figure 3. Fairness ratings

*Note: In this figure, UH represents group Unfair-Hard, UE represents group Unfair-Easy, FH represents group Fair-Hard, and FE represents group Fair-Easy. The solid bars represent a difficult game while striped bars represent an easy game. Black indicates an unfair game while gray indicates a fair game. After the game, each participant was asked to rate on a 1-7 scale how fair they believed the game to be, with higher numbers indicating that the game was more fair. Error bars were calculated as one standard error.*
Within-Game Physiological Measures

Facial EMG

Facial EMG as measured by the activity of the corrugator muscle indicates negative affect (Huang & Hu, 2009; Rana, 1993). EMG analyzed 0-2 seconds after seeing the sample in each trial was averaged over 10, 8-trial blocks for each participant. Figure 4 shows the scores averaged across participants in each group presented in of the 80 trials averaged over 10 blocks. In order to determine if there was a difference between groups, a repeated measures ANOVA was conducted with groups as the between-subjects factor and trial blocks as the within-subjects factor. The ANOVA found that there was a difference between groups as supported by an overall group effect, $F(3, 86) = 4.63, p = 0.016$. In addition there was a block effect, $F(9, 774) = 12.98, p < 0.001$ indicating that the scores differed over the course of the game. There was also a group x block interaction, $F(27, 774) = 2.034, p = 0.002$ indicating that the groups’ scores changed differently over the course of the game. Unfair-Hard had higher EMG scores than the other groups which supports the initial hypothesis that Unfair-Hard would experience more negative affect during the game.

Skin Conductance

Skin conductance levels (SCL) analyzed 0-2 seconds after the participants viewed the target stimuli produced an SCL score. The scores were averaged over 10, 8-trial blocks for each participant. Figure 5 shows the scores averaged across participants in each group presented in 10 blocks. In order to determine if there was a difference between groups, a repeated measures ANOVA was conducted with groups as the between-subjects factor and trial blocks as the within-subjects factor. While it appeared that Unfair-Hard had lower SCL scores than the rest of
Figure 4. Facial EMG scores by group averaged over 10 blocks

Note: In this figure, UH represents group Unfair-Hard, UE represents group Unfair-Easy, FH represents group Fair-Hard, and FE represents group Fair-Easy. The lines with solid circles indicate a difficult game while lines with solid squares indicate an easy game. Black solid lines indicate an unfair game while gray dotted lines indicate a fair game. EMG analyzed 0-2 seconds after seeing the target in each trial produced an EMG score. Figure 4 shows the scores of the 80 trials averaged over 10 blocks.

The groups, this was not supported statistically. The ANOVA found no overall group effect ($F < 1$). However, there was a block effect, $F(9, 774) = 22.15$, $p < 0.001$, indicating that the scores changed over time. In addition, there was a block x group effect indicating that the groups changed differently over time, $F(9, 774) = 1.52$, $p = 0.046$. Previous unpublished experiments in our lab have indicated that when participants get the problems correct, they show an increase in SCL. The current results suggest that Unfair-Hard may have shown lower SCL arousal due to getting fewer correct than their opponents.
Figure 5. SCL scores by group averaged over 10 blocks  
Note: In this figure, UH represents group Unfair-Hard, UE represents group Unfair-Easy, FH represents group Fair-Hard, and FE represents group Fair-Easy. The lines with solid circles indicate a difficult game while lines with solid squares indicate an easy game. Black solid lines indicate an unfair game while gray dotted lines indicate a fair game. Skin conductance levels (SCL) analyzed 0-2 seconds after the participants viewed the target stimuli produced an SCL score. Figure 5 shows the scores of the 80 trials averaged over 10 blocks.

Post-Game Physiological Analyses

Cortisol

Salivary cortisol samples were taken 10 minutes after the participant arrived in the lab and directly after the participant finished playing the game. Each sample was tested twice by the commercial laboratory Salimetrics and we analyzed the mean raw scores of each test. Figure 6 shows these resulting post / pre scores averaged across participants in each group. In order to determine if there was a difference in these scores between groups, a repeated measures ANOVA was conducted with groups as the between-subjects factor and the pre and post cortisol scores as the within-subjects factor. Overall there were no
differences between the groups ($F < 1$) and no effect of difficulty ($F < 1$). However, a second repeated measures ANOVA was conducted with fairness as the between factor and pre and post cortisol scores as the within factor. These results indicated that there was a fair vs unfair effect, $F(1,92) = 5.03, p = 0.027$. The unequal groups Unfair-Hard and Unfair-Easy had significantly higher cortisol than the fair groups Fair-Hard and Fair-Easy. These results suggest that although there was no significant difference between the groups, there was a difference in whether or not the game the participant was fair or unfair. This could suggest that experiencing disadvantages or advantages in an unequal environment is equally stressful.

![Figure 6](image_url)

_Figure 6. Post/pre cortisol scores_

*Note: In this figure, UH represents group Unfair-Hard, UE represents group Unfair-Easy, FH represents group Fair-Hard, and FE represents group Fair-Easy. The solid bars represent a difficult game while striped bars represent an easy game. Black indicates an unfair game while gray indicates a fair game. Salivary cortisol samples were taken 10 minutes after the participant arrived in the lab and directly after the participant finished playing the game. Each participant’s post score was divided by their pre score. Figure 5 shows these resulting post / pre scores averaged across each group with higher numbers indicating higher cortisol levels. Error bars were calculated as one standard error.*
Heart Rate Variability

An analysis of HRV took place during three 5-minute sections while playing the game at the beginning, the middle, and the end. In the automated analysis available in the AcqKnowledge program through Biopac, three scores are provided: sympathetic, vagal and sympathetic/vagal. The sympathetic score represents activity of the sympathetic nervous system and high stress while the vagal component represents parasympathetic activity and lower stress; therefore the higher the sympathetic/vagal (S/V) score the greater the theoretical stress levels of the individual. Figure 7 shows the S/V scores averaged across participants within each group for the beginning, middle and end 5-minute block. A repeated measures ANOVA was run with groups as the between-subjects factor and the time of the measurement as the within-subjects factor. There was an over time effect, $F(2, 178) = 8.72, p < 0.001$ indicating that S/V increased in score as they played, but there was not an overall group effect, $F(1, 91) = 2.12, p = 0.10$ and no group x time interaction ($F < 1$). Because we found an effect of fairness with cortisol, a similar analysis was conducted with HRV combining groups that experienced an unfair game and those that experienced a fair game and ran an ANOVA with fairness as the between-subjects factor and time as the within-subjects factor. As with cortisol, there was an overall fairness effect, $F(1, 91) = 5.27, p = 0.024$, but there was no fairness x group interaction ($F < 1$).
Figure 7. HRV x fairness effect

Note: In this figure, UH represents group Unfair-Hard, UE represents group Unfair-Easy, FH represents group Fair-Hard, and FE represents group Fair-Easy. The lines with solid circles indicate a difficult game while lines with solid squares indicate an easy game. Black solid lines indicate an unfair game while gray dotted lines indicate a fair game. An analysis of HRV took place during three 5-minute sections while playing the game at the beginning, the middle, and the end. The sympathetic score represents activity of the sympathetic nervous system and high stress while the vagal component represents parasympathetic activity and lower stress; therefore the higher the sympathetic/vagal (S/V) score the greater the theoretical stress levels of the individual. Figure 6 shows the S/V scores averaged across participants within each group for the beginning, middle and end 5-minute block.
CHAPTER 5: DISCUSSION

Economic inequality has been rising in countries around the world. Countries with higher rates of inequality also have higher rates of various societal ills and their citizens have a host of physical and psychological illnesses (Burns et al., 2014; Wilkinson & Pickett, 2009). Some researchers indicate that stress caused by inequality is the primary mechanism for the development of these issues (Pickett & Wilkinson, 2010). Ultimately the goal of the study was to see if the physiological issues associated with stress appear in an unequal environment. In general, the results support the original hypothesis that playing an unfair game in which the participant receives disadvantages is an unpleasant experience resulting in higher levels of physiological stress compared to being involved in a fair game. What was interesting was that while the disadvantaged group (Unfair-Hard) did have some higher measures of stress, the winning group with the advantage (Unfair-Easy) also showed signs of being stressed by the experience.

Summary

The various physiological measures supported some hypotheses but not others. Facial EMG taken from corrugator muscle activity has been established as an unambiguous measure of negative emotions (Huang & Hu, 2009; Rana, 1993). Unfair-Hard showed higher EMG activity 0-2 seconds after viewing their targets and their opponent’s targets. This brief period of time is a good measure of how the participants feel about the game—it is the time that they are able to see the difficulty of the problem. Unfair-Hard had consistently difficult problems, and as expected, had higher levels of negative affect as reflected by EMG levels.
However, it was more than the difficulty of the problems that contributed to this result since Fair-Hard had the same problems but did not show the elevated EMG scores. This indicates that the elevation in stress response Unfair-Hard experienced while playing the game was due to either due to losing or being treated unfairly.

Skin conductance level (SCL) results were less clear but ultimately supported the hypothesis. Unfair-Hard had the lowest SCL responses over the course of the game, but SCL could be serving as a measurement of general physiological arousal and not necessarily a measurement of stress. Previous studies in this lab have shown that a participant shows an elevated SCL response when he or she gets a problem correct. This might suggest that as the participants in Unfair-Hard continued to fail at the game while their opponents succeeded, they were less aroused by the gameplay than the participants in the other groups. That said, groups Unfair-Hard and Fair-Hard had the same problems and scored equally on the game, so the results cannot be contributed solely to the errors made by the participant or the difficulty of the game. However, SCL responses varied widely, with some participants showing average microsiemen levels of below 1 and others over 25. This amount of variability may have contributed to the lack of significant difference between the groups.

Cortisol analyses reflected the stress the participants experienced over the course of the game. Overall, the groups had lower cortisol levels after they were finished playing the game. This could be due to the timing of the samples. When the first sample was taken, the cortisol level was reflective of what the participant was doing just before he or she came into the lab. For most participants, this was trying to find the correct lab and make it to the study on time. In addition, the participants did not know what they were going to be doing in the study. It
would not be unreasonable to say that this uncertainty caused them some amount of stress. When they learned that they would be playing a computer game they relaxed. That said, we were most interested in how cortisol changed for each person during the experiment. If cortisol levels dropped less under some conditions, as they did in groups experiencing the unfair game (Unfair-Hard and Unfair-Easy), that could be an indication that the experience maintained a higher level of stress regardless of the overall drop in cortisol levels.

Heart rate variability (HRV) as measured by the sympathetic value/vagal value has been used in studies as an indication of stress (Hjortskov et al., 2004). HRV rates were averaged over three points: the beginning of the game, the middle, and the end of the game. When combined, the unfair groups (Unfair-Hard and Unfair-Easy) had higher HRV scores than those playing a fair game (Fair-Hard and Fair-Easy), and this difference approached statistical significance. This seems to indicate that one does not have to experience disadvantages in an unfair situation to have a stress response. The participants in Unfair-Easy had similar physiological responses to inequality even though they won the game. This suggests that either receiving advantages or disadvantages in an unfair situation is enough to elicit a stress response. It could be that the higher rates of physical, mental, and sociological effects seen in countries with high inequality are due to experiencing either the advantages or disadvantages of inequality on a regular basis.

While HRV has become a more recent measure of stress, cortisol is still the most common measure and is utilized in a variety of studies. These studies traditionally use dramatic means of stressing the participant, using anything from physical discomfort to intense social judgment--such as giving a speech in
front of an audience (Dickerson & Kemeny, 2004). Both HRV and cortisol can be used to determine how a person responds to an unpleasant experience. In the present study, although the two measures are distinct, both results suggest the same conclusion: that experiencing an unfair environment is stressful regardless of whether the person receives advantages or disadvantages from it. Although Unfair-Easy rated the game as more fair and directly benefitted from the game’s advantages, they experienced physiological stress responses similarly to Unfair-Hard. It is possible that when reporting the fairness of the game, Unfair-Easy did not want to admit that they had advantages over their opponent—an attitude that reflects society’s when considering the wider context of economic inequality. Even though Unfair-Easy reported that the game was fair, they experienced something that caused them to respond physiologically similarly to Unfair-Hard, which experienced an unfair game.

Unfair-Hard experienced difficult problems and an unequal situation while Fair-Hard experienced the same difficult problems in an equal situation. As predicted, Fair-Hard experienced lower physiological stress response and rated the game as more fair. However, the fairness of the game was not the only variable that differed between the two groups. Unfair-Hard also lost the game. As a result, Unfair-Hard dealt with both losing, unfairness, and difficult problems while Fair-Hard only dealt with the difficult problems. One can conclude that solving difficult problems, in and of itself, was not the cause of the elevated stress levels seen in Unfair-Hard. In addition, Unfair-Hard and Unfair-Easy only had in common the unfair environment because Unfair-Hard had difficult problems and lost. This indicates that the elevated cortisol and HRV recorded in this group compared to the other two “fair” groups can only be attributed to the variable of fairness. This seems to support the notion that losing
was not the sole cause of stress in Unfair-Hard because Unfair-Easy won and still showed heightened stress.

**Limitations and Confounds**

There were methodological improvements that could have strengthened this study. The present study marks the first time this lab has used cortisol analysis. The largest issue that may have affected the results was the timing of the cortisol samples. When a stressor occurred, the resulting free cortisol peak occurred approximately 20 minutes after the onset of the stressor (Kirschbaum & Helhammer, 2000). In the case of this study, the initial cortisol sample was taken after the participant had been in the lab approximately 10 minutes. This suggests that the pre-cortisol sample reflected the peak of an event that occurred before the participant arrived at the lab, suggesting that the pre cortisol sample was not a standardized baseline across subjects. There were no differences in experience across the groups, so it is reasonable to assume that this did not make a difference in the results when comparing across groups. In addition, the post cortisol sample occurred directly after the participant finished playing the game. This sample reflects the stress experienced by the participant in the middle of the game and does not reflect the ultimate culmination of stress the participant experienced over the time spent playing the game. However, by this point in the game, Unfair-Hard was already losing and Unfair-Easy was already winning while the other two groups were tied with their opponents indicating that the timing of the sample reflected an accurate representation of the culmination of the game. Modifying the timing of the cortisol samples or analyzing a third sample may allow the cortisol samples to be more sensitive to changes over the course of the game.
The stressors implemented in the study to elicit a physiological and endocrine response may have not been as salient as they needed to be, as suggested by the findings of the fairness ratings and physiological measures. If unable to identify their opponent’s advantages the participant would be unlikely to realize the game’s inequality and would not have a physiological stress response. These advantages were essential for creating a stressful, unequal environment and included longer time to look at the sample and easier pictures to match. It is possible that the advantages within the game were too subtle. For example, the amount of time the confederate was allowed to look at the sample might not have been noticeably longer to the participant. In future studies, the amount of time can be made longer in order for the participant to notice. Another advantage was the difficulty of the problem. The level of distinctiveness between the sample and target determined how difficult the problem was. For example, if the sample was a picture of a sign, the targets in an easy problem would contain pictures of clearly different signs. In the future, these problems could be made more obviously distinctive. The advantages in the game ultimately may need to be exacerbated for the participant to notice and, consequently, respond physiologically.

**Future Directions**

Unfair-Easy responded similarly to Unfair-Hard in terms of cortisol and HRV. This could due to two possibilities. The group that experienced advantages (Unfair-Easy) could have been overall more aroused by the game due to winning. They beat their opponents by a large margin throughout the game and this excitement could have been reflected in their physiology. While this is a possibility, it is unlikely considering research regarding game cortisol and game
play. Research has indicated that winning a game or experiencing dominance over an opponent is linked with high levels of testosterone (i.e., Mehta & Josephs 2010; Mehta & Prasad, 2015). Some research indicates that cortisol and testosterone are negatively correlated. That is, when testosterone levels are high, cortisol levels are low (Mehta & Josephs, 2010). If the elevated stress response experienced in group Unfair-Easy was due to winning, there would not have been a fair/unfair effect of cortisol with both unfair groups having higher cortisol levels. If the results were not due to winning, it is also possible that the elevation in stress responses in participants in group Unfair-Easy was due to concern for their opponents.

Previous research has indicated that not only are testosterone and cortisol related, but that testosterone and cortisol are also related to empathy (Zilioli, Ponzi, Henry, & Maestripieri, 2015). Testosterone and cortisol have been used to predict self-reported empathy. In people with low baseline cortisol, testosterone is negative correlated with empathy. In people with high baseline cortisol, testosterone and empathy were positively correlated (Zilioli et al., 2015). This research suggests that these hormones create an interaction that affects empathy. While the current study only analyzed cortisol, it would be beneficial in future studies to additionally measure testosterone to further investigate the interaction of the hormones and unequal game play.

Inequality in society is the result of a myriad of complex interactions and experiences producing equally complex reactions. The present study attempted to investigate an assumed outcome of experiencing inequality – that of physiological stress responses. The results of the present research suggest that there is a relationship between being treated unfairly and having a physiological stress response. It would be interesting in future studies to amplify the unfair
aspects of the game. In the current study, the participant plays an unequal game for 45 minutes. This is a different experience than for people who experience inequality in their everyday lives. For some people, inequality is a chronic experience which leads to various physiological and psychological problems. Similarly, how people respond to the game may differ depending on what kind of prior experience with inequality that the person has. Someone who has experienced the negative aspects of inequality may respond more strongly to the game than someone who has never experienced inequality. Future studies should focus on racial minority groups or other groups that traditionally experience inequality.
REFERENCES


APPENDICES
APPENDIX A: SHORT STRESS STATE QUESTIONNAIRE
State Pre-Questionnaire

Please indicate how well each word describes how you feel at the moment.
Not at all = 1      A little bit = 2    Somewhat = 3    Very much = 4    Extremely = 5

1. Dissatisfied
2. Alert
3. Depressed
4. Sad
5. Active
6. Impatient
7. Annoyed
8. Angry
9. Irritated
10. Grouchy

Please indicate how true each statement is of your thoughts during the past ten minutes.
Not at all = 1      A little bit = 2    Somewhat = 3    Very much = 4    Extremely = 5
11. I am committed to attaining my performance goals.
12. I want to succeed on the task.
13. I am motivated to do the task.
14. I’m trying to figure myself out.
15. I’m reflecting about myself.
16. I’m daydreaming about myself.
17. I feel confident about my abilities.
19. I am worried about what other people will think of me.
20. I feel concerned about the impression I am making.
21. I expect to perform proficiently on this task.
22. Generally, I feel in control of things.
23. I thought about how others have done on this task.
24. I thought about how I would feel if I were told how I performed.
APPENDIX B: FIELD POLL
The next few questions are about the distribution of income and wealth in California.

1. How satisfied are you with the way income and wealth are distributed in Californian?

Very satisfied, somewhat satisfied, somewhat dissatisfied or very dissatisfied?

2. Thinking about the gap between how much money wealthy people have compared with how much money the rest of the population has…

Do you think this gap is larger, smaller, or about the same than it’s been in the past?

3. In your opinion, how much, in anything should government do to reduce the gap between the rich and everyone else?

A lot some, not much, or nothing at all?
APPENDIX C: DESCRIPTIVE COMBINED IDEOLOGIES SCALE
Thinking about the people in the United States, answer the following questions.

Please rate the following on a 7-point scale:
1. Strongly disagree
2. Moderately disagree
3. Slightly disagree
4. Neither disagree nor agree
5. Slightly agree
6. Moderately agree
7. Strongly agree

1. In organizations, people who do their job well do rise to the top.
2. In life, people are rewarded on the basis of their competence and ability.
3. Success is possible for anyone who works hard enough.
4. Anyone who is willing to work hard enough is able to find a decent job.
5. People who work hard do have the most opportunities for advancement.
6. In general, you find society is fair.
7. Everyone does have a fair shot at wealth and happiness
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