THE NEUROPHYSIOLOGICAL CORRELATES OF DECISION-MAKING IN THE ULTIMATUM GAME ACROSS SOCIAL VALUE ORIENTATION

by

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ABSTRACT

This senior thesis used electroencephalography (EEG) to explore the neurophysiological correlates of decision-making in the Ultimatum Game (UG) in search of individual differences across the personality variable Social Value Orientation (SVO). Participants were selected from an undergraduate research requirement pool according to responses to a series of questionnaire items that characterized them as Cooperators, Individualists, or Competitors. The task consisted of a presentation of a series of fair and unfair offers supposedly decided by fellow classmates, followed by stochastic offers generated by a spinning wheel that participants later chose to either accept or reject. No main effects for SVO were observed for either MFN or the P300/LPP complex. A main effect was observed for both MFN and the P300/LPP complex such that advantageous wheel outcomes produced more MFN and a larger P300/LPP amplitude than both equal and disadvantageous wheel outcomes, which did not differ. A three-way global interaction in MFN was observed between participant sex, participant SVO and the proposer offer.

Chapter 1

INTRODUCTION

1.1 General Overview and Purpose

Imagine the following scenario. Two students, A and B, are in a simple experiment that involves $10 that is going to be divided between them. Neither student knows anything about the other except for the fact that he/she is another student. Neither knows what the other looks like, and each knows that they will ever knowingly meet. At the beginning of the trial a spinner wheel is spun. This wheel is divided into three sections that are equally large. Each section corresponds to a different division of the $10 between Student A and B. One section of the wheel (Equal) divides the $10 equally, so that each student would receive $5. The other two sections are unequal divisions. One of these unequal (Advantage) divisions provides Student A with a relative advantage, in which he/she would receive $8 and Student B would receive $2. The other unequal division (Disadvantage) puts Student A at a relative disadvantage where he/she would receive $2 and Student B would receive $8. Once the wheel has been spun, Student A is shown the result (Equal, Advantage, or Disadvantage) and is then required to make a choice between two options. If Student A chooses the “accept” option then each student receives the amount corresponding to the wheel outcome. If Student A chooses the “reject” option then neither student receives anything. After Student A makes his/her decision, the experiment is over. That is, Student B will never be in a position to choose between Accept and Reject.

Now let's complicate the experimental scenario a bit. To this point, Student A has no information about Student B. But imagine that Student A does know something about Student B, namely that in the very recent past Student B was either "fair and sharing" with regards to Student A, or that Student B was "unfair and selfish". Combining the result of the wheel with the "character" information about Student B produces a set of six outcomes or events, as shown in Table 1 below.

Table 1. Experimental scenario outcomes.

	Wheel: Equal	Wheel: Advantage	Wheel: Disadvantage
Student B is Fair/Sharing	Event A	Event B	Event C
Student B is Unfair/Selfish	Event D	Event E	Event F

The present thesis was an exploratory investigation of the neurophysiological reactions to the six events shown in Table 1, as measured by the technique of electroencephalography (EEG).

In addition to determining the effects of the wheel outcome and Student B's "character", this thesis also focused on an aspect of Person A's personality, known as Social Value Orientation (SVO). For more than four decades research in Social Psychology has shown that people differ in their Social Value Orientation (SVO), which is a chronic predisposition to be Cooperative, Individualistic or Competitive in social relationships (Messick and McClintock, 1968). As will be seen, recent SVO research gives reason to expect that EEG event-related potentials (ERPs) of Cooperators, Individualists and Competitors might differ.

In this thesis, the decision scenario described above was modeled by a variation of a much studied economic decision problem knows as the Ultimatum

Game (UG). In addition to reviewing research on the UG, the following sections of this introduction will review the relevant neuroscience literature, and also provide a more detailed description of SVO research.

1.2 Theoretical Background and Research on the Ultimatum Game

The motives that fuel economic decision-making in socially interdependent situations have gained considerable attention from economists and social psychologists alike. A popular paradigm used in laboratory settings to study social motivations is the Ultimatum Game (UG; Güth, Schmittberger, & Schwarze, 1982). In the UG, two people decide how to split a fixed amount of money, usually $10, amongst themselves. Each person has a specific role in the decision-making process. The first person, the Proposer, decides how much of the total amount of money to keep for him/herself and how much of the total amount to offer to the other person, the Responder. Once the allocation has been proposed, the Responder decides whether to accept or reject it. If the Responder accepts, the money is split accordingly. If the Responder rejects, neither person receives any of the money and the game is over.

The UG is such a simple interaction between two people that it cannot possibly model the complex nature of bargaining behavior between two individuals in the real world. However, the UG is useful in studying the final step in bargaining (Camerer, 2003), namely the decision to accept or reject proposed utility. By isolating this last step, researchers can investigate the possibility of individual differences in preferences for, and/or reactions to fair or unfair behavior in socially interdependent situations.

Surprisingly, early economic theorists argued that such individual differences would not occur and that fairness would not play an important role in the UG. Classic economic game theory assumed that the Responder in the UG would accept any amount of utility offered because it is the mathematically self-maximizing choice (Rubenstein, 1982). After all, accepting an offer of $1 results in greater utility than rejecting to receive $0. However, research shows that offers of 20% of the total amount in the UG are rejected nearly 50% of the time, and offers of 10% or less are rejected almost always (Camerer, 2003; Camerer & Thaler, 1995). Little variation in these results is observed cross-culturally (Roth, Prasnikar, Zamir, & Okuno-Fujiwara, 1991) or between differing amounts of money used (Hoffman, McCabe, & Smith, 1996a).

Behavioral economists and social psychologists have since become interested in the motivations behind the decision to accept or reject proposed utility in the UG. Among others, these motivations likely include the evaluation of fairness (Walster, Berscheid, & Walster, 1973; Messick & Sentis, 1985; Kahneman et al., 1986; Loewenstein, Thompson, & Bazerman, 1989), reciprocity (Rabin, 1993; Hoffman, McCabe, & Smith, 1994, 1996b; Falk & Fischbacher, 2006), inequity aversion (Fehr & Schmidt, 1999), altruistic punishment (Fehr & Gachter, 2002), intentionality (Blount, 1995), and concern for social image (Andreoni & Bernheim, 2009). It has been found that skin conductance increases in response to unfair offers in the Ultimatum Game and that skin conductance is positively associated with reject decisions, but only for human proposer offers and not for offers generated by computers (van ‘t Wout, Kahn, Sanfey, & Aleman, 2006). This suggests the roles of affective state and human intentionality in UG decision-making, which are both highly relevant to the present thesis.

1.3 A Modified Ultimatum Game

The present thesis uses the general standard procedure of the UG with a modification. The participant is presented on a computer with an offer (either an even split - $5 out of $10 - or an unfair split - $2 out of $10) supposedly originating from a peer in an introductory psychology course, but the participant does not actually make an accept/reject decision to this offer. Instead, a spinning wheel appears on the screen, stochastically choosing a “new offer” for that trial (either an even split - $5 out of $10, an unfair split in a disadvantageous direction - $2 out of $10, or a split in an advantageous direction - $8 out of $10), and that is what the participant ultimately accepts or rejects. And for whichever offer the wheel “chooses”, the result of the trial (the participant’s accept/reject decision) still has monetary consequences for both the participant and the “other student” whose offer was originally presented. The computer task will be described in more detail in the methods section.

As described next, a considerable amount of neuroscience research in the past decade has added to the literature on decision-making within the UG and is relevant to the specific aims of the present study.

1.4 Neuroscience Research: functional Magnetic Resonance Imaging (fMRI) and Electroencephalography (EEG)

Neuroscience has joined the effort to theorize and predict economic behavior by aiming to understand the neural processes associated with, if not underlying, decision-making. One of the earliest functional magnetic resonance imaging (fMRI) studies of the UG showed that receiving unfair offers was correlated with higher activations within regions of the brain called the dorsolateral prefrontal cortex

(DPFC), the anterior cingulate cortex (ACC), and the anterior insula (Sanfey et al., 2003). These findings suggest elevated negative emotion in response to unfair offers and fit into previous research regarding the involvement of the anterior insula in the experience of negative emotional states (Calder, Lawrence, & Young, 2001; Phillips, Young, Senior, et al., 1997). Activation of the ACC has been found to correlate with differences in rejection sensitivity in response to disapproving facial expressions (Burklund, Eisenberger, & Lieberman, 2007), suggesting involvement in the evaluation of social pain. Similarly, the ACC is implicated in the evaluation of outcomes that differ negatively from expectations (Holroyd & Coles, 2002; Amiez, Joseph, & Procyk, 2005; Matsumoto, Matsumoto, Abe, & Tanaka, 2007). ACC activity increases in individuals making errors (Ullsperger, Nittono, & Von Cramon, 2007) and also in individuals receiving performance feedback of lower outcomes than expected (Nieuwenhuis, Schweizer, Mars, et al., 2007). Tricomi, Rangel, Camerer, & O'Doherty (2010) found that the ventral striatum and the ventromedial prefrontal cortex (vMPFC), brain structures associated with reward, are involved with both advantageous and disadvantageous inequity. Civai et al. (2013) observed a high level of activity in the anterior insula in situations of inequality, suggesting that a deviation from the norm of fairness leads to heightened anterior insula activity. This study in particular relates importantly to the present thesis because as will be discussed later on, there is reason to believe that there are individual differences in reactions to inequality, and especially across SVO.

While fMRI procedures allow for the precise determination of brain structures that are activated in the process of UG decision-making, the present study utilizes electroencephalography (EEG) to examine time-locked event-related potentials

(ERPs) in more immediate response to the six events listed in Table 1. The following paragraphs summarize research that has identified a number of ERP components associated with the UG and other tasks that are relevant to UG decision-making.

1.5 Medial Frontal Negativity (MFN) / Feedback-Related Negativity (FRN) / 200ms Negativity (N200)

An ERP component that is examined in the present thesis has a dipole source in the ACC (Gehring & Willoughby, 2002) and is referred to as negative-going medial frontal negativity (MFN), peaking between 200 and 350ms at fronto-central recording sites. The MFN component is also referred to as feedback-related negativity (FRN) or the N200, indicating that the peak is in the negative direction and occurs around 200ms. MFN has been found to reflect a motivational/affective evaluation of adverse outcomes (Gehring & Willoughby, 2002; Hajcak, Moser, Yeung, & Simons, 2005; Boksem, Tops, Kostermans, & De Cremer, 2008) and to be particularly sensitive to the violation of social expectancy or norms (Polezzi, Daum, Rubaltelli, et al., 2008; Boksem & De Cremer, 2010; Hewig, Kretschmer, Trippe, et al., 2011; Wu, Leliveld, & Zhou, 2011; Van der Veen & Sahibdin, 2011). MFN is proposed to reflect the activation of a reinforcement learning system, incorporating information of rewards, punishments, or a lack of reward (Holroyd & Coles, 2002). In a recent ERP study of the UG, which is highly relevant to the present thesis, Boksem & De Cremer (2010) found that MFN amplitudes were significantly larger both in response to unfair offers than to fair offers, and also larger in participants with higher concerns for fairness as measured by a moral identity measure. Although a study has not previously looked at this moral identity measure in the context of SVO, past SVO research suggests that Cooperators are the most likely SVO group to show a high concern for fairness as opposed to Individualists and Competitors. At the least, the results of Boksem & De Cremer (2010) demonstrate that theoretically meaningful individual differences in personality exist, at least for MFN.

Wu, Zhou, van Dijk, Leliveld, & Zhou (2011) conducted an ERP study of the UG using a social comparison manipulation. In addition to the offer to themselves (as the recipient), participants received information regarding the average offers made in other proposer-recipient dyads within the study. Such a comparison is called social comparison (Bohnet & Zeckhauser, 2004), which can affect behavior in comparisons in both an upward direction (to an individual in better standing) and in a downward direction (to an individual in inferior standing; Festinger, 1954). Wu et al. (2011) found that participants were more likely to reject offers when they had been offered less than other participants within the study, and especially for unfair offers. Highly unequal offers produced more MFN than moderately unequal offers in the time window of 270-360ms after the presentation of the offer, but were not modulated by the social comparison manipulation.

1.6 Late Positive Potential (LPP)

In addition to the MFN results reported above, Wu et al. (2011) found in a later time window of 450-650ms, an additional ERP component called the late positive potential (LPP). This component exhibited more positivity for moderately unequal offers than for highly unequal offers in an upward social comparison, and this difference disappeared when participants were manipulated by a downward social comparison or received the same amount as another recipient. Other research on the LPP (Ito et al., 1998) has suggested that it is functionally similar to the P300 (which is described below), and it has been implicated in social evaluation, with increased motivated attention associated with increased positive amplitudes. The LPP is generally most pronounced for higher levels of autonomic arousal, for motivationally relevant stimuli, and for high reports of affective experience (Schupp et al., 2004; Briggs & Martin, 2009). The LPP results suggest that the brain responds to fairness at two levels: the first is an abstract, earlier, and semi-autonomous process, and the second is a later cognitive appraisal process that incorporates factors such as comparison and fairness norms into decision-making.

1.7 300ms Positivity (P300)

An additional ERP component that manifests itself as a positive-going inflection around 300ms is the P300. The P300 is viewed as relating to processes of attentional allocation (Gray et al., 2004; Linden, 2005) and a high level of motivational/affective evaluation (Yeung & Sanfey, 2004; Nieuwenhuis et al., 2005). The P300 shows larger amplitudes in response to larger rewards than to smaller rewards (Yeung & Sanfey, 2004; Sato et al., 2005) and is also sensitive to reward valence, with a larger positive amplitude for positive rewards than for negative rewards (Hajcak et al., 2005). Within the UG specifically, the P300 is larger in response to equal offers than unequal offers (Wu et al., 2011).

The P300 and LPP are often lumped into a P300/LPP complex because of the difficulty often encountered in separating out the two components. This interaction is most often attributed to similar neural processes associated with or underlying both components. The present study will examine results in the context of the P300 and LPP combined into the P300/LPP complex.

In summary, the above research on the UG provides an a priori basis for selection of specific ERP components to be examined in the present thesis: the

MFN/P200 and LPP/P300 complex. The next section provides a summary of the personality variable studied in the present thesis.

1.8 Social Value Orientation (SVO)

It has already been demonstrated that personality differences in concern with fairness and moral identity play a large role in a Responder's perceptions of an unfair offer and the consequent decision to accept or reject. The present study examines one such personality variable called Social Value Orientation (SVO), first identified by Messick & McClintock (1968). SVO is a personality variable that corresponds to differences in preferences for distributions of rewards to one's self and to others (See also McClintock, Messick, Kuhlman, & Campos (1973)).

SVO is assessed by a simple decision task known as the "decomposed game" (Messick & McClintock, 1968), as shown in Table 2. In this task, the participant is asked to choose between alternatives that differ in the number of points each provided to the participant him/herself and some other person with whom the participant has been randomly paired. The individual is told to make their decisions knowing that he/she would never knowingly meet or communicate with this other person in the future. Although a variety of SVO assessment methods exist (Kuhlman & Marshello, 1975a; Liebrand, 1984; VanLange, 1999) they are all based on the use of decomposed games.

Table 2. A decomposed game.

	Alternative A	Alternative B	Alternative C
Points for you	6	7	6
Points for the other	4	2	0

Since 1968, research has shown that participants show consistent preferences for one of three types of outcome, or gain. Those who seek to maximize joint gain or collective welfare are identified as Cooperators. In the game above, Cooperators would choose A. Those who seek to maximize their own gain with no concern for the welfare of others are labeled as Individualists, and they would choose B in the game above. Those who seek to maximize the difference between their gains and the gains of others are identified as Competitors, and they would choose C in the game above. An additional social motive to maximize other's gain without concern for own gain was identified as Altruism (Kuhlman & Marshello, 1975a, 1975b). However, Altruists occur in such very low numbers in the population that they are not often studied.

Thus, Cooperators, Individualists, and Competitors make up the categories of SVO studied most commonly by researchers (Van Lange, 1999). Studies often combine Individualists and Competitors into a category of Proselfs because of the similar non-cooperative behavior exhibited by both groups, and because of the low number of Competitors in the general population (Au & Kwong, 2004; Bogaert, Boone, & Declerck, 2008). In much SVO research it is common to refer to Proselfs (Individualists and Competitors) and Prosocials (Cooperators).

Research has shown SVO to be relatively stable over time (Kuhlman, Camac, & Cunha, 1986; McClintock & Allison, 1989; Van Lange & Semin-Goossens, 1998). Robust findings in the SVO literature have demonstrated predictive and convergent validity (Hessing & Elffers, 1987; Kramer, McClintock, & Messick, 1986; Liebrand, 1984; Liebrand & Van Run, 1985). Prosocials exhibit greater cooperation than Proselfs in experimental games such as the public goods game (De Cremer & Van Vugt, 1999), the resource dilemma (Kramer et al., 1986), the two-person prisoner's dilemma (Kuhlman & Marshello, 1975b), and the chicken game (McClintock & Liebrand, 1988). Research on "real world" social dilemmas has found that Prosocials prefer to travel using public transportation than to travel by car for the greater good of the community (Van Vugt, Meertens, & Van Lange, 1995), and Prosocials more often donate money to virtuous causes than Proselfs (Van Lange, Bekkers, Schuyt, & Van Vugt, 2007). The SVO literature is much more extensive than the studies described above, and the interested reader can find excellent reviews by Au & Kwong (2004) and Bogaert, Boone, & Declerck (2008).

1.9 SVO and the Ultimatum Game

Recently, researchers have examined SVO differences in the Ultimatum Game, which game is the focus of the present thesis. Prosocials (Cooperators) and Proselfs (Individualists and Competitors) have been found to behave differently as the Proposer in the UG. Prosocials make offers that are more fair than those made by Proselfs. (Van Dijk, De Cremer, & Handgraaf, 2004).

As Karagonlar and Kuhlman (2013) recently found, Prosocials tend to accept unfair offers more often than Proselfs. Before their study, there were two conflicting theories that the authors put to the test; one was that Prosocials would reject offers more often than Proselfs because of a phenomenon called altruistic punishment, suggesting that Prosocials would reject unfair offers in order to "punish" the unfair Proposer for violating the norm of fairness. Another theory concerned emotion regulation and cognitive reappraisal, which predicted that Prosocials would accept unfair offers more often than Proselfs because of emotional and cognitive processes overriding negative feelings in response to an unfair offer. Karagonlar and Kuhlman found strong support for the emotion regulation hypothesis. Thus, at the behavioral level, there is clear indication that SVO plays an important role in UG decision-making. Further, it appears that emotion plays an important role in SVO differences in this game. The present thesis further examines SVO differences at the level of ERP's.

1.10 Neural Evidence for Inequity Aversion in Prosocials and Proselfs

Haruno and Frith (2010) conducted a functional Magnetic Resonance Imaging (fMRI) study investigating the emotions of Prosocials and Proselfs in response to inequity. To the knowledge of the author, this is the only study to date that has used neuroimaging to investigate individual differences in SVO. The study asked participants to respond with desirability ratings to certain reward values for him/herself and for another person. The authors hoped to find evidence for one of two explanations for Prosocial behavior in response to unequal rewards to self and other: 1) if Prosocial attitudes depend on deliberate control of selfish impulses then a relatively large amount of prefrontal activity would be seen as compared to Proselfs, or 2) if Prosocial attitudes depend on inequity aversion, then a relatively large amount of anterior insula or amygdala activity would be seen. The results of the study found that Prosocials predictably did not rate favorably large differences between the amount of reward for self and other (inequity), and that Proselfs (who were all Individualists in the study) did not mind. Activity in the dorsal amygdala was found to differ significantly between Prosocials and Proselfs; amygdala activity correlated positively with inequity in Prosocials while amygdala activity correlated slightly negatively with inequity in Proselfs. Differences in activity within the prefrontal cortex were not observed, suggesting that it is a rapid, intuitive response that was responsible for inequity aversion in the study, rather than deliberation.

1.11 Hypotheses

The present study aims to find neural differences between Cooperators, Individualists, and Competitors to add to previous literature demonstrating individual differences in the UG. Further, it is hoped that the paradigm may shed light on the role of inequality aversion and cognitive reappraisal in the decision to accept in Prosocials.

It is hypothesized that Cooperators will have larger MFN/N200 and P300/LPP complex amplitudes than Competitors and Individualists to *ad*vantageous unequal wheel outcomes, on the basis that Cooperators are more likely than the other two SVOs to feel negatively about an unequal offer, even if it is in a favorable direction. It is hypothesized that Proselfs will show larger MFN to equal outcomes than Prosocials, and that Prosocials will show larger MFN to *ad*vantageous wheel outcomes than Proselfs. It is not certain which SVO will show larger MFN/N200 amplitudes for *dis*advantageous wheel outcomes since each SVO could be might show large amplitudes for differing reasons: Individualists and Competitors would react negatively towards a small gain and a small relative gain, respectively, and Cooperators might feel negatively about inequity and a lack of fairness.

In general, participants are expected to show larger P300/LPP amplitudes for wheel outcomes in which they win the largest amount of money possible ($8), as is consistent with previous literature. If Cooperators (Prosocials) do indeed experience high levels of emotion in response to unequal offers, it is expected that Cooperators will produce larger P300/LPP amplitudes for both disadvantageous and advantageous wheel outcomes due to cognitive activity working to override initial, negative emotions. It is of interest to see if Proselfs will exhibit more P300/LPP activity to fair wheel outcomes than Prosocials, due to the fact that Proselfs will be disappointed to have not gotten the greatest amount of money possible.

Behaviorally, it is expected that Proselfs will accept advantageous wheel outcomes less often than Proselfs, and that Proselfs will accept disadvantageous wheel outcomes more often than Proselfs.

Chapter 2

METHODS

2.1 Participants

Participants were selected from a pool of undergraduate students completing a research requirement for an introductory psychology course at the University of Delaware. The students had completed a pretesting questionnaire at the beginning of the semester, in which the 12-item version of the Ring Measure (Liebrand, 1984) was administered to determine the SVO of each student. The student's "choice consistency index" had to amount to at least 0.6 to be classified as a Cooperator, Individualist, or Competitor. Participants were also selected based on the negation of three previous health conditions: a) an unexplained loss of consciousness, b) seizures, or c) brain surgery. Recruitment of participants occurred over the course of two consecutive academic semesters.

A roughly even distribution of Cooperators, Individualists, and Competitors were selected for the study. A total of 79 subjects completed the study, 18 of which were dropped on the basis of EEG data that could not be processed and/or did not have enough trials (20) to average for each condition. A total of 61 participants were included for statistical analyses. The final participant sample consisted of 25 Cooperators (13 male), 21 Individualists (11 male), and 15 Competitors (8 male).

2.2 Pretesting

During the pretesting phase, in addition to completing the Ring Measure and in addition to completing various questionnaires administered for other studies within the psychology department, each participant answered an item that would relate to the present study, although this relation was unbeknownst to the participant at the time of pretesting. The item asked the participant to divide $10 between him/herself and another student in the introductory psychology course using two available options. The student could choose to either divide the $10 to yield $5 for him/herself and $5 for the other student, or to yield $8 for him/herself and $2 for the other student. We represent these divides of $10 from now on as $5/$5 and $8/$2, respectively. The importance of this pretesting item will be discussed below in the task section.

2.3 Task

The task consisted of trials presented on a 17-inch monitor with a Dell optiplex GX270 computer and Gateway VX270 monitor using MediaLab and DirectRT software (both v2012, Empirisoft Corporation) to control the placement & timing of stimuli, to record participant decisions & reaction times, and to interface with the EEG recording software.

The task consisted of 300 trials containing stimuli superimposed on a black background. Each trial consisted of six events, each separated by 1,000 ms of the background screen. The task consisted of a series of events that led up to a UG situation in which the participant played the role of Responder (as opposed to the role of Proposer during pretesting), and ultimately accepted or rejected a split of $10. The study utilized the following deception: whereas the participant was told that the

“Proposer’s Offer” originated from the results of the $10 splits decided by students during pretesting, in actuality the study used an even distribution of $5/$5 and $8/$2 splits presented in a random order. With that in mind, the six events that occur in a single trial are listed on the next page:

Event 1- Fixation Cross: A white fixation cross (see Appendix C) appeared in the center of the screen for a duration of 1,000 ms. The purpose of the fixation cross was to focus the participant's attention towards the center of the screen in anticipation of the following stimulus.

Event 2 – Proposer's Offer: A pie chart (see Appendix D) displaying the P's offer appeared in the center of the screen for a duration of 2,000 ms. The participant was led to believe that the offer was a split of $10 decided by a fellow psychology student during pretesting, but in actuality the offer was a random presentation of either $5/$5 or $8/$2, each of which occurred for exactly half of the trials.

Event 3 – Wheel: A spinning wheel (see Appendix E) containing three options for the final offer for the trial appeared on the screen for a duration of 2,000 ms. The wheel symbolically represented the computer choosing from random a final offer for that trial from the options of: $8/$2, $5/$5, or $2/$8. It is worth noting that the last offer, that of $2/$8, was not one of the original options for the proposer's original offer; in this offer, the participant may receive $8.

Event 4 –Wheel Outcome: A pie chart (see Appendix F) displaying the wheel's decision for the final offer for that trial appeared on the screen for a duration of 2,000 ms. The final offer had a 1/3 chance of being $8/$2, a 1/3 chance of being $5/$5, and a 1/3 chance of being $2/$8.

Event 5 – Accept or Reject Decision: A prompt (see Appendix F) appeared on the screen, asking the participant to either accept or reject the final offer for that trial, using the keys "1" and "2", respectively, on the number pad of the keyboard. The participant had an indefinite amount of time to make the decision.

Participants were informed of the opportunity to win money as a result of participation in the study. A trial would be selected from random at the end of the study; if the participant had accepted the final offer generated by the spinning wheel, he/she would receive his/her allocation and the "other student" would supposedly be contacted and paid their allocation as well; if the participant had rejected the final offer, neither party would receive anything.

Within the study there were six possible conditions, originating from a 2 [Proposer Offer ($8/$2, $5/$5)] x 3 [Wheel Outcome ($8/$2, $5/$5, $2/$8)] design. Each of the 6 conditions was presented randomly exactly once before moving onto the next block of each of the 6 conditions, and so on and so forth. Each of the conditions was presented exactly 50 times during the course of the task. After every 18 trials (~ 7 minutes) there was a break for the participant to move around and readjust. During half of the breaks, the experimenter entered the room to check on the participant, offer water, and fix any recording problems. During the other breaks, the participant remained alone in the room with directions on the screen to continue with the study when ready. If there were problems with electrodes, they were addressed during the nearest break time. The entire computer task took approximately 45 minutes to complete.

2.4 Procedure

Upon arrival, participants were given a consent form along with encouragement to ask any questions that arose concerning participation and the reminder of the option to withdraw from participation in the study at any time and without penalty. Upon consenting, the participant was fitted with an electrode cap embedded with 30 Ag/Cl sintered electrodes, an average reference, and a forehead ground. A 5mL syringe fitted with a 16 gauge ¾-inch blunt needle was inserted into each electrode space to move aside hair, scrape away dead skin cells from the scalp, and fill each electrode hole in the cap with EEG conductance gel.

The participant was led into the computer task room and seated 12-18 inches away from the computer screen. The room was a small, square room with white walls and empty except for the computer desk, a small table, two chairs, and the electrode recording system. The lights remained on and the door remained closed for the duration of the experiment. Before beginning the subject on the computer task, the experimenter demonstrated to the participant how sensitive the EEG equipment is to muscle movement by having the participant blink his/her eyes and clench his/her jaw. The participant was instructed to move as little as possible during the trials and to wait for the breaks between blocks of trials to make bodily adjustments. The participant was then shown a 7-minute instructional PowerPoint presentation with accompanying audio instructions. The PowerPoint presentation: 1) reminded the participant of the item on the pre-testing questionnaire asking him/her to divide $10 between him/herself and another student in the introductory psychology course, 2) informed the participant of the opportunity to win money as a result of the study, 3) described the study in detail, 4) and walked the participant through two sample trials step by step. Directly following the PowerPoint instructions, the participant completed six practice trials. After the practice trials the experimenter entered the computer room to test comprehension by asking the participant to explain the study, to answer any questions, and to remind the participant about the breaks between blocks of trials. Both the PowerPoint instructions and the experimenter avoided mention of reasons a participant may accept or reject an offer, as instructing participants to further either their own gain or collective gain may have influenced behavior (O'Connor & Carnevale, 1997).

Following completion of the computer task, the participant was brought into another room to a different computer to respond to a series of post-experiment questions on an online Qualtrics survey. The questions determined the participant's perceptions, understanding, suspicions, and feelings of the study. Upon completion of the questionnaire, the participant was given two options to receive money for participation. The participant could either 1) leave the study with a guaranteed $5, or 2) wait for the actual results from picking a trial at random (the participant could receive $0, $2, $5, or $8). Waiting for the actual results required that the experimenter dismiss the participant for the day and on a later day randomly choose one of the trials from that participant's computer data. If for that trial the participant accepted the final offer, he/she would receive the amount allocated to him/her; if the participant rejected the final offer, he/she would receive nothing. The participant was then uncapped and released from the visit. Debriefing forms were emailed to all participants at the conclusion of data collection for the present study.

2.5 Neurophysiological Recording, Data Reduction, and Analysis

Participants were fitted with an electrode cap embedded with 30 Ag/Cl sintered electrodes, an average reference, and a forehead ground. EEG impedances were below 20 KΩ with an occasional impedance between 20-35 KΩ which would not go down further, and the data were digitized at 512 Hz using ANT acquisition hardware (Advanced Neuro Technology, Enschede, The Netherlands). Offline, continuous EEG was corrected for eye blinks with ASA software from ANT. The data was band-pass filtered from 0.1 to 30 Hz with a Butterworth digital filter and re-referenced to the average of the mastoids. Trials in which artifacts exceeded a threshold of ±75 μV were automatically rejected. Epochs were extracted from 100ms before and 900 ms after the presentation of the offers for each trial. For each ERP, activity that was 200ms prior to the stimulus served as a baseline.

Primary regions of interest (ROIs), in which the MFN/N200 and P300/LPP complex components were statistically analyzed, were chosen according to literature localizing the components and were confirmed through head plots. Four fronto-central electrodes (Fz, FC1, FC2, Cz) formed the ROI for the MFN/N200 and four centro-parietal electrodes (Pz, Cz, CP1, CP2) formed the ROI for the P300/LPP. The ERPs of the respective electrodes were averaged together to quantify each component. The mean amplitudes of the components were then measured during time windows consistent with visual inspection of the ERPs and with previous literature: 220-420ms for the MFN/N200 and 420-720ms for the P300/LPP complex).

Chapter 3

RESULTS

3.1 General

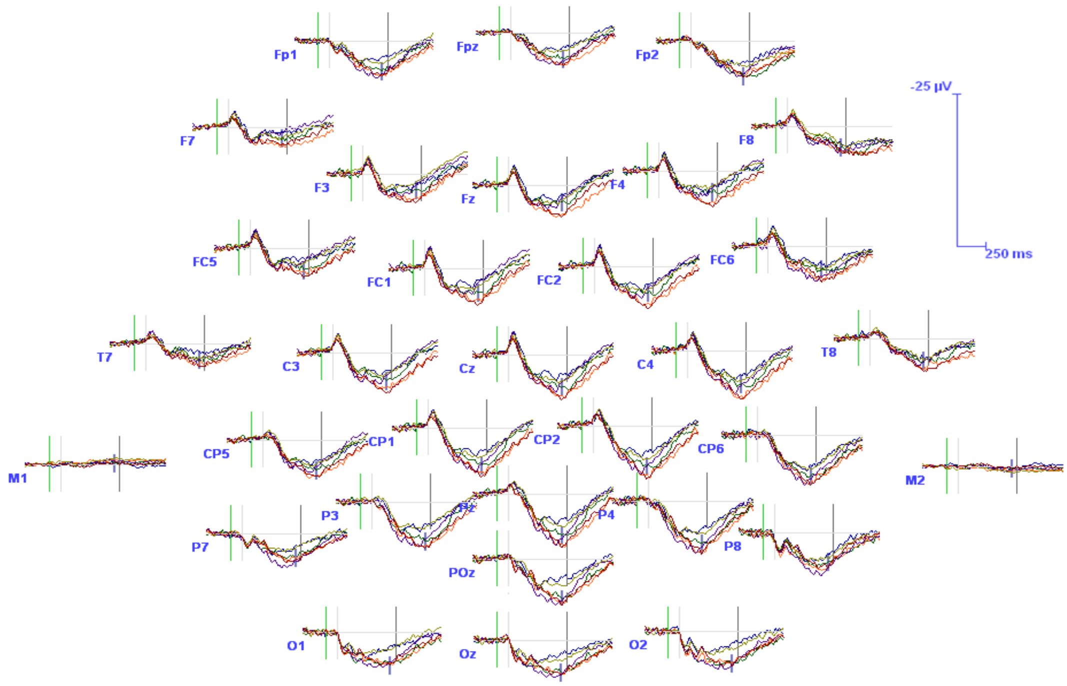
Two separate analyses of variance (ANOVAS) were performed, one for each of the two ERP components (MFN/N200 and P300/LPP) described earlier. The design for each ANOVA was a 2(Sex) by 3(SVO) by 2(Proposer Offer) by 3(Wheel Outcome) factorial in which sex and SVO were between subject variables and proposer offer and wheel were within subject (or, repeated measures) variables.

For each ANOVA, null hypotheses for global effects were tested using the Multivariate Model, and also the more traditional Mixed Model. Results were the same for both models. For this reason, only ANOVA results for the Mixed Model will be reported. The ANOVA summary tables for the global effects for MFN/200 and P300/LPP are given in Appendices A and B, respectively.

Significant global effects with more than 1 degree of freedom were decomposed via single degree of freedom contrasts. The specific contrasts employed will be described at the time they are presented in this results section.

Figure 1, containing the ERP waveforms of the six wheel outcomes for all 32 electrodes, is shown on the next page.

Figure 1. Wheel outcomes for all 32 electrodes.

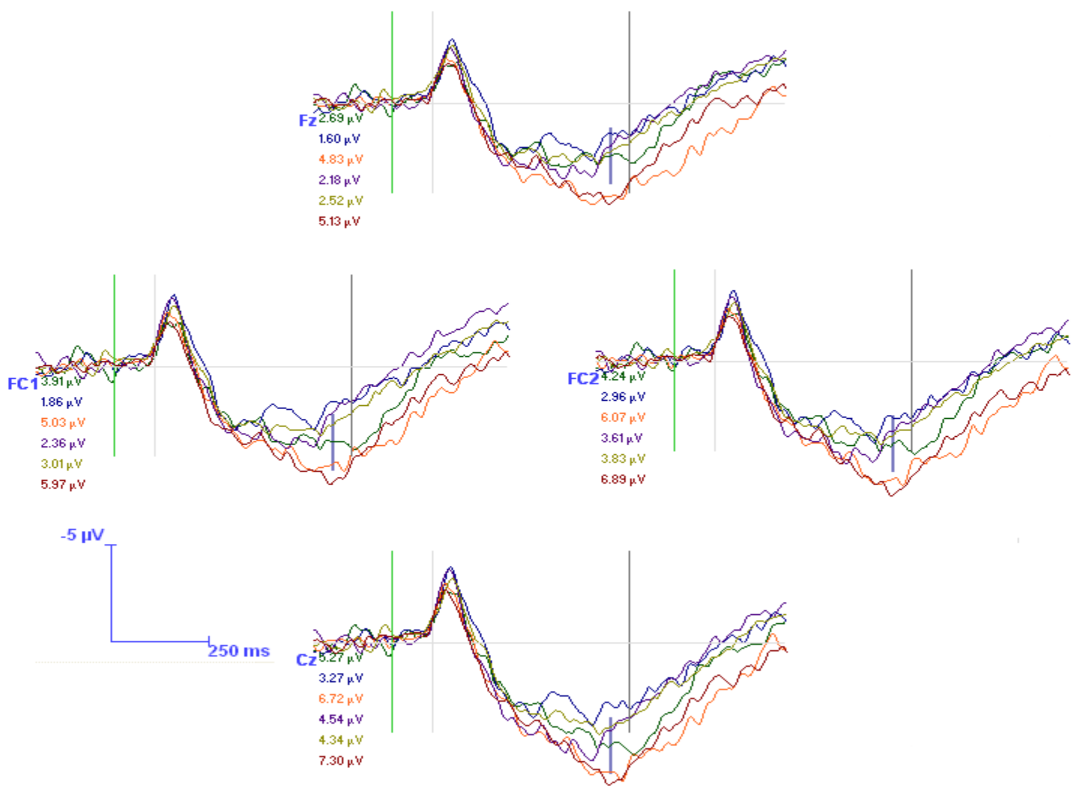


Divider $5/$5, Wheel $5/$5
Divider $5/$5, Wheel $8/$2
Divider $5/$5, Wheel $2/$8
Divider $8/$2 Wheel $5/$5
Divider $8/$2, Wheel $8/$2
Divider $8/$2, Wheel $2/$8

3.2 Results for the MFN/N200 Component

The ERP waveforms for the MFN/N200 ROI are shown in Figure 2 below.

Figure 2. Wheel outcomes for MFN/N200.



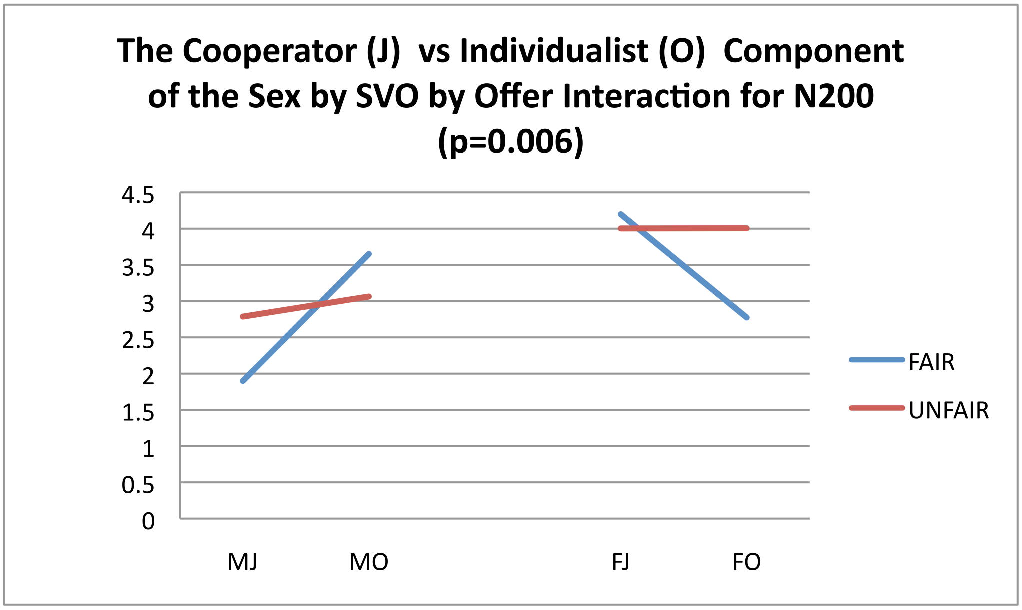
Divider $5/$5, Wheel $5/$5
Divider $5/$5, Wheel $8/$2
Divider $5/$5, Wheel $2/$8
Divider $8/$2 Wheel $5/$5
Divider $8/$2, Wheel $8/$2
Divider $8/$2, Wheel $2/$8

There were no main effects for participant sex, SVO, or the Sex by SVO interaction for the overall average of MFN/N200. However, interaction effects for the proposer offer (fair, unfair) and also for the wheel outcome (equal, advantageous split, disadvantageous split) were found.

For the proposer offer, the only significant global effect was the three-way interaction between participant sex, participant SVO and the proposer offer ($F(2,55)=4.08$, $p=0.022$). This 2-df global interaction was decomposed into two 1-df contrasts. The first examined the Cooperator vs. Individualist by Proposer Offer interaction in males and females, and was found to be significant ($F(1,55)=7.902$, $p=0.006$). The second examined the Cooperator vs. Competitor by Proposer Offer interaction in males and females, which was not significant ($F(1,55)=2.628$, $P=0.111$).

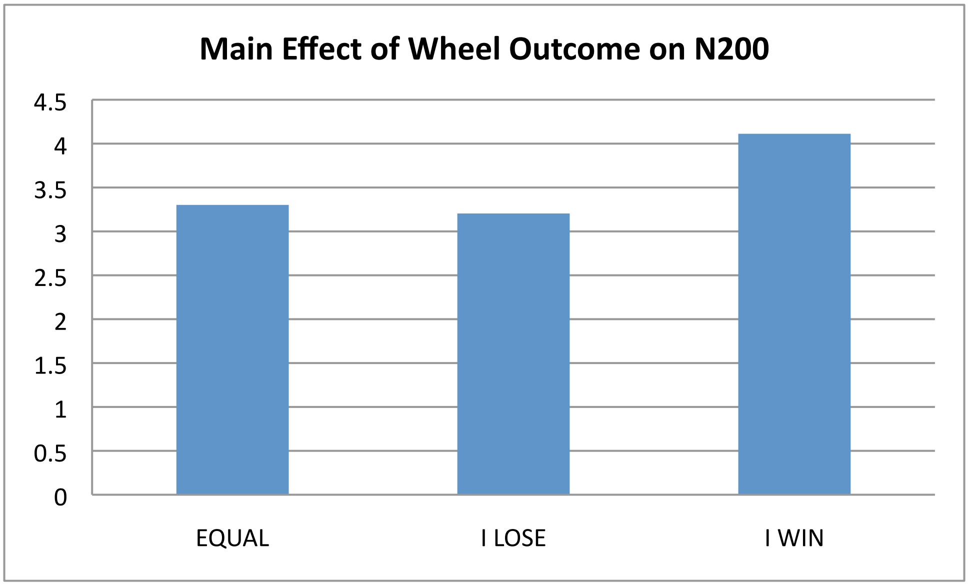
The means associated with the significant contrast (Cooperator vs. Individualist by Sex by Proposer Offer) are shown in Figure 3. This figure suggests that the Cooperator vs. Individualist difference in response to the unfair proposer offer was quite small in males and non-existent in females. For the fair proposer offer however, the Cooperator vs. Individualist difference is larger and goes in different directions for males and females.

Figure 3. The Cooperator vs. Individualist component of the Sex by SVO by Offer Interaction for N200.



For the wheel outcome, there was one significant global effect, which was the main effect for wheel outcome ($F(2,55)=4.62$, $p=0.012$). The means for this effect are shown in Figure 4. The main effect was decomposed into two 1-df contrasts. The first contrast compared the equal outcome (where both parties receive $5) with the *dis*advantageous outcome (the participant gets only $2 and the other person gets $8). As suggested by the figure, this contrast was not significant ($F(1,55)=1.414$, $p=0.239$). The second contrast compared the *dis*advantageous outcome with the *ad*vantageous outcome (the participant gets $8 and the other person gets $2), which was found to be reliable ($F(1,55)=8.644$, $p = 0.005$).

Figure 4. Main effect of wheel outcome on N200.



For the interaction between Proposer Offer and Wheel Outcome, no global effects were found; all p-values were 0.29 or greater. Although main effects for each of the within subject variables were found, there is no evidence for the N200 that response to the wheel was different for the fair and unfair proposer.

3.3 Results for the P300/LPP Complex

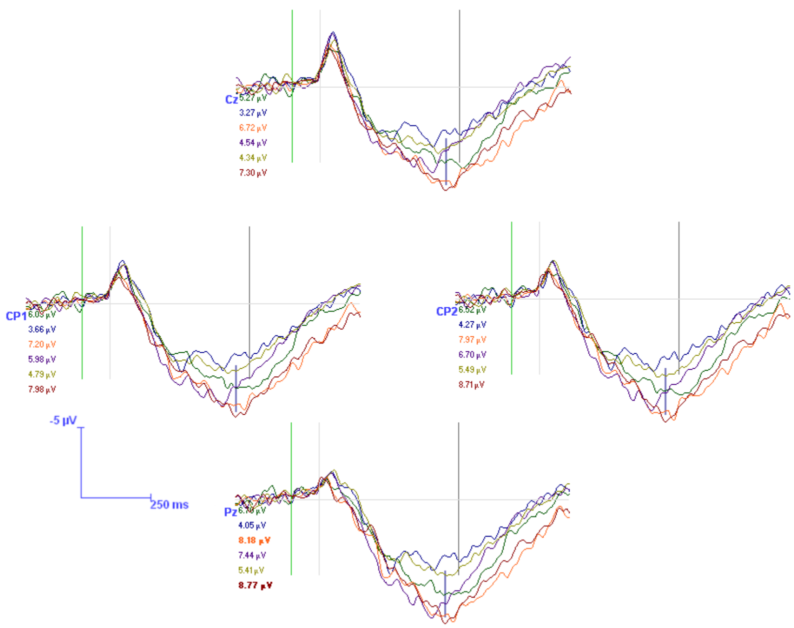
The ERP waveforms for the MFN/N200 ROI are shown in Figure 5. For this ERP complex there were no global effects found for the overall average. The significant effects for the proposer offer and for the wheel outcome are described below.

For the proposer offer, the P300/LPP was smaller for the fair offer (Mn = 5.29) than for the unfair offer (Mn = 5.85), ($F(1,55) = 5.82$, $P = 0.019$). This effect was not moderated by participant sex, SVO, or the sex by SVO interaction.

For the wheel outcome, a significant main effect on P300/LPP was observed ($F(2,55) = 19.00$ $p < 0.001$), which was remarkably similar to the same effect on N200 reported above. The means for this effect are shown in Figure 6. This effect was decomposed into the same two 1-df contrasts used above for the N200 component. The comparison of equal with *dis*advantageous offer was not significant ($F(1,55)=1.438$, $p = 0.236$). The comparison of *dis*advantageous with *ad*vantageous was reliable ($F(1,55) = 19.54$, $p <0.0001$). The effect for wheel outcome was not moderated by participant sex, SVO, or the Sex by SVO interaction.

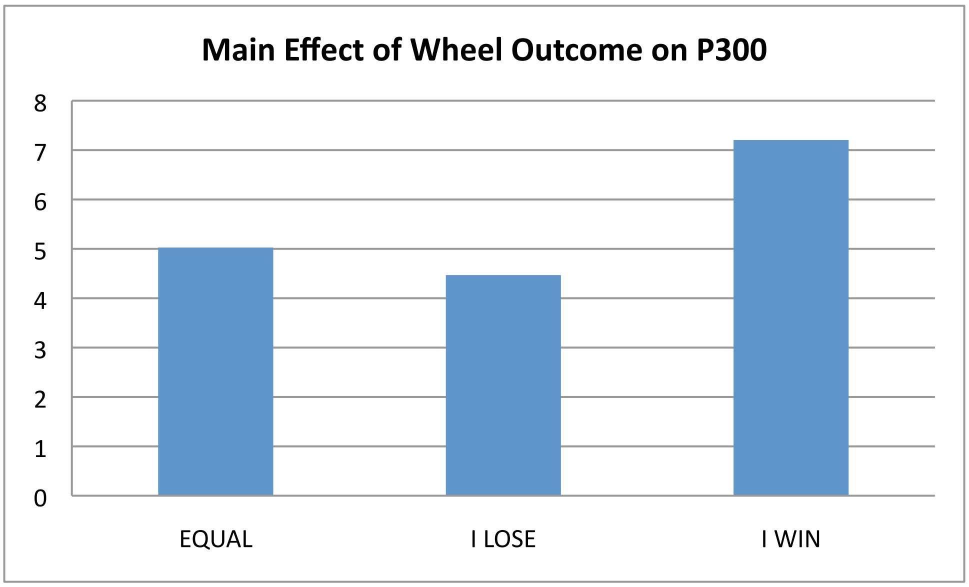
For the proposer offer by wheel outcome interaction, no global effects were found; all p values were greater than 0.11. And for this component, again, there is no evidence that the ERP response to the wheel was moderated by (or different from) the original fairness/unfairness of the other person.

Figure 5. Wheel outcomes for P300/LPP.



Divider \$5/\$5, Wheel \$5/\$5
Divider \$5/\$5, Wheel \$8/\$2
Divider \$5/\$5, Wheel \$2/\$8
Divider \$8/\$2 Wheel \$5/\$5
Divider \$8/\$2, Wheel \$8/\$2
Divider \$8/\$2, Wheel \$2/\$8

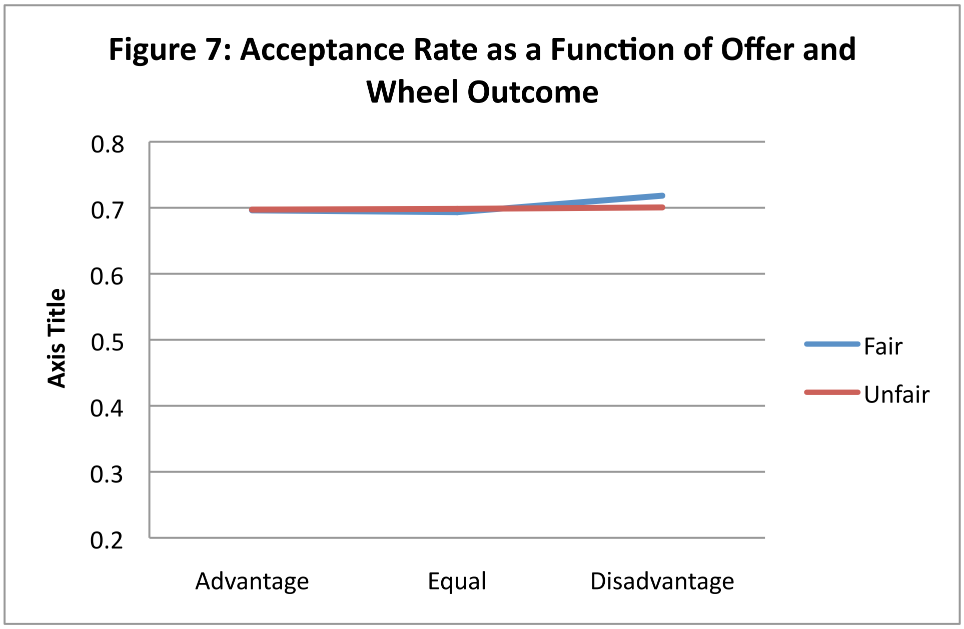
Figure 6. Main effect of wheel outcome on P300.



3.4 Results for Choice Behavior

Although the major focus of this thesis was on the ERP components as reported above, it is important to know if the participant's decision to accept the wheel offer was influenced by any of the independent variables in the study. A 2(Sex) by 3(SVO) by 2(Person) by 3(Wheel) ANOVA was conducted in which the dependent variable was the proportion of Accept responses the participant made in each of the six cells of the design shown in Table 1. Results are easily summarized: no significant effects were observed. Figure 7 shows this virtual lack of variation in acceptance rates.

Figure 7. Acceptance rate as a function of offer and wheel outcome.



Chapter 4

DISCUSSION

4.1 General Discussion

The present thesis aimed to investigate the neurophysiological correlates of decision-making in the UG across the personality trait SVO. Disappointingly, no main effects for SVO were observed for either the MFN/N200 or P300/LPP components.

MFN/N200 results revealed only one significant global effect, which was the three-way interaction between participant sex, participant SVO and the proposer offer. In this global effect, Cooperators differed from Individualists for the proposer's offer, and there were differences observed between males and females. Specifically, females and males exhibited similar N200 amplitudes in Cooperators and in Individualists for unfair offers, but exhibited N200 amplitudes in opposite directions for fair offers. The results suggest that male Cooperators exhibited the most MFN and that female Cooperators exhibited the least MFN for fair offers within the Cooperator and Individualist groups. The author is not sure how to explain these results in terms of SVO research and is curious if future studies produce similar results.

MFN/N200 results in general revealed more negativity for wheel outcomes in which the participant received an *ad*vantageous outcome, which is contradictory to previous literature that has found that MFN/N200 outcomes reflect a motivational/affective evaluation of adverse outcomes (Gehring & Willoughby, 2002; Hajcak, Moser, Yeung, & Simons, 2005; Boksem, Tops, Kostermans, & De Cremer, 2008) and to be particularly sensitive to the violation of social expectancy or norms

(Polezzi, Daum, Rubaltelli, et al., 2008; Boksem & De Cremer, 2010; Hewig, Kretschmer, Trippe, et al., 2011; Wu, Leliveld, & Zhou, 2011; Van der Veen & Sahibdin, 2011). From this knowledge it would be expected that *dis*advantageous outcomes in particular would elicit the most MFN followed by the equal offer and then the *ad*vantageous offer. The only explanation that can be offered is that the P300/LPP values began earlier than their usual window of time, thus erasing MFN effects, and this is observable in the ERP waveform.

The results seen in the MFN/N200 component contradict the results from Haruno and Frith (2010) that demonstrate that Prosocials evaluate inequality with emotion derived from the amygdala. Specifically, Prosocials experience high emotionality to unfair offers. It was expected from the present study that Cooperators would exhibit more MFN than both Individualists and Competitors because they are more inequality adverse, but this was not seen. It is possible that the participants within the study felt differently about the wheel outcomes for varying reasons (attributable to their SVO) but that their reactions are not quantitatively different as recorded by EEG. Additional behavioral data in the form of an online Qualtrics survey was collected at the end of each participant visit and might provide interesting individual differences where EEG did not. However, there was not enough time between the end of collecting data and this thesis defense to analyze the results of the surveys.

As predicted for the P300/LPP complex, participants exhibited larger positive amplitudes to wheel outcomes in which they received $8 (*ad*vantageous inequality) as compared to equal or *dis*advantageous inequality, which is consistent with previous studies that show larger positive amplitudes for positive rewards than for negative rewards (Yeung & Sanfey, 2004; Sato et al., 2005) and show sensitivity to reward valence (Hajcak et al., 2005, 2007; Yeung et al., 2005). Contradictory to the finding of Wu et al. (2011), equal offers did not elicit more positivity than unequal offers (*dis*advantageous offers only were used). Furthermore, it is disappointing that there was not an effect for SVO in this component. Cooperators were expected to have larger P300/LPP amplitudes in general due to a certain amount of "dwelling" on the unfairness of inequality, in line with the idea that the P300/LPP complex reflects increased motivated attention (van Hooff et al., 2010) and that the LPP is generally the most pronounced for higher levels of autonomic arousal, for motivationally relevant stimuli, and for high reports of affective experience (Schupp et al., 2004; Briggs and Martin, 2009).

As mentioned before, the general observations for the main effects for wheel outcome between MFN/N200 and P300/LPP are the same, suggesting some continuity of brain activity in the participants across the time interval of 220-720ms. The lack of findings for a main effect for SVO is consistent with the findings of van't Wout et al. (2006) that found that skin conductance, a measure of affective state, did not increase in response to unfair offers for computer generated offers as compared to human generated offers. The results of the present study indicate that the character information provided before the wheel outcome in each trial was not a strong enough manipulation to create an effect for individual differences in the responses to the wheel outcomes.

Results for the choice behavior reveal no significant effects. Acceptance rates were virtually identical for both unfair and fair proposer offers and for all wheel outcome types. This is perhaps consistent with the expectations derived from the van't

Wout et al. (2006) study discussed above, which predicted little affective response to computer generated offers. Traditional UG literature, however, uses offers generated from humans. Had the present thesis collected accept/reject decisions directly after the proposer offer, we may have observed a higher acceptance rate to unfair offers in Cooperators as seen in Karagonlar & Kuhlman (2013).

4.2 Limitations

A methodological limitation to the present study is the complexity of the paradigm that was used. Karagonlar and Kuhlman (2013) used the standard UG paradigm when the authors found that Prosocials accept unfair offers more often than Proselfs and that a subgroup of Prosocials who reject the unfair offer reported a high level of negative emotion. The present thesis attempted to find results that would generalize to the results obtained by Karagonlar and Kuhlman (2013), but the paradigm was altered to answer an additional question about inequality in the context of SVO. If the present study were designed to solely look for evidence of initial emotional reactions and an attempt to cognitively override them, then the accept/reject decision of the participant should have come directly following the proposer's offer. Similarly, if the present study were designed to find further evidence for inequality aversion in Prosocials, then the first part of the trials when the participant saw a proposer's initial offer should have been left out of the paradigm. The multi-staged paradigm of the present thesis gave way for an interesting exploratory study, but may also have complicated the questions that were asked.

The next avenue for the present thesis is to explore the Qualtrics survey data, which explored thoughts, feelings, and perceptions regarding the study, to see if there are SVO effects that manifested themselves behaviorally and not neurophysiologically.

REFERENCES

Amiez, C., Joseph, J.P., & Procyk, E. (2005). Anterior cingulate error-related activity is modulated by predicted reward. *European Journal of Neuroscience*, 21(12), 3447-3452.

Andreoni, J., & Bernheim, B. (2006). Social image and the 50-50 norm, a theoretical and experimental analysis of audience effects. *Econometrica*, 77, 1607-1636.

Au, W.T., & Kwong, J.Y.Y. (2004). Measurements and the effects of social-value orientation in social dilemmas: a review. In R. Suleiman, D.V. Budescu, I. Fischer, & D.M. Messick (Eds.), *Contemporary psychological research on social dilemmas* (pp. 71-98). New York, NY: Cambridge University Press.

Blount, S. (1995). When social outcomes aren't fair: the effect of casual attribution on preferences. *Organizational Behavior and Human Decision Processes*, 63(2), 131-144.

Bogaert, S., Boone, C., Declerck, C. (2008). Social value orientation and cooperation in social dilemmas: a review and conceptual model. *British Journal of Social Psychology*, 47, 453-480.

Bohnet, I., & Zeckhauser, R. (2004). Social comparisons in ultimatum bargaining. *Scandanavian Journal of Economics*, 106, 495-510.

Boksem, M.A.S., & De Cremer, D. (2010). Fairness concerns predict medial frontal negativity amplitude in ultimatum bargaining. *Social Neuroscience*, 5, 118-128. doi:10.1080/17470910903202666

Boksem, M.A.S., Tops, M., Kostermans, E., & De Cremer, D. (2008). Sensitivity to punishment and reward omission: evidence from error-related ERP components. *Biological Psychology*, 79, 185-192.

Briggs, K.E., & Martin, F.H. (2009). Affective picture processing and motivational relevance: arousal and valence effects on ERPs in an oddball task. *International Journal of Psychophysiology*, 72(3), 299-306.

Burklund, L.J., Eisenberger, N.I., & Lieberman, M.D. (2007). The face of rejection: rejection sensitivity moderates dorsal anterior cingulate activity to disapproving facial expressions. *Social Neuroscience*, 2(3-4), 238-253.

Calder, A.J., Lawrence, A.D., & Young, A.W. (2001). Neurophysiology of fear and loathing. *Nature Reviews Neuroscience*, 2(5), 352-363.

Camerer, C. F. (2003). *Behavioral game theory: experiments in strategic interaction.* NJ, USA: Princeton University Press.

Camerer, C., & Thaler, R.H. (1995). Anomalies: ultimatums, dictators, and manners. *The Journal of Economic Perspectives*, 9(2), 209-219.

Civai, C., Corradi-Dell'Acqua, C., Gamer, M., & Rumiati, R.I. (2010). Are irrational reactions to unfairness truly emotionally-driven? Dissociated behavioral and emotional responses in the ultimatum game task. *Cognition*, 114, 89-95.

De Cremer, D., & Van Vugt, M. (1999). Social identification effects in social dilemmas: a transformation of motives. *European Journal of Social Psychology*, 29, 871-893.

Falk & Fischbacher (2006). A theory of reciprocity. *Games and Economic Behavior*, 56, 293-315.

Fehr, E., & Gachter, S. (2002). Altruistic punishment in humans. *Nature*, 425, 785-791.

Fehr, E. & Schmidt, K. (1999). A theory of fairness, competition, and cooperation. *Quarterly Journal of Economics*, 114, 817-868.

Festinger, L. (1954). A theory of social comparison processes. *Human Relations*, 7, 117-140

Gehring, W.J., & Willoughby, A.R. (2002). The medial frontal cortex and the rapid processing of monetary gains and losses. *Science*, 295(5563), 2279-2282.

Gray, H.M., Ambady, N., Lowenthal, W.T., & Deldin, P. (2004). P300 as in index of attention to self-relevant stimuli. *Journal of Experimental Social Psychology*, 40, 216-224.

Güth, W., Schmittberger, R., & Schwarze, B. (1982). An experimental analysis of ultimatum bargaining. *Journal of Economic Behavior and Organization, 3,* 367-388.

Hajcak, G., Moser, J.S., Yeung, N., & Simons, R.F. (2005). On the ERN and the significance of errors. *Psychophysiology*, 42(2), 151-160.

Hessing, D.J. & Elffers, H. (1987). Sociale dilemma's: De psychologie van de belastingontduiking en het tekort aan donororganen [Social dilemmas: the psychology of tax evasion and the shortage of donor organs]. *Recht der Werkelijkheid*, 8: 7-29.

Hewig, J., Kretschmer, N., Trippe, R.H., Hecht, H., Coles, M., Holroyd, C.B., & Miltner, W.H. (2011). Why humans deviate from rational choice. *Psychophysiology*, 48, 507-514.

Hoffman, E., McCabe, K., Shachat, K, & Smith, V. (1994). Preferences, Property Rights and Anonymity in Bargaining Games. *Games and Economic Behavior*, 7, 346-80. 653-660.

Hoffman, E., McCabe, K., & Smith, V. (1996a). On expectations and the monetary stakes in ultimatum games. *International Journal of Game Theory*, 25, 289-301.

Hoffman, E., McCabe, K., & Smith, V. (1996b). Social Distance and Other-Regarding Behavior in Dictator Games. *The American Economic Review*, 86 (3), 653-660.

Holroyd, C.B., & Coles, M.G.H. (2002). The neural basis of human error processing: reinforcement learning, dopamine, and the error-relate negativity. *Psychological Reviews*, 109(4), 679-709.

Ito, T.A., Larsen, J.T., Smith, N.K., & Cacioppo, J.T. (1998). Negative information weights more heavily on the brain: the negativity bias in evaluative categorizations. *Journal of Personality and Social Psychology*, 75(4), 887-900.

Kahneman, D., Knetsch, J, & Thaler, R.H. (1986). Fairness as a constraint on profit seeking: entitlements in the market. *American Economics Review*, 76, 728-41.

Karagonlar, G. & Kuhlman, D.M. (2013). The Role of Social Value Orientation in Response to an Unfair Offer in the Ultimatum Game. *Organizational Behavior and Human Decision Processes*, 120, 228-239.

Kramer, R., McClintock, C.G. & Messick, D.M. (1986). Social values and cooperative response to a simulated resource regression and clustering approach.

Kuhlman, D.M., Camac, C.R., & Cunha, D.A. (1986). Individual differences in orientation. In: Wilke, H., Messick, D., and Rutte, C. (Eds), *Experimental Dilemmas*, Peter Lang, Frankfurt am Main, pp. 151-176.

Kuhlman, D.M. & Marshello, A. (1975a). Individual differences in the game motives of own, relative, and joint gain. *Journal of Research in Personality*, 9, 240-251.

Kuhlman, D.M. & Marshello, A. (1975b). Individual differences in game motivations as moderators of preprogrammed strategic effects in prisoner's dilemma. *Journal of Personality and Social Psychology*, 32, 922-931.

Liebrand, W.B. (1984). The effect of social motives, communication and group size on behaviour in an N-person multistage mixed-motive game. *European Journal of Social Psychology*, 14, 239-264.

Liebrand, W.B. & Van Run, G.J. (1985). The effect of social motives across two cultures on behavior in social dilemmas. *Journal of Experimental Social Psychology*, 21, 86-102.

Linden, D.E.J. (2005). The P300: where in the brain is it produced and what does it tell us? *Neuroscientist*, 11, 563-576.

Lowenstein, G.F., Thompson, L., & Bazerman, M.H. (1989). Social utility and decision making in interpersonal contexts. *Journal of Personality and Social Psychology*. 57, 426-441.

Matsumoto, M., Matsumoto, K., Abe, H., & Tanaka, K. (2007). Medial frontal cell activity signaling prediction errors of action values. *Nature Neuroscience*, 10(5), 647-656.

Messick, D.M. & McClintock, C.G. (1968). Motivational basis of choice in experimental games. *Journal of Experimental Social Psychology*, 4, 1-25.

Messick, D.M. & Sentis, K.P. (1985). Estimating social and nonsocial utility functions from ordinal data. *European Journal of Social Psychology*, 15, 389-399.

McClintock, C.G. & Allison, S. (1989). Social value orientation and helping behavior. *Journal of Applied Social Psychology*. 4, 353-362.

McClintock, C.G., & Liebrand (1988). Role of interdependence structure, individual value orientation, and another's strategy in social decision making: a transformational analysis. *Journal of Personality and Social Psychology*, 55, 396-409.

McClintock, C.G., Messick, D.M., Kuhlman, D.M., & Campos, F.T. (1973). Motivational basis of choice in three choice decomposed games. *Journal of Experimental Psychology*, 9, 572-590.

Nieuwenhuis, S., Aston-Jones, G., & Cohen, J.D. (2005). Decision making, the P3, and the locus coeruleus-norepinephrine system. *Psychology Bulletin*, 131, 510-532.

Nieuwenhuis, S., Schweizer, T.S., Mars, R.B., Botvinick, M.M., & Hajcak, G. (2007). Error-likelihood predication in the medial frontal cortex: a critical evaluation. *Cerebral Cortex*, 17(7), 1570-1581.

O'Connor, K.M., & Carnevale, P.J. (1997). A nasty but effective negotiation strategy: misrepresentation of a common-value issue. *Personality and Social Psychology Bulletin*, 23, 504-515.

Phillips, M.L., Young, A.W., Senior, C., Brammer, M., Andrew, C., Calder, A.J., et al. (1997). A specific neural substrate for perceiving facial expressions of disgust. *Nature*, 389(6650), 495-498.

Polezzi, D., Daum, I., Rubaltelli, E., Lotto, L., Civai, C., Sartori, G., & Rumiati, R. (2008). Mentalizing in economic decision-making. *Behavioral Brain Research*, 190, 218-223.

Rabin, M. (1993). Incorporating fairness into game theory. *Games and Economic Behavior*, 83, 1281-302.

Roth, A.E., Prasnikar, V., Zamir, S, & Okuno-Fujiwara, M. (1991). Bargaining and market behavior in Jerusalem, Ljublijana, Pittsburgh, and Tokyo: an experimental study. *American Economic review*, 81, 1068-1095.

Rubenstein, A. (1982). Perfect equilibrium in a bargaining model. *Econometrica, 50*, 97-109.

Sanfey, A.G., Rilling, J.K., Aronson, J.A., Nystrom, L.E., & Cohen, J.D. (2003). The neural basis of economic decision-making in the ultimatum game. *Science, 300*, 1755-1758.

Schupp, H. T., Cuthbert, B. N., Bradley, M. M., Hillman, C. H., Hamm, A. O., & Lang, P. J. (2004). Brain processes in emotional perception: motivated attention. *Cognition and Emotion*, 18, 593- 611.

Tricomi, E., Rangel, A., Camerer, C.F., & O'Doherty, J.P. (2010). Neural evidence for inequality-averse social preferences. *Nature*, 463, 1089-1091.

Ullsperger, M., Nittono, H., & von Cramon, D.Y. (2007). When goals are missed: dealing with self-generated and externally induced failure. *Neuro-Image*, 35(3), 1356-1364.

Van der Veen, F.M., & Sahibdin, P.P. (2011). Dissociation between medial frontal negativity and cardiac responses in the ultimatum game: effects of offer size and fairness. *Cognitive, Affective, and Behavioral Neuroscience*, 11, 516-525.

Van Dijk, E., DeCremer, D., & Handgraaf, M.J.J. (2004). Social value orientations and the strategic use of fairness in ultimatum bargaining. *Journal of Experimental Social Psychology*, 40, 697-707.

Van Lange, P.A.M., Bekkers, R., Schuyt, T.N.M., & Van Vugt, M. (2007). From games to giving: social value orientation predicts donations to noble causes. *Basic and Applied Social Psychology*, 29, 375-384.

Van Lange, P.A.M. (1999). The pursuit of joint outcomes and equality in outcomes: an integrative model of social value orientations. *Journal of Personality and Social Psychology*, 77, 337-349.

Van Lange, P.A.M., & Semin-Goossens, A. (1998). The boundaries of reciprocal cooperation. *European Journal of Social Psychology*, 28, 847-854.

Van Vugt, M., Meertens, R.M., & Van Lange, P.A.M. (1995). Car versus public transportation? The role of social value orientations in a real-life social dilemma. *Journal of Applied Social Psychology*, 25, 258-278.

Van't Wout, M., Kahn, R.S., Sanfey, A.G., & Aleman, A. (2006). Affective state and decision-making in the ultimatum game. *Experimental Brain Research*, 169, 564-568.

Walster, E., Berscheid, E., & Walster, G.W. (1973). New directions in equity research. *Journal of Personality and Social Psychology*, 25, 151-176.

Wu, Y., Leliveld, M.C., & Zhou, X. (2011). Social distance modulates recipient's fairness consideration in the dictator game: an ERP study. *Biological Psychology*, 88, 253-262.

Wu, Y., Zhou, Y., van Dijk, E., Leliveld, M.C., & Zhou, X. (2011). Social comparison affects brain responses to fairness in asset division: an ERP study with the ultimatum game. *Frontiers in Human Neuroscience*, 5, 131.

Yeung, N., & Sanfey, A.G. (2004). Independent coding of reward magnitude and valence in the human brain. *Journal of Neuroscience*, 24, 6258-6264.

Appendix A

ANOVA SUMMARY TABLE FOR N200

OVERALL AVERAGE OF N200

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	3883.17	55	70.60		
SEX	35.37	1	35.37	.50	.482
SVO	37.72	2	18.86	.27	.767
SEX BY SVO	63.12	2	31.56	.45	.642

EFFECTS OF THE PERSON'S OFFER ON N200

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	250.44	55	4.55		
PERSON	11.03	1	11.03	2.42	.125
SEX BY PERSON	5.46	1	5.46	1.20	.278
SVO BY PERSON	.08	2	.04	.01	.991
SEX BY SVO BY PERSON	**37.13**	**2**	**18.57**	**4.08**	**.022**

EFFECTS OF WHEEL OUTCOME ON N200

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	687.82	110	6.25		
WHEEL	**57.78**	**2**	**28.89**	**4.62**	**.012**
SEX BY WHEEL	4.68	2	2.34	.37	.689
SVO BY WHEEL	20.71	4	5.18	.83	.510
SEX BY SVO BY WHEEL	12.66	4	3.16	.51	.731

EFFECTS OF OFFER BY WHEEL OUTCOME ON N200

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	584.82	110	5.32		
PERSON BY WHEEL	13.25	2	6.62	1.25	.292
SEX BY PERSON BY WHL	4.77	2	2.39	.45	.640
SVO BY PERSON BY WHL	6.95	4	1.74	.33	.859
SX BY SV BY PER BY WHL	21.23	4	5.31	1.00	.412

Appendix B

ANOVA SUMMARY TABLE FOR P300

OVERALL AVERAGE OF P300

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	6896.82	55	125.40		
SEX	300.39	1	300.39	2.40	.127
SVO	25.16	2	12.58	.10	.905
SEX BY SVO	70.78	2	35.39	.28	.755

EFFECTS OF THE PERSON'S OFFER ON P300

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	262.97	55	4.78		
PERSON	**27.84**	**1**	**27.84**	**5.82**	**.019**
SEX BY PERSON	7.72	1	7.72	1.61	.209
SVO BY PERSON	17.41	2	8.70	1.82	.172
SEX BY SVO BY PERSON	21.34	2	10.67	2.23	.117

EFFECTS OF WHEEL OUTCOME ON P300

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	1407.58	110	12.80		
WHEEL	**486.18**	**2**	**243.09**	**19.00**	**.000**
SEX BY WHEEL	22.43	2	11.21	.88	.419
SVO BY WHEEL	83.18	4	20.80	1.63	.173
SEX BY SVO BY WHEEL	30.97	4	7.74	.61	.660

EFFECTS OF OFFER BY WHEEL OUTCOME ON P300

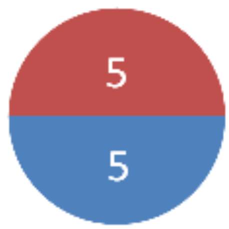
Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	922.92	110	8.39		
PERSON BY WHEEL	16.70	2	8.35	1.00	.373
SEX BY PERSON BY WHL	7.83	2	3.91	.47	.628
SVO BY PERSON BY WHL	42.52	4	10.63	1.27	.287
SX BY SV BY PER BY WHL	64.76	4	16.19	1.93	.111

Appendix C

FIXATION CROSS

Appendix D

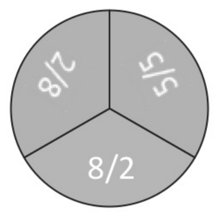
PROPOSER OFFER STIMULI



OR

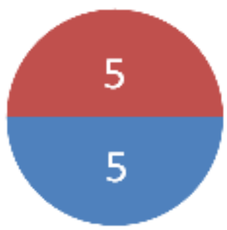
Appendix E

WHEEL



Appendix F

WHEEL OUTCOME STIMULI



OR

OR