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Variation of social context in a bargaining game and its  
effects on event-related potentials

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## 1 Abstract

In economic theories of human decision-making, fairness and social concerns played a marginal or non-existent role for a long time. Behavioral economics and Neuroeconomics make the attempt to integrate the fields of psychology and economics and emphasize the influence of psychological constructs on economic theories. The present study tried to elucidate the importance of social context and fairness (especially other-regarding fairness) for decision-making and their representation in the human event-related potential by monitoring the human EEG while playing the Güth van Damme game (an extended Ultimatum Game) in two social contexts. Therefore the experiment was splitted in two parts: In the first run, subjects remained in the responder role all the time, while in the second run they continually switched positions with the dummy player. Behavioral measures showed an increased acceptance rate for responder-unfair/dummy-fair offers in the second run in comparison to the first run (17% vs. 31%). ERP analyses revealed a change of P200 amplitude pattern between runs, with higher amplitudes for equal than for unequal offers in the first run, and for dummy-unfair offers in the second run. This can be interpreted in terms of allocation of attentive resources, shifted from equity in the first run to strategic evaluations in the second run, or in terms of an early assessment of outcomes, where a “gain” was defined as “equity” in the first run, but as “dummy-unfair offer” in the second run (because of the dummy's strategic relevance and the established competition). MFN and P300 amplitudes differed significantly only in the second run. The MFN showed a second-run pattern similar to the P200. This was taken to mean a negative coding of those events because of their strategic meaning for the dummy's later decisions. The P300 showed much higher values for equally fair offers than for any other offer-type, seemingly indicating the positive valence of those offers. Non-significant results of MFN and P300 in the first run were interpreted as an effect of the lower involvement in the first run and the limited structure of offers. According to these results, a major effect of social context on other-regarding fairness and economic decision-making, mirrored in the human event-related potential and in behavioral data, can be assumed.





# Theoretical Part



## 2 Economic decision-making

Human decision-making behavior has always been of great scientific interest. How do we make our decisions? Why do we decide on this way or the other way? Do we behave fully rational or do emotions affect our decisions? If so, to what extent do they influence us? Do we just care for ourselves or also for others when interacting with people?

For a long time, the Homo Economicus was the model economists built their theories of human economic decision-making upon. According to these theories, humans are rational beings, who only care for their own outcome (von Neumann & Morgenstern, 1944). When von Neumann & Morgenstern developed their theory of games, they did not include any concepts of fairness or emotional factors in their work. They thought of decision-making as a straight-forward rational process, where people maximize their own utility, guided by information and self-interest. Since then, many scientists have formed their theories about human economic behavior. For example, Herbert A. Simon first tried in the 1950s to integrate economics and psychology. He doubted the ability of man to calculate utility functions for every single possible outcome of a situation, furthermore he did not want to underestimate the unconscious. The author pictured decision-making as being done by “a choosing organism of limited knowledge and ability”<sup>1</sup> instead of an economic man.

Kahneman (2003) came to the conclusion that an agent's behavior “is not guided by what they are able to compute, but by what they happen to see at a given moment”<sup>2</sup>. He proposed a central role of emotions on decision weights, and the importance of fear and optimism in risk taking. In fact, there are more contributions to economic decision-making than rational matters (Fehr & Schmidt, 1999).

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<sup>1</sup> Simon, H. A. (1955). A Behavioral Model of Rational Choice. *The Quarterly Journal of Economics*, 69, p. 114.

<sup>2</sup> Kahneman, D. (2003). Maps of Bounded Rationality. *The American Economic Review*, 93, p. 1469.

## **2.1. Game theory**

Game theory has been an emerging field since at least the 1940s, when von Neumann & Morgenstern (1944) wrote their book on that topic (Leonard, 1995). It was designed to explain individual choice of humans by means of specified rules of the game. The basic assumptions of game theory are, that “players (1) have accurate beliefs about what others will do (i.e. players are in equilibrium); (2) have no emotions or concern about how much others earn (a useful auxiliary assumption); (3) plan ahead; and (4) learn from experience”<sup>3</sup>. The basic message of this theory is that people are rational beings, who try to maximize their personal outcome by increasing their expected utility function. According to this assumption, humans in financial decision situations will always choose the most valuable alternative for themselves, i.e. the option with the highest possible monetary outcome (for example the one portfolio out of many with the best revenue). Game theory makes predictions about interpersonal situations, where people come to trade, play, or bargain with each other. If the assumptions of the expected utility function are applicable to these situations, people are expected to act rationally and selfishly, meaning that they would try to maximize their own utility, without caring about the outcome for or the well-being of other players involved. This makes them the so-called Homo Economicus, a rational being who acts straightforward to maximize his utility, regardless of sentimental or emotional matters.

In game situations, which are normatively described by game theory, the players' behavior is expected to approach a so called Nash equilibrium (Nash, 1950; Nash, 1951) while playing. This equilibrium, as an optimal solution for the game, tells every player how to behave in any possible situation within the game. When every single player uses this specific strategy, the best possible outcome will be achieved for all of them, and not one of them would have to deviate from his strategy (van Damme, 1991).

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<sup>3</sup> Camerer, C., Loewenstein, G., Prelec, D. (2005). Neuroeconomics: How Neuroscience Can Inform Economics. *Journal of Economic Literature*, 43, p. 46.

This mathematical approach relies on the assumption of egoistic players that do not care about other-regarding fairness or the motivation of others, just taking into account the one and only rational way to behave.

Von Neumann & Morgenstern also turned the attention of scientists to the experimental investigation of interactive behavior (Kagel & Roth, 1995). There are some paradigms, which are frequently used to test game-theoretical predictions in interpersonal situations, such as the public goods game, the prisoner's dilemma or the Ultimatum Game. When these paradigms were tested for conformity with theoretical predictions, some deviations were noticed. People did seem to care about fairness and equity and did not only maximize their own outcomes by following a rational strategy (Kahneman, Knetsch, & Thaler, 1986).

Nowak, Page, & Sigmund (2000) tried to explain such results with evolutionary dynamics and linked fairness to reputation. Therefore, fairness would be necessary to “survive”.

These results seemed not only to contradict game-theoretic predictions but also most other economic theories, which do not include any social matters (Rabin, 1993).

## **2.2. Fairness concerns in decision-making**

Fairness is always related to social comparison. The relevance of the latter has been stated in social psychology for a long time (Festinger, 1954; Adams, 1963). Social comparison means nothing more than the great importance of relative material payoffs, which affect people's behavior: “Without the assumption that relative material payoffs matter, it is difficult, if not impossible, to make sense of the empirical regularities observed in many experiments”<sup>4</sup> (Fehr & Schmidt, 1999).

As Fehr & Schmidt (1999) reported, there is “a bewildering variety of evidence”<sup>4</sup> considering fairness in economic decision-making. “Some pieces of evidence suggest

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<sup>4</sup> Fehr, E., & Schmidt, K. (1999). A theory of fairness, competition and cooperation. *Quarterly Journal of Economics*, 114, p. 818 ff.

that many people are driven by fairness considerations, other pieces indicate that virtually all people behave as if completely selfish, and still other types of evidence suggest that cooperation motives are crucial<sup>4</sup>. They close with the statement that at least some of the people are motivated by fairness considerations, which let them assume a considerable role of fairness in economic decision-making.

For this fact, much experimental evidence has been found (Rabin, 1993). People in public goods games generally contribute more than they are expected to by the assumption of pure self-interest (for example Orbell, 1978; Marwell & Ames, 1981). Consequently, several models have been developed which try to explain an individual's decisions under consideration of fairness concerns. Two of these shall be explained here.

### 2.2.1 The Fehr & Schmidt model

Fehr & Schmidt (1999) modelled fairness as self-centred inequity aversion. They suggest, in addition to selfish subjects, also the existence of subjects who dislike inequitable outcomes. According to their theory, inequity is experienced when people are better or worse off than other participants in a bargaining experiment or game, whereas disadvantageous inequity (being worse off in monetary terms) leads to more suffering than advantageous inequity (being better off in monetary terms).

According to Fehr & Schmidt, a player's utility function looks like that:

$$(1) \quad U_i(x) = \underset{1}{x_i} - \alpha_i \underset{2}{\frac{1}{n-1} \sum_{j \neq i} \max\{x_j - x_i, 0\}} - \beta_i \underset{3}{\frac{1}{n-1} \sum_{j \neq i} \max\{x_i - x_j, 0\}},$$

Figure 2.1 Utility function of the Fehr & Schmidt model, modified from Fehr & Schmidt (1999).

$x_i$  (1) denotes the vector of the monetary payoff. The second term (2) measures the utility loss from disadvantageous inequity and the last term (3) measures the loss from advantageous inequity.

If there are more than two players, player  $i$  compares his income with all other  $n-1$  players (each of them for themselves), but does not care about inequalities within the group of his opponents.

### 2.2.2 The Bolton & Ockenfels model

Bolton & Ockenfels (2000) developed another model, called ERC (Equity, Reciprocity, Competition). According to their model, players care only about their own absolute and own relative payoffs, but do not care about the outcomes of other individuals. There is a slight difference regarding the absolute payoffs to the Fehr & Schmidt model: In the Fehr & Schmidt model, absolute payoffs of other players directly enter into the utility function, whereas in the Bolton & Ockenfels model they do not. This concept is called self-centred fairness.

In this model, Bolton & Ockenfels propose the following motivation function:

$$v_i = v_i(y_i, \bar{\sigma}_i)$$

where

$y_i$  = own absolute payoff

$\bar{\sigma}_i$  = own relative payoff =  $\bar{\sigma}_i(y_i, c, n)$

$c$  = total pecuniary payout

They assume that “the motivation function increases in the absolute payoff  $y_i$ , and decreases as the relative payoff  $\bar{\sigma}_i$  moves away from the social reference share  $1/n$ , the average proportion of the cake”<sup>5</sup>. The authors also assume players to be selfish

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<sup>5</sup> Bolton, G. E., & Ockenfels, A. (2002). Self-centered fairness in games with more than two players.

enough to prefer an advantageous distribution for themselves to an equal distribution in which all players receive nothing.

### **2.2.3 Experimental investigation of fairness**

Johansson & Svedsäter (2009) recently conducted three experiments, the first of them being an allocation game, in which undergraduates had to allocate money between themselves and two others (with a questionnaire). The game was like a dictator game, so the two other players could not decide about the allocation. Although allocators did not know whom they were playing with (they just knew that it were two people out of a bigger group), 65.3% of offers were in favor of reducing inequity between all players. According to the authors' results, people are averse to inequalities between themselves and others and (in contrast to the Fehr & Schmidt model) to inequalities between others.

Most experiments regarding fairness in economic decision-making are conducted using the standard paradigms of behavioral economics, as there are: The public goods game (for example Orbell, 1978; Marwell & Ames, 1981), the dictator game (Forsythe, Horowitz, Savin, & Sefton, 1994; Hoffman, McCabe, Shachat, & Vernon Smith, 1994), and the Ultimatum Game (Mitzkewitz & Nagel, 1993; Suleiman, 1996).

When Fehr & Schmidt or Bolton & Ockenfels developed their models, they wanted to test their predictions within experiments. Both of them used the Ultimatum Game, which is the key paradigm of this study.



## 3 The Ultimatum Game

### 3.1 *The original Ultimatum Game*

One central paradigm of game theory is the so called Ultimatum Game (Güth, Schmittberger, & Schwarze, 1982). It has quite often been investigated and much research has been done on it. It obtains its attraction from the easy rules everyone understands and from the many predictions that can be derived from it.

In this game, two players have to divide a specified amount of money among themselves. One of them plays the proposer, who makes an offer (e.g. Me: 7€, You: 3€) and the other person plays the responder, who can decide about the proposer's offer. If he accepts the offer, it comes to a split-up as suggested. But if he rejects, none of the players gets any money. At this point, the game comes to an end.

According to game theory it would be the only rational way of acting for the proposer to make the smallest possible offer, and likewise it would be rational for the responder to accept any offer, because any amount of money is better than no money at all in case of rejection. In reality, proposers make more or less fair offers and responders punish unfair proposers by rejecting their offers (Bolton & Zwick, 1995). The mean proposal in experiments is around 50%. Proposals within this range are mostly accepted by responders, while proposals around 20% are refused about 50% of the time (Nowak et al., 2000; Bolton & Zwick, 1995). These results lead to the question, why people act like that and seem to care about a moral or social norm within their economic decisions. As far as proposers are concerned, one could ask about their motives for making a fair offer. Some consider earnest concern for fairness responsible for it, and some say that proposers only try to seem fair or just fear rejection (Roth, 1995).

Ultimatum Game behavior is quite stable across different conditions and cultures, and these results are well investigated. For example, Roth, Prasnikar, Zamir, & Okuno-Fujiwara (1991) ran Ultimatum Games in the cities of Jerusalem, Ljubljana, Pittsburgh and Tokyo and found no significant differences between modal offers or rejections.

Camerer & Thaler (1995) investigated the impact of amounts to be split up, because they were interested in how representative common experiments were. They compared Ultimatum Games with \$10 proposals to Ultimatum Games with \$100 proposals and found no significant differences between these conditions. In the \$100 condition, responders turned down offers of \$10 (10 / 90) three out of four times and also offers of \$30 (30 / 70) were rejected two out of five times to their surprise. So they came to the conclusion that common experiments must be representative also for high-stake conditions.

### **3.1 Modifications of the Ultimatum Game**

In the last years, different modifications were made to the original Ultimatum Game, in order to investigate different fields of interest within this paradigm. By using such modifications, aspects like other-regarding fairness can be investigated more precisely, while the game still preserves its easily understandable rules and the scientific body of results, which can be applied and complemented.

#### **3.1.1 Ultimatum Game with Responder Competition**

Grosskopf (2003) introduced her own variant of the Ultimatum Game, namely the Ultimatum Game with Responder Competition. In that game, there is one proposer as well, but three responders, and all of them can accept or reject the offer. If just one of the responders accepts the offer, the money will be split accordingly between himself and the proposer. If more than one responder accepts, a randomized process decides which of the responders will be granted the money. Participants of Grosskopf's study played both the traditional and the modified (Responder Competition) Ultimatum Game. One half played the traditional Ultimatum Game first and then the modified Ultimatum Game (condition TM), and the other half played the other way round (condition MT).

Grosskopf found out that proposers tend to demand a larger piece of the cake for themselves in the modified version of the game and that those demands are more seldom rejected by the responders. Another interesting effect she found, was that proposers in the MT condition lowered their demands significantly in the traditional Ultimatum Game whereas proposers in the TM condition did not change their demands significantly between the two types of the game. This indicates a major effect of social conditions on offer structure and rejection rates.

### 3.1.2 Ultimatum Game with Consolation Prizes

Kagel & Wolfe (2000) made another interesting extension to the Ultimatum Game: In their version, there was still one proposer, but two responders, and one of them was chosen by chance to accept or reject the offer. As usual, rejection led to zero income for the responder and the proposer, but let the passive non-responder get a consolation prize. Kagel & Wolfe supposed rejections to disappear from the game, as this modification established a strong income inequity between the parties. Surprisingly, the authors did not find any reductions in rejection rates under both conditions (with and without consolation prizes). They suggested alternative explanations, such as a key role of intentionality: That means that inequity resulting from a low offer differs in quality and perception from unintentional inequity (the inequity between the responder and the non-responder). Another possible but unattractive explanation would be to abandon the assumption “that the natural reference group is simply the set of subjects playing against each other and that the reference point is equality.”<sup>6</sup>

The authors' results point out the importance and influence of changing circumstances, which also seem to have great impact on the perception of inequalities. A remaining question about the above cited sentence is: Does this reference group include passive players too, or do they have far less importance than active players? Whose payoff does affect the responder (Fehr & Schmidt, 2005)?

### 3.1.3 The Güth van Damme Game: Ultimatum Game with three players

Güth & van Damme (1998) developed another extended version of the Ultimatum Game. They added a third player to the game, the so called “Dummy”, who has no power. So the structure of the game is just the same, with the only difference being

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<sup>6</sup> Kagel, J. H., & Wolfe, K. (2000). Tests of Difference Aversion to Explain Anomalies in Simple Bargaining Games. Ohio State University. p. 18.

the proposer's obligation to allocate at least 1 € to the dummy. The responder then makes a decision on the proposer's offer and the money will be allocated accordingly (or nobody gets any money). The dummy can just sit and watch, without any option to act. Because of that, this version of the Ultimatum Game can be viewed as a mixture of Ultimatum Game and dictator game.

The authors made their participants play under different information conditions, whereas only the condition with constant complete information shall be described here. Under this condition, the responder got full information about the proposer's offer ( $x$  = proposer's share,  $y$  = responder's share, and  $z$  = dummy's share) and six rounds of the game were played. Offer structure and behavior settled at a constant level after about three rounds, whereas the proposer demanded almost two thirds of the stake, leaving the responder with 30 percent and the dummy with the small rest of about 8%. High acceptance rates (which could be traced back to responder's share) led to the conclusion that neither the proposer nor the responder care much about the dummy's outcome. This seems rational, because the dummy has no power and will get no power in the game.

A recently conducted newspaper experiment by Güth, Schmidt, & Sutter (2007) with more than 5,000 participants revealed an average offer structure of 43 % for the proposer, one third for the responder and about 24 % for the dummy, whereas the equal split was the most common type of offer. Responders frequently rejected the so called power-coalition offer (in this case  $x = 600$ ,  $y = 500$ ,  $z = 100$ ; 1,200 Deutsche Mark had to be divided), with an acceptance rate of only 23 %. Nevertheless, offers with  $y \geq 400$  were accepted by a majority of subjects, which indicated the higher relevance of  $y$ -offers for the decision of acceptance.

Bolton & Ockenfels (2008) found no rejections when the responder was at least offered the social reference share (1/3 of the cake), regardless of the dummy's share. They proposed that neither proposers nor responders cared about the dummy's outcome.

While the standard Ultimatum Game only allows the observation of the responder's reactions (rejections or acceptances) to fair or unfair offers to himself, the Güth van

Damme Game (GvD game) adds another dimension to the game by authorising the responder to take a decision for an additional person. This lets the researcher differentiate between fairness towards the dummy and the responder and allows deep research, especially in combination with new methods of research, which shall be described beneath.

So the main question arising from this new design is the following: Does a player care about the fairness of the offer for the dummy player, too? Güth & van Damme (1998) came to the conclusion, that “fairness, as a social norm, seems restricted to those who have strategic influence”<sup>7</sup>. Following this statement, there should be no concern for the outcome of the dummy, unless the dummy has power himself.

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<sup>7</sup> Güth, W., & van Damme, E. (1998). Information, strategic behavior and fairness in ultimatum bargaining - an experimental study. *Journal of Mathematical Psychology* 42, p. 243.

## 4 Behavioral Economics and Neuroeconomics

### 4.1 History and development of Neuroeconomics

In earlier times, economics relied on mathematical theorems to try to describe economic decision behavior, whereas social and psychological factors did not play any important role in the field's theories (Rabin, 1993).

An important factor in ignoring emotional aspects was a missing direct insight into emotions: "Since feelings were meant to predict behavior but could only be assessed from behavior, economists realized that, without direct measurement, feelings were useless intervening constructs"<sup>8</sup>.

In the past two decades, behavioral economics and its many experiments spread rapidly over the scientific landscape. These new theories include concepts like fairness and reciprocity (Camerer, 2003) and try to integrate psychology and economics to achieve more realistic economic models.

As methods of electrophysiology and neuroimaging got cheaper and easier to access, psychologists and economists started to use these techniques for investigating their theories on this new level. From then, scientists could more or less "see" the emotions people had in decision situations, or could at least make more reasonable assumptions about them. So the problem of missing direct measurement got easier to solve and emotions and social variables got more attractive for economists and their scientific models. The next step in integrating the fields of psychology and economics had to be the rising new field of neuroeconomics.

Neuroeconomical science uses brain imaging techniques like electro-encephalogram (EEG) or functional magnetic resonance imaging (fMRI) for investigating theoretically predicted processes and how they are mirrored in the brain. The most popular

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<sup>8</sup> Camerer, C., Loewenstein, G., & Prelec, D. (2005). Neuroeconomics: How Neuroscience Can Inform Economics. *Journal of Economic Literature*, 43, p. 10.

technique at this time is the fMRI, which is based on the measurement of changes in magnetic properties due to blood oxygenation (called the “BOLD”-signal) and has a very high spatial resolution. With this technique it is indirectly possible to determine the activity of a specific brain area very precisely. Having a good spatial resolution, fMRI lacks of temporal resolution, so only differences in activity within the range of seconds can be observed (Camerer et al., 2005).

To measure changes in brain activity within the range of milliseconds, the EEG is the method of choice. EEG uses electrodes attached to the scalp to measure electrical activity synchronized to stimulus events or behavioral responses. These activities are called event related potentials (ERPs) (Camerer et al., 2005). Other advantages of EEG, besides temporal resolution, are its unobtrusiveness, portability, and its low costs in comparison to fMRI or positron emission topography (PET). The weakness of EEG is its poor spatial resolution. But if a researcher wants to measure subconscious immediate changes in brain activity as a reaction to interactions in social environments or to cues in experimental tasks, it is a cheap and highly effective method to do so.

## ***4.2 fMRI studies and important brain areas***

Several fMRI studies concerning the Ultimatum Game and related neural activation were carried out and the most prominent ones shall be described in this chapter.

Economic behavior is mirrored in the brain by activation of specific areas, as Sanfey, Rilling, Aronson, Nystrom, & Cohen (2003) stated in their fMRI-study. In short, they found out that three areas play a major role in economic decision-making: The anterior insula, the dorsolateral prefrontal cortex (DLPFC) and the anterior cingulate cortex (ACC) (see Figure 4.1).



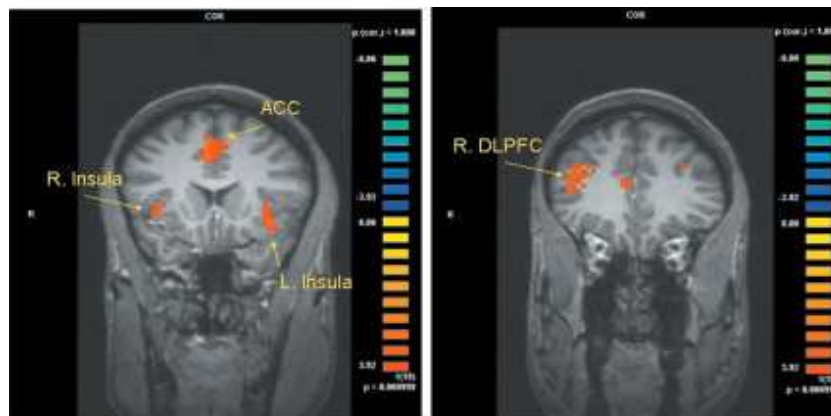


Figure 4.1: Activation of specific brain areas. Left: Activation for the contrast [fair human offer – unfair human offer]. Right: Activation for the contrast [unfair human offer – fair human offer] (Sanfey et al., 2003)

Sanfey and colleagues let their subjects play the standard Ultimatum Game in the role of the responder while being scanned in the fMRI, and compared neural activity between conditions (getting fair or unfair offers from human partners). They identified anterior insula, DLPFC and ACC as areas with greater activation for unfair than for fair offers. Besides, this activation was even greater for human than for computer partners. This led to the conclusion that not only the amount of money offered, but also the social context played a major role in the quantity of activation.

The anterior insula seemed to represent the emotional part of decision-making in the Ultimatum Game. This region is often associated with negative emotional states (Calder, Lawrence, & Young, 2001) and activation was getting stronger with increasing unfairness of the offers and was significantly stronger for rejected unfair offers. In contrast to the anterior insula the DLPFC seemed to represent the cognitive part of decision-making. This region is often mentioned along with cognitive processes such as goal maintenance and executive control (Miller & Cohen, 2001; Wagner, Maril, Bjork, & Schacter, 2001). Its higher activation for unfair offers was interpreted as the higher cognitive demands needed to overcome the emotional tendency to reject the offer. Finally, activation in the ACC seemed to reflect the conflict between the other two areas. ACC activity was also significantly higher for unfair than for fair offers, which corresponds to studies which see the ACC involved in cognitive

conflict (MacDonald, Cohen, Stenger, & Carter, 2000; Botvinick, Nystrom, Fissell, Carter, & Cohen, 1999). By receiving an unfair offer, a conflict occurs in the brain. As stated before, it would be rational to accept any offer and the activation in the DLPFC could reflect this will to accept the offer or at least strategic thoughts. The activation in the insula mirrors the emotional reluctance to accept an unfair offer. The conflict of these regions is reflected by ACC activity.

Rilling, King-Casas, & Sanfey (2008) reported fMRI-study results concerning brain activation of subjects who played the Ultimatum Game (among other games) and stated that “visceral feedback in response to negative social interactions, represented in the anterior insula, influences decision-making in both the PD and UG games”<sup>9</sup>, and that social behavior disorders (associated with schizophrenia, borderline, or antisocial personality disorder) often occur after or because of abnormalities in the above mentioned neural substrates, which support social decision-making. These findings strongly recommend an important role of emotions and social cues in human economic decision-making.

Another interesting study by Koenigs & Tranel (2007) investigated the role of the ventromedial prefrontal cortex (VMPFC) in decisions within the Ultimatum Game. They compared rejection rates between a control group and a group of patients with damages of the VMPFC. The authors supposed a major role of the VMPFC for emotional regulation. The patients' rejection rates for unfair offers (\$7/\$3, \$8/\$2, \$9/\$1) were significantly higher than those of the control group. These results suggested a critical role of the VMPFC for the functionality of normal economic decision-making through emotion regulation processes.

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<sup>9</sup> Rilling, J. K., King-Casas, B., & Sanfey, A. G. (2008). The neurobiology of social decision-making. *Current opinion in Neurobiology*, 18, p. 163.

### **4.3 Correlates of fairness in the EEG – relevant ERPs**

Apart from the fMRI also the EEG plays a major role in investigating the theories of neuroeconomics. Several event-related potentials have been identified, which seem to reflect the processes accompanying economic decisions. Some of them are specifically related to the Ultimatum Game, which intended to lay the focus of this study on these ERPs.

#### **4.3.1 The P200**

The P200 is a positive potential associated with economic decisions, which is assumed to reflect an early assessment of the outcomes and is presumably generated by the orbitofrontal cortex (Polezzi, Lotto, Daum, Sartori, & Rumiati, 2008). It normally occurs between 200 and 300 ms after stimulus presentation. Carretié, Mercado, Tapia, & Hinojosa (2001) found it to have higher amplitude for negative stimuli than for positive ones, as well as shorter latency. In a visual oddball task it was enhanced only to the target (task-relevant) stimuli but not to infrequent irrelevant stimuli (Potts, Dien, Hartry-Speiser, McDougal, & Tucker, 1998a).

Potts, Martin, Burton, & Montague (2006) made their subjects play a game in which their expectations were either met, not met, or exceeded. They observed the most positive P200 when outcomes were better than expected (positive valence) and the least positive amplitude when the outcomes were worse than expected. These results were in contrast to earlier theories about the component, which connected it to attentive resources (attended items elicit a more positive P200; see Potts, 2004).

Rigoni, Polezzi, Rumiati, Guarino, & Sartori (2010) investigated the P200 in subjects who played a gambling task in different social contexts. There was one condition without social context, one where subjects compared their own outcomes with those of others (comparison) and one where they competed for a specified amount with another player (competition). They were revealed the outcome of an unselected

alternative before being told about the outcome of their own choice. They found out that this component, which reflects early outcome evaluation, is larger within a non-social context than within a social context. In detail, their analysis showed an effect for the P200 in the neutral condition (larger P200 for gains than for losses), but did not find this effect in the comparison and competition condition. In the latter conditions the effect could be seen by visual inspection, but did not approach significance. The authors assumed that the relevance of payoffs decreased within the social context, “presumably because attentive resources are partially shifted toward social cues”<sup>10</sup>.

### 4.3.2 The Medial Frontal Negativity

The Medial Frontal Negativity (MFN) is a potential that is elicited about 300 ms after stimulus presentation and reflects expectation violation. It is meant to have a dipole source in the ACC (Dehaene, Posner, & Tucker, 1994) and was investigated within the standard Ultimatum Game several times (Boksem & De Cremer, 2009; Polezzi, Daum, Rubaltelli, Lotto, Civai, Sartori, & Rumiati, 2008).

This component occurs in different situations and is usually named accordingly. When subjects commit errors, it is called error-related negativity (ERN; Gehring, Coles, Meyer, & Donchin, 1990), but when subjects receive negative performance feedback, it is named the feedback-related negativity (FRN; Miltner, Braun, & Coles, 1997). Although the ERN and FRN have different scalp topography, they show similar time-frequency characteristics (Gehring & Willoughby, 2004). To get to a consistent naming of this component, it is referred to as the MFN (Gehring & Willoughby, 2004) in this study. It has also been suggested to reflect an affective or motivational evaluation of negative outcomes (Boksem, Tops, Kostermans, & De Cremer, 2008), or to be regarded as an N200, which is an ERP component that is elicited by unexpected or task-relevant events, of which feedback is just a specific instance (Holroyd, Pakzad-Vaezi, & Krigolson, 2008 in Boksem & De Cremer, 2009).

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<sup>10</sup> Rigoni, D., Polezzi, D., Rumiati, R., Guarino, R., & Sartori, G. (2010). When people matter more than money: An ERPs study. *Brain Research Bulletin*, 81, p. 450.

Nieuwenhuis, Holroyd, Mol, & Coles (2004) summarized four core predictions of the ERN theory: The ERN (1) reflects a good/bad evaluation; (2) it depends on actual vs. expected outcome relation; (3) feedback ERN varies inversely with error ERN amplitude as a function of learning; (4) the feedback ERN is generated in the ACC.

Van Schie, Mars, Coles, & Bekkering (2004), who let their subjects participate in an active (task execution) and a passive (task observation) version of a task, namely the Eriksen flanker task, suggested the involvement of similar neural mechanisms in monitoring one's own actions and the actions of others and insisted on the MFN as representing these neural mechanisms. In both the execution condition and the observation condition they found a significantly larger negative deflection on incorrect trials compared to correct trials. The authors' results seem to indicate an involvement of the MFN (and its presumed generator, the ACC) in both passive and active evaluation of outcomes, which may be transferable to fairness-of-offer considerations in the Ultimatum Game.

Fukushima & Hiraki (2006) found out that there are gender differences in eliciting an MFN after an opponent's loss. Their participants played a competitive two-person gambling game and their EEG was examined while observing an opponent's losses. Women elicited a significantly higher MFN than men in this situation. But the other interesting result (only for female participants) was the differentiation of the so called "other-MFN" and the "self-MFN", the first being activity generated in observing another person's outcome. Female participants elicited a relevant "other-MFN". According to Luu & Tucker (2004) and their assumption of the MFN reflecting emotional or motivational judgement, Fukushima & Hiraki (2006) came to the conclusion that the MFN, as an early performance-monitoring system, "categorized the other's loss as a more negative impact than the other's gain"<sup>11</sup>.

When subjects played a passive gambling task for a study of Fukushima & Hiraki (2009), their ERPs were investigated while watching outcomes (gains and losses) of computer and human partners. Only outcomes of human partners significantly elicited an MFN.

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<sup>11</sup> Fukushima, H., & Hiraki, K. (2006). Perceiving an opponent's loss: gender-related differences in the medial-frontal negativity. *Social, Cognitive, and Affective Neuroscience*, 1, p. 154.

Two EEG-studies recently investigated the ERPs involved in the decisions in the Ultimatum Game. In the first study, Boksem & De Cremer (2009) recorded the EEG of participants while they were receiving offers as a responder in the Ultimatum Game. Their results showed that the MFN amplitude was more pronounced for unfair offers compared to fair offers. Additionally, in subjects with high concerns for fairness (measured with the Moral Identity Inventory), this effect was even stronger. The authors suggested that the MFN not only reflects expectation violations, but also whether the process by which the outcomes came about matched a social or even a moral norm.

In the second UG-related EEG-study, Polezzi et al. (2008) investigated the role of the MFN in the EEG of subjects receiving offers in the Ultimatum Game. They found the MFN to reflect a fast initial distinction between fair and unfair offers. Interestingly, mid-value offers elicited an even higher MFN than obviously unfair offers. For these mid-value offers, MFN amplitudes explained 40.7% of variance in individual acceptance behavior, whereas higher MFN amplitudes were associated with lower acceptance rates.

### **4.3.3 The P300**

The P300 is a positive potential with peak latency between 300 and 600 ms, which was first mentioned in 1965 (Desmedt, Debecker, & Manil, 1965; Sutton, Braren, Zubin, & John, 1965) and is one of the most intensively studied ERP components. It is located at centroparietal electrode sites and the locus coeruleus-norepinephrine (LC-NE) system has been suggested to be its neural generator (Nieuwenhuis, Aston-Jones, & Cohen, 2005). According to Nieuwenhuis et al. (2005) it either reflects the LC-NE system's response to the outcome of stimulus evaluation and decision making, or an important information-processing function of this system, which is to amplify the response to motivationally significant events.

Many hypotheses on the P300 component's significance have been stated. For example, its amplitude is said to reflect the allocation of attention resources (Ma,

Wang, Shu, & Dai, 2004) and it is often linked to stimulus processing (Nieuwenhuis et al., 2005).

Yeung & Sanfey (2004) investigated the influence of valence and magnitude of an outcome on the P300 (and MFN) component within a simple gambling task. Their task consisted of a choice period, in which subjects could decide between two cards, and two feedback periods, where the first feedback indicated the outcome of the chosen card (“+7€”, for example) and the second feedback showed the outcome for the alternative card. Interestingly, the P300 amplitude did not differentiate between gains and losses but between small and large outcomes. It has to be mentioned that the authors discovered the opposite pattern for the MFN. So the P300 was greater for large outcomes than for small outcomes. The authors suggested the P300 and the MFN as being representations of two separate neural coding systems for valence and reward magnitude.

Rigoni et. al (2010) recently investigated the role of the P300 within a gambling task and discovered the component to differentiate between obtained and non-obtained outcomes, being larger for the former. There was no effect for the social context factor though. In contradiction to the assumptions of Yeung & Sanfey (2004), the P300 was also significantly larger for gains than for losses. The authors came to the conclusion, that the P300 reflects higher motivation induced by self-regarding rewards and penalties.

## **5 Justice Sensitivity**

There are several questionnaires and constructs which measure a subject's care for fairness. In order to get a valid value of a subject's care for fairness and to be able to differentiate between fairness for oneself and fairness to others, a suitable method had to be found for this study. One of those constructs, first to be proposed in 1995, is the so called “dispositional sensitivity to befallen injustice” (Schmitt, Neumann, & Montada, 1995). Based on this construct, Schmitt, Gollwitzer, Maes, & Arbach (2005)

developed the Justice Sensitivity Questionnaire (JSQ), a rather short questionnaire with four scales with 10 items each. It is meant to measure sensitivity for unjust actions on different levels. First, the scale JS-Observer measures sensitivity for injustice when others are harmed or treated badly in some way (Example: "It worries me when someone has to work hard for things that come easily to others.").

Second, the scale JS-Victim gives a measure of how easily people get disturbed by unjust actions against themselves (Example: "It gets me down when I get fewer opportunities than others to develop my skills.").

The third scale is called JS-Perpetrator and it measures the sensitivity for being privileged or vantaged without purpose (Example: "It bothers me when someone tolerates things with me that other people are being criticized for.").

The fourth scale, finally, indicates a subject's sensitivity to doing harm and injustice to someone else (Example: "It bothers me, when I take something that others should have.") and is called JS-Committer.

The value of this questionnaire for this study simply lies in the fact that justice sensitivity, as an equivalent to fairness, is measured on a "self vs. other" level, i.e. it separates the measurement of fairness into observing unfair offers (in case of the Ultimatum Game) for others and for oneself. This opens the opportunity to eventually correlate different kinds of offers in the Ultimatum Game and the corresponding ERP-waveforms with the single scales.

Fetchenhauer & Huang (2003) found a relationship between justice sensitivity and unfair offers to the dummy player in the extended UG. In detail, they found that the higher JS-Observer (measures reactions to observing unjust events) and JS-Perpetrator (dealing with reactions to profiting from unjust events oneself) were, the less people were willing to accept an unfair offer to the dummy player. In their regression model, JS-Observer could explain 11% of the total variance.



## 6 Research Question

The GvD game extends the range of possible research on fairness in economic decision-making. Since there is not too much evidence on other-regarding fairness in this game and the application of neuroscientific methods on this paradigm has not been thoroughly investigated yet, the attempt to investigate this shall be made by this study. In order to evaluate the impact of social context on fairness considerations, participants shall first play the GvD game as responders, but shall play 50% as a dummy and 50% as responder (alternating) in the second run of the game. Will the players care about the dummy player when he has no influence on the game, or will they only care about their own outcome? How will the relevant event related potentials (ERPs) be affected by these changes of social context?

According to Fehr & Schmidt (1999), subjects are expected to be more fair to the dummy in the second run, when he has power too. This should be reflected in higher acceptance rates for dummy-fair offers.

Additionally, the results of the Justice Sensitivity Questionnaire will be examined and set in relation to ERP and behavioral data. People with higher scores in JS-Observer and JS-Perpetrator are expected to reject unfair offers to the dummy more frequently in both runs than people with lower scores.

Three ERPs will be examined in detail, namely the MFN, the P200 and the P300.

The main focus will be laid on the MFN, which plays a major role in decision-making. The different conditions of the game will be investigated in view of the strength of the MFN. The MFN amplitude is assumed to be higher for responder-unfair offers in general and especially for fair (for the responder) / unfair (for the dummy) offers in the role-changing condition (second run) compared to the fixed-roles condition (first run). That is because the dummy gets power in the second stage and the responder is expected to care more about him.

Additionally unfair/unfair offers in the second condition should elicit the highest MFN amplitudes over all conditions and offer-types. The strength of the MFN amplitude is expected to be correlated with the concern for fairness (JSQ) and the subjects'

rejection rates. According to Fukushima & Hiraki (2006) a lower MFN amplitude is expected in men than in women, when perceiving a bad result (= unfair offer or 'loss') for the dummy. This effect should be more pronounced in the second run.

The P200 is assumed to be more pronounced in the first run. According to Rigoni et al. (2010) the attentive resources should be shifted toward social cues in the second run, "neutralizing" the distinction between small and large offers. In consideration of the literature (Potts et al., 2006; Rigoni et al., 2010), the P200 amplitude should be highest for fair/fair and fair/unfair offers in the first run (positive valence) and should show less pronounced differences between all offer-types in the second run.

The P300 amplitude is assumed to be higher for large outcomes than for small outcomes (Yeung & Sanfey, 2004). Additionally, it will be interesting to investigate the difference in the P300 between the two runs of the game. Presuming that a player cares more for the outcome of the dummy (as he is assumed to do in the second run), he will possibly elicit higher P300 amplitudes for fair/fair than for fair/unfair (and other) offers. This difference will be investigated within and between conditions.

The results of this study will allow insight into the modulation of fairness considerations in economic decision-making due to changes in social context. Assumptions on the perception of others and the relevance of strategic power for these perceptions can be derived.





# Empirical Part



## 7 Materials and method

### 7.1 Participants

Thirty undergraduate students of the University of Vienna (13m, 17f; age range 19-34 years, mean age: 24,43; SD = 3,66) have participated in this study. They were all tested for being suitable for the present study, using the “Edinburgh inventory” (Oldfield, 1971) to be sure about their right-handedness and were questioned about different typical reasons for being excluded from an EEG-study (for example having a nerve disease like epilepsy or being afraid of needles). All subjects had normal or corrected-to-normal vision and gave informed consent.

### 7.2 Task

The task consisted of two runs of a modified Ultimatum Game, the so called GvD game. In the first run, the subject was in the role of the responder. The supposed second player (who was always called “Julia”, a female student) was in the role of the dummy. In the second run, roles changed continually (50% responder, 50% dummy). The modified Ultimatum Game used here was a single-shot-version of the game, so each of the offers came from a different proposer. Subjects just had to accept or deny one offer after another. The amounts to split up were either 12 €, 15 €, or 18 €, the offer-structure is listed in Table 7.1 below.

Table 7.1 Offer structure;

Legend: FF = fair/fair; FU = fair/unfair; UF = unfair/fair; UU = unfair/unfair

Offers are listed in the order Proposer/Responder/Dummy

Amount to divide	FF	FU	UF	UU
12 €	4€ / 4€ / 4€	7€ / 4€ / 1€	7€ / 1€ / 4€	10€ / 1€ / 1€
15 €	5€ / 5€ / 5€	9€ / 5€ / 1€	9€ / 1€ / 5€	13€ / 1€ / 1€
18 €	6€ / 6€ / 6€	11€ / 6€ / 1€	11€ / 1€ / 6€	16€ / 1€ / 1€

The first run consisted of four blocks with 30 offers each. People were first presented the photos of 30 proposers (15m, 15w) shown on two sequential screens. The second screen was followed by a fixation cross (100 ms) and the current proposer's offer. After 3000 ms two buttons with possibilities of reactions appeared on the screen ("accept" or "deny"), always shifting position to achieve better attention during the task. The subject then had to press 1 on the Numpad for the left option or 2 for the right option. After having chosen an option, the subjects were shown a text message ("Accepted!" or "Denied!") indicating the choice on screen for 1500 ms. Afterwards a new proposal was presented, preceded by another fixation cross with variable inter-stimulus interval. Please see Figure 7.1 for a detailed time-line.



Figure 7.1: Detailed time-line for the first run

After 120 trials there was a break and a change of conditions. Following the instruction for the second run, 240 trials were played, separated into 8 blocks with 30 trials each. In the second run there was a continual change of roles, so in every block of 30 trials the subjects were in the role of the responder as well as in the role of the dummy for 15 trials each. There were 30 trials which were fair/fair (fair for the responder and fair for the dummy = FF), 30 fair/unfair (FU), 30 unfair/fair (UF) and 30 unfair/unfair (UU) for every role (2x120) (see Figure 7.2). The only difference to the time-line of the first run was an additional screen preceding the first fixation cross, which indicated the allocation of the roles for the subsequent trial (2000 ms). Dummy



players behaved like average players in recent studies according to their acceptance rates (Güth et al., 2007).

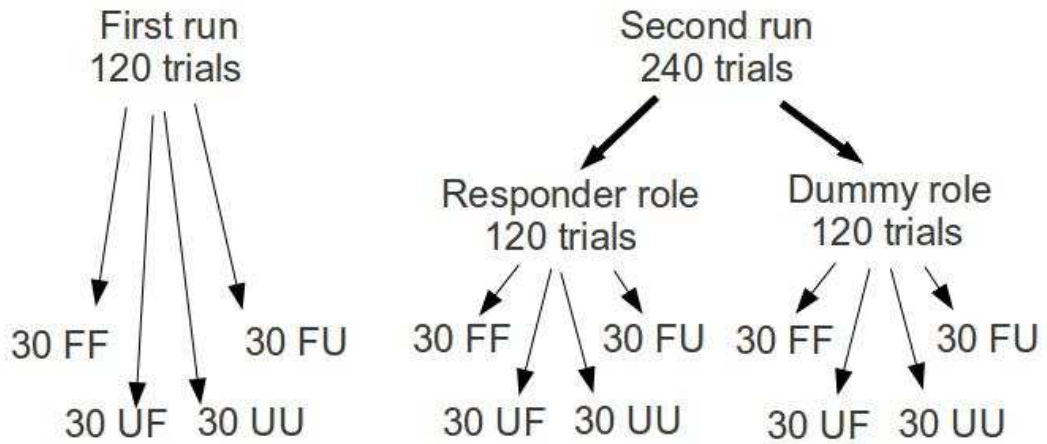


Figure 7.2: Trial structure of both runs.

Legend: FF = fair/fair; FU = fair/unfair; UF = unfair/fair; UU = unfair/unfair

### 7.3 Procedure

Previous to the experimental session itself, people were informed that they would play a game against another person, who would be connected to the EEG in another laboratory simultaneously. By that and by some simulated phone calls during the procedure, people should get the realistic feeling that they interacted with another human being in the following extended Ultimatum Game. After being prepared in the laboratory and being seated in the experimental chamber (a sound-attenuated, air-conditioned room, to allow for consistent experimental conditions for all of the subjects) in front of the CRT monitor, subjects were instructed about the task and the procedure:

They received written instructions on the Ultimatum Game and were told that there was a randomized fixed choice of the roles for the whole game, so one of them would be the responder and the other one would be the dummy. Participants were always assigned to the responder role. Then the subjects were told that they would stay in

the assigned role for the whole duration of the experiment and that every one of their decisions would influence the payoff of the proposers, the dummy and themselves. They were told that the proposers were students who had filled in a document with two types of proposals and that the most successful proposers (those whose offers were accepted by most of the participating subjects) would be paid (for detailed game instructions please see the appendix). At this point, they did not know anything about the second stage of the game. Then the game was started. After the first stage of the game, subjects had a little break to refresh themselves. Afterwards, they were told about the context of the game's second stage and could proceed as soon as they were ready.

After the experiment, participants had to fill in two questionnaires:

To measure the participants' care for social norms and fairness, they filled in the "Justice Sensitivity Questionnaire" (Schmitt, Neumann, & Montada, 1995).

Participants additionally had to fill in a self-designed "Ultimatum Game Questionnaire" to measure perceived fairness of the dummy on the one hand (Item 1: "Please judge the other players fairness on a scale from 1 to 7 (with 1 being very unfair)"), and perceived fairness of the participant himself (Item 2: "Please judge your own behavior (your fairness) to the other player on a scale from 1 to 7 (with 1 being very unfair)" and item 4: "Do you think that you took the other player more into account in the second run, than in the first run?") on the other hand. It was also designed to measure the subject's belief in the existence of the dummy player (Item 3: "How strong did you feel the presence of the other player despite the spatial distance (with 7 being very strong)?").

Participants were paid an amount in accordance to their success in the game (10 – 25 €). Real monetary payoffs were implemented because it adds some relevance to the game (Fantino, Gaitan, Kennelly, & Stolarz-Fantino, 2007). In the end they were debriefed and were told about the non-existence of the other player and that the most successful proposers would not really receive money for the acceptance of their offers.

## **7.4 EEG Recording**

For the recording of the multi-channel scalp DC-EEG Ag/Ag Cl electrodes were used. Electrodes were positioned equidistant according to an extended version of the 10-20 system developed by Jasper (1958). The system applied includes 61 scalp electrodes (frontopolar, frontal, central, temporal, parietal and occipital), two noncephalic reference electrodes (one on the sternal end of the right clavícula and one on the vertebra prominens), one electrode for recording the ECG, and four electrooculographic (EOG) electrodes for recording of eye movement to later eliminate artifacts related to eye movement and blinks. To ascertain electrode impedances that would be stable and  $\leq 1 \text{ k}\Omega$  the skin at each recording site was slightly scratched using a sterile single-use needle (Bauer, 1998). Signals were sampled at 1000 Hz (250 Hz downsampling for digital storage) and recorded within a frequency range from DC to 30 Hz.

## **7.5 Data analysis**

### **7.5.1 Behavioral data**

Reaction Times (RTs) and acceptance rates (ARs) were recorded automatically by ePrime 2.0 software (Psychology Software Tools, Inc.; <http://www.pstnet.com>). RTs were compared within and between all the different conditions, and so were ARs. ARs between conditions were of special interest because they were expected to give interesting insights into change of behavior induced by change of social context (when the dummy becomes a player with equal rights and possibilities). ARs were analysed with a Friedman test and pairwise comparisons (Wilcoxon test) of matching offer-types between runs and of all offer-types within runs. Behavioral data were related to ERP data to find certain relations or to determine the percentage of variance explained through the different ERPs.

RTs were first transformed with a logarithmic function (Knutson, Rick, Wimmer, Prelec, & Loewenstein, 2007), afterwards a 2 x 2 x 2 repeated measures analysis of variance (ANOVA) was conducted with the factors POWER (Run 1 vs. Run 2), RESPONDER (fair vs. unfair) and DUMMY (fair vs. unfair). Subject gender was used as between-subjects variable.

The results of both questionnaires (Justice Sensitivity Questionnaire and “Ultimatum Game Questionnaire”) were examined in relation to the results of the EEG and in relation to the behavioral data. For this purpose, correlation analyses were carried out.

### **7.5.2 ERP data**

Before analysing ERP data, several steps had to be conducted, starting with the removal of artifacts due to eye movements or blinks (EOG activity). These artifacts are relatively easy to remove, which was done with a linear regression approach with

channel-specific correction coefficients. These coefficients were derived through a simple task, in which subjects had to follow a continually moving red dot on the screen with their eyes (once horizontally and once vertically). The calibration of the parameters was done prior to the experiment and was controlled for sufficient values immediately (Bauer & Lauber, 1979). The parameters were then transformed using a template matching procedure and subtracted from each EEG-channel (Lamm, Fischmeister, & Bauer, 2005).

Afterwards, off-line analysis was done using EEGLAB 6.0.3b (Delorme & Makeig, 2004) integrated in Matlab 7.5.0 (The MathWorks). EEG data were low-pass filtered up to a cut-off frequency of 30 Hz and EEG epochs of 1200 milliseconds were extracted for each condition. These 1200 milliseconds consisted of a 200 ms baseline (the time before stimulus onset) and 1000 ms after the offer. The different conditions of the experiment were separated from each other (split up according to fairness to dummy, fairness to responder, accepted and rejected) to make comparison possible. Data were then merged (accepted and denied offers in every condition were merged to one dataset) and down-sampled from 1000 Hz to 250 Hz for further work on it.

Heavily artifact-distorted trials were identified through visual inspection and were removed.

Then, EOG and ECG channels were removed and channel locations were integrated into the files. Noisy channels, which were mostly located near the ears, were interpolated (two to three at a max). Linear trends, which occur frequently in EEG DC recordings, were removed from the data using a standardized procedure. An independent component analysis (ICA) was conducted to identify signal-distorting components and to remove artifacts like blinks or ECG activity effectively. This procedure can find as many components as channels were recorded. These latent components, which are maximally independent, form the combined signal when added together. The components to be removed were identified by visual inspection, the variance explained by them and the topographic pattern. Usually there were about two to seven components per subject to be removed.

When data were as clean as possible, the last artifact-polluted trials were removed

(fine rejection) and every trial was baseline-corrected. The latter was done by subtracting the baseline from the whole time-interval.

Afterwards, the grand averages of the single trials within every condition and subject were calculated, which led to eight different conditions: (1) First run: fair/fair, (2) first run: fair/unfair, (3) first run: unfair/fair, (4) first run: unfair/unfair, (5) second run: fair/fair, (6) second run: fair/unfair, (7) second run: unfair/fair, (8) second run: unfair/unfair. Data of the subject being in the dummy role were ignored within this thesis. The relevant peaks of the waveforms were visually detected and marked with BRL peak finder 0.1b, implemented in EEGLAB, and saved (by amplitude and latency) for further statistical analysis with SPSS.

The P200 peak was defined as the most positive peak within the time-frame between 140 and 240 ms. The value of the amplitude was determined via a base-to-peak-approach (Rigoni et al., 2010).

The MFN peak was defined as the most negative peak within the time-frame of 200-350 ms after the baseline. The MFN was calculated in line with Polezzi et al. (2008), who used a peak-to-peak approach, i.e. they calculated the difference between the MFN peak and the preceding P200 peak.

Both of the components (P200 and MFN) were marked at locations Fz, FCz and Cz. Visual inspection of grand averages showed the most pronounced amplitudes at Fz, which led to the use of the data of this electrode for the final statistical analyses.

The P300 was identified as the most positive peak in the time-frame between 400 and 600 ms and was marked at location Pz.

A 2 x 2 x 2 repeated measures ANOVA was carried out for every single component, with the factors POWER (Run 1 vs. Run 2), RESPONDER (fair vs. unfair), and DUMMY (fair vs. unfair) to determine the relevance of the component for every factor. Gender was used as between-subjects factor. Additional ANOVAs were carried out for each run with the factors RESPONDER and DUMMY. Additionally, ANOVAs were conducted for component latencies to detect potential effects of fairness of the offer on latency. Pairwise comparisons of offers were made.

Although 30 subjects were tested within this experiment, not all of them could be used in the final statistical analysis because of different reasons: First, some of the subjects simply delivered noisy and heavily distorted data. Eight of the subjects had to be excluded in early phases of data processing for this reason. Another three had to be excluded after the artifacts and components were removed and it got obvious that their data could not be corrected appropriately, or because they showed extreme values. The remaining 19 subjects (11m, 8f; mean age: 25,21 (SD: 3,95)) were included into further analysis and delivered the results mentioned below.

## 8 Results

### 8.1 Behavioral results

#### 8.1.1 Reaction times

Mean RTs of all conditions (see Table 8.1) were compared and a certain pattern for both runs was discovered: FF and UU offers always had significantly lower mean RTs than FU and UF, indicating an easier and faster decision for equitable than for inequitable proposals.

In the second run, the pattern was just the same, but decisions seemed to be getting faster within all conditions. This could be interpreted in terms of the subjects getting used to the game and having established a certain pattern of behavior to deal with it.

A 2 x 2 x 2 ANOVA revealed significant effects of RT for the factors POWER ( $F(1, 17) = 12,676$ ,  $p = .002$ ,  $\eta^2 = .427$ ) and RESPONDER ( $F(1, 17) = 11,824$ ,  $p = .003$ ,  $\eta^2 = .410$ ). Factor DUMMY did not reach significance. Significant interactions between P x D ( $F(1, 17) = 6,815$ ,  $p = .018$ ,  $\eta^2 = .286$ ), R x S ( $F(1, 17) = 9,270$ ,  $p = .007$ ,  $\eta^2 = .353$ ), D x S ( $F(1, 17) = 4,817$ ,  $p = .042$ ,  $\eta^2 = .221$ ), and R x D ( $F(1, 17) = 27,093$ ,  $p = .000$ ,  $\eta^2 = .614$ ) were revealed.

Table 8.1: Mean Reaction Times for all conditions in both runs

Condition	Run 1	Run 2
FF	1217,62 (SD= 354,96)	1027,52 (SD= 194,64)
FU	1624,01 (SD= 778,49)	1220,03 (SD= 330,55)
UF	1548,79 (SD= 685,16)	1351,12 (SD= 331,79)
UU	1389,34 (SD= 496,54)	1162,42 (SD= 283,72)



## 8.1.2 Acceptance rates

A Friedman test was conducted and revealed significant differences for offer types within both runs:

Run 1:  $\chi^2 = 52,483$ ,  $p < .01$ .

Run 2:  $\chi^2 = 49,972$ ,  $p < .01$ .

See Table 8.2. for ARs and ranks (within runs) for the different types of offers.

Table 8.2: Acceptance rates and ranks in both conditions

Condition	Run 1		Run 2	
	Acceptance rate	Rank	Acceptance rate	Rank
FF	98.95%	3,87	99.12%	3,71
FU	84.74%	3,11	90.88%	3,24
UF	17.54%	1,71	31.05%	1,89
UU	3.68%	1,32	3.16%	1,16

For comparisons of offer-types between runs, Wilcoxon tests were used.

As expected, for the conditions with equal outcomes for both responder and dummy there were no significant differences between the two runs (FF:  $T = 4$ , exact  $p = 1.00$ ,  $r = -.086$ ; UU:  $T = 6$ , exact  $p = .65$ ,  $r = -.038$ ). Interestingly, the between-runs ARs for FU and UF offers showed differences. For FU offers, the AR rose from 84.74% to 90.88%, indicating a different perception of the dummy as an opponent, but this change was not significant ( $T = 14$ , exact  $p = .11$ ,  $r = -.38$ ). The rise of the AR for UF offers was even higher; it climbed from 17.54% to 31.05%, which also did not represent a significant change ( $T = 9$ , exact  $p = .15$ ,  $r = -.33$ ). A result that, in contrast to the FU offers result, would indicate a more pro-social attitude towards the dummy.

There were no significant correlations between ARs and RTs, neither in run 1 ( $r = .010$ ) nor in run 2 ( $r = -.150$ ). For sex differences, there were no significant effects. Men accepted 93% of FU offers, whereas women only accepted 73% of those. Generally, men tended to accept more offers than women (see Table 8.3).

Table 8.3. Acceptance rates male/female in both runs

Condition	Run 1		Run 2	
	female	male	female	male
FF	98,33%	99,39%	99,17%	99,09%
FU	72,50%	93,64%	90,42%	91,21%
UF	10,83%	22,42%	27,50%	33,64%
UU	00,83%	05,76%	05,00%	01,82%

### 8.1.3 Justice Sensitivity Questionnaire results

Statistical analyses revealed a correlation between ARs for equally unfair offers in both runs with one or more scales of the JSQ. In the first run scales victim (-.524,  $p = .021$ ), observer (-.562,  $p = .015$ ) and perpetrator (-.582,  $p = .009$ ) were significantly correlated with such offers, whereas in the second run only the victim-scale (.484,  $p = .036$ ) reached significance. The change of directions of these correlations is quite interesting. While in the first run the AR of equally unfair offers decreased with higher values in the scales of the questionnaire, it increased in the second run.

There were no correlations between ERP data and the scales of the JSQ.

### 8.1.4 Ultimatum Game Questionnaire results

Statistical analyses of unequal offers and the UG Questionnaire revealed a correlation between ARs for UF offers in the second run and three of the questionnaire's items:

Item 2 ("Please judge your own behavior (your fairness) to the other player on a scale from 1 to 7 (with 1 being very unfair)") correlated with  $r = .689$ ,  $p = .001$  with UF offers, item 3 ("How strong did you feel the presence of the other player despite the

spatial distance (with 7 being very strong?)” reached  $r = .525$ ,  $p = .021$ , and item 4 (“Do you think, that you took the other player more into account in the second run, than in the first run?”) reached  $r = .578$ ,  $p = .010$ .

## 8.2 ERP results

As expected, offer types as well as social context had a visible influence on ERPs, as can be seen by visual inspection of the ERP waveforms (see Figures 8.1 and 8.2). The most salient difference in the first run can be seen at 200 ms, where FF and UU offers showed distinctly higher amplitudes than the other offer types. This obviously changed in the second run, with still high UU amplitudes, followed by FU amplitudes. Exemplary scalp topographies are shown in Figures 8.3 and 8.4.

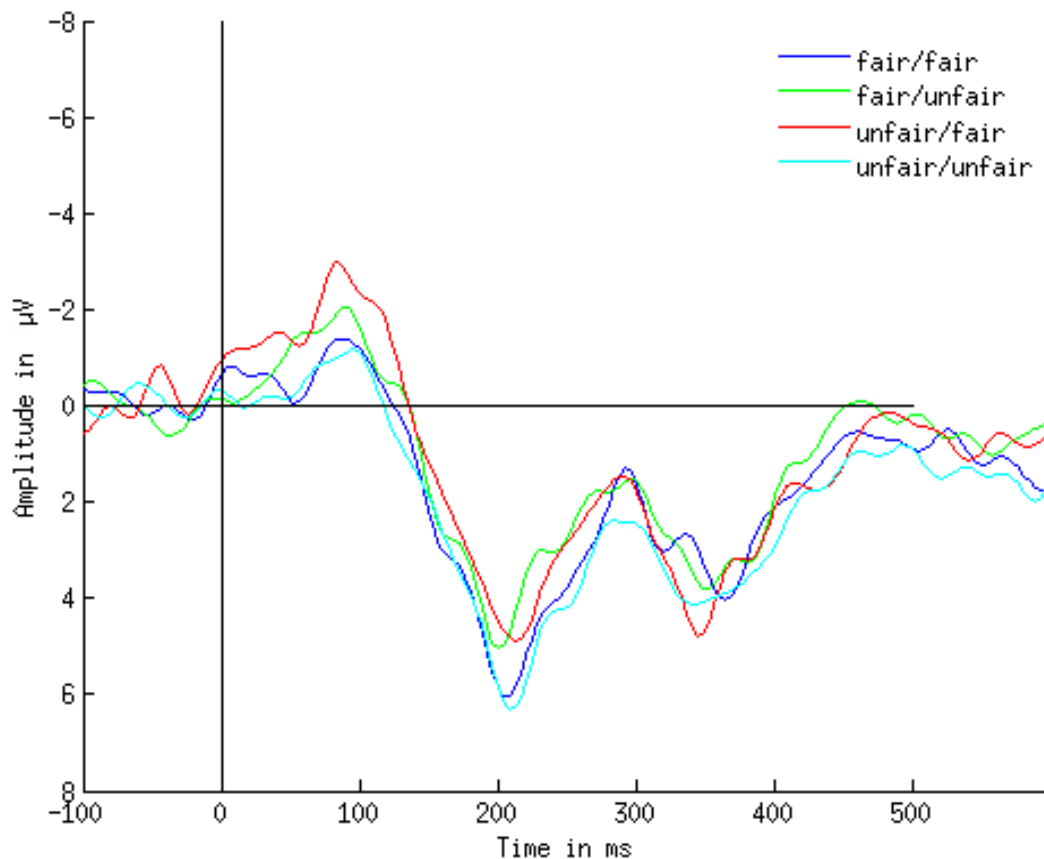


Figure 8.1: ERP waveforms at location Fz in the first run. Negative is plotted upwards.

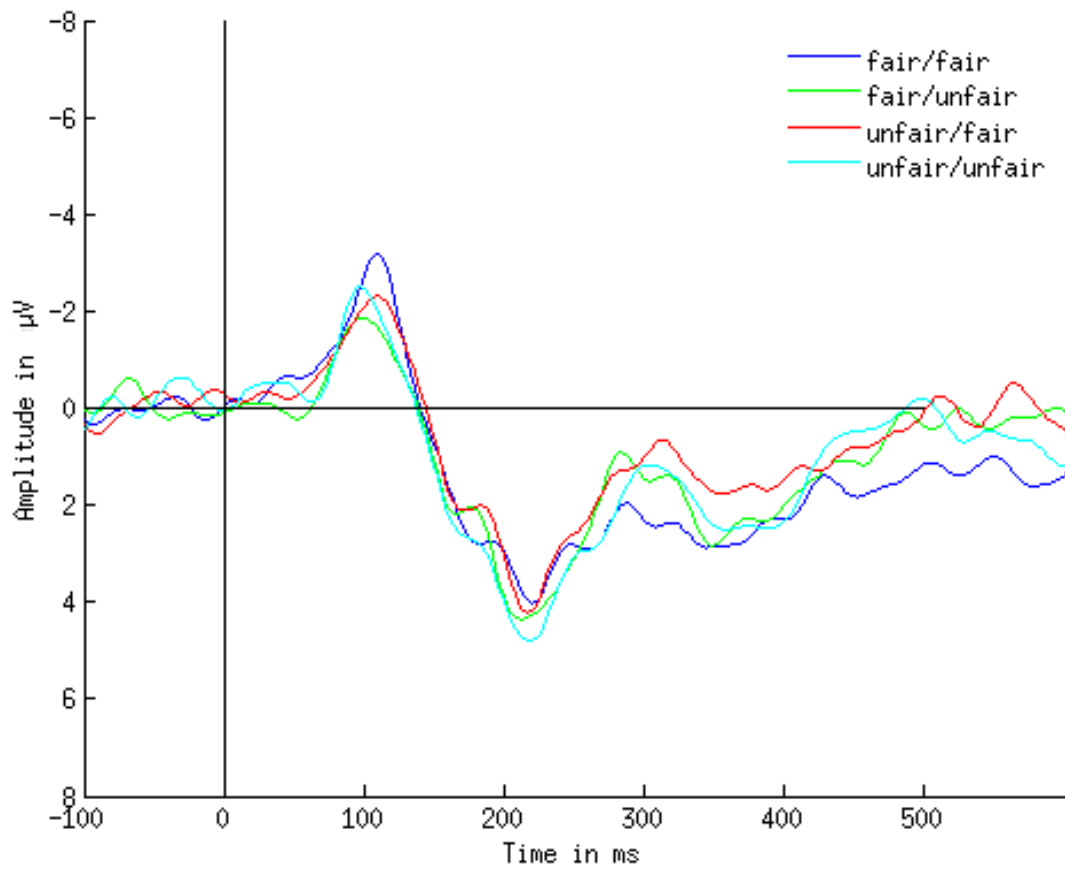


Figure 8.2: ERP waveforms at location Fz in the second run. Negative is plotted upwards.

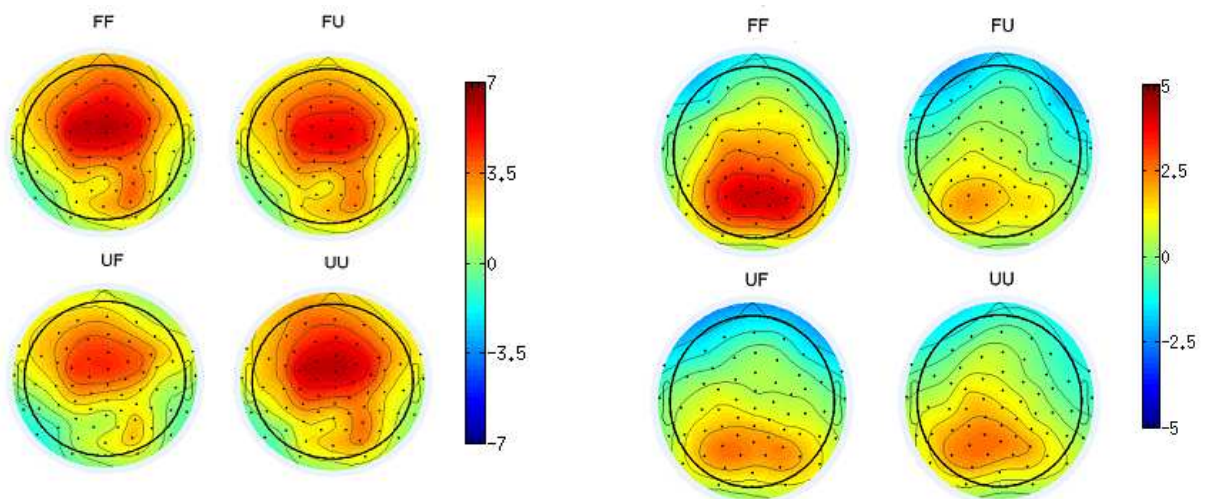


Figure 8.3: Exemplary scalp topographies:  
 Left: Scalp topographies of voltages at 200ms (P200) in the first run.  
 Right: Scalp topographies of voltages at 530ms (P300) in the second run.

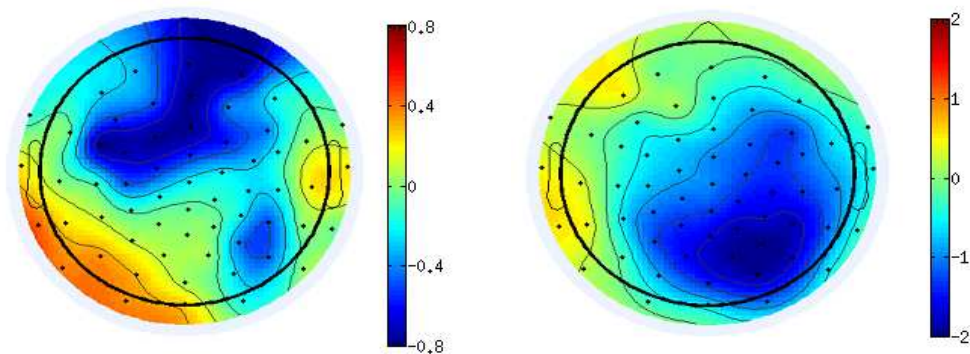


Figure 8.4: Exemplary scalp topographies of voltage differences:  
 Left: Voltage differences at 200ms in the first run for FU - FF offers.  
 Right: Voltage differences at 530ms in the second run for UU - FF offers.

### 8.2.1 P200 results

P200 analysis delivered the most interesting results of this study, because there were significant results in both of the two runs and those results differed between conditions.

The 2 x 2 x 2 ANOVA for P200 revealed a significant main effect of the factor POWER (Run 1 vs. Run 2;  $F(1, 17) = 6,819$ ,  $p = .018$ ,  $\eta^2 = .286$ ) as well as an interaction between POWER x RESPONDER x DUMMY ( $F(1, 17) = 10,371$ ,  $p = .005$ ,  $\eta^2 = .379$ ). There were no between-subjects differences related to gender. Separated ANOVAs for both runs revealed the results described below.

#### *First run:*

In the first run, P200 amplitudes were largest for offers in which both responder and dummy received a fair share (FF;  $7,59 / \mp 3,45$ ), whereas offers that were unfair for both players nearly reached the same amplitudes (UU;  $7,57 / \mp 3,3$ ). Amplitudes of these equal-share offers were much larger than amplitudes for unequal-share offers. Offers, in which only the dummy received an unfair share, elicited the smallest P200 (FU;  $6,44 / \mp 3,03$ ), but these weren't much smaller than the amplitudes of offers

unfair to the responder (UF; 6,60 /  $\mp$  3,36).

In accordance with these results, ANOVA revealed a significant interaction effect between RESPONDER and DUMMY ( $F(1, 18) = 10,575, p = .004, \eta^2 = .370$ ). None of the factors RESPONDER or DUMMY had a significant main effect.

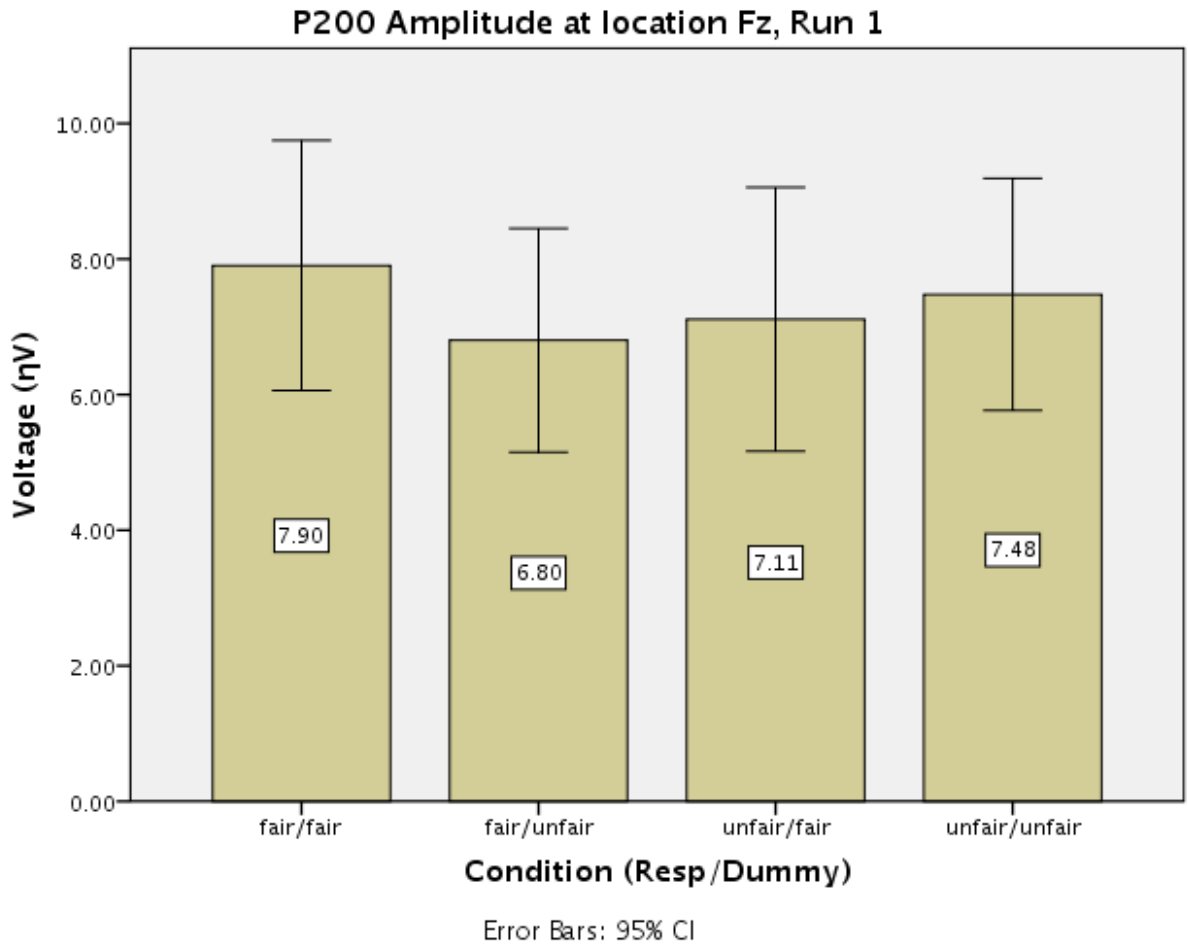


Figure 8.5: P200 Amplitudes at location Fz in Run 1

*Second run:*

In the second run, the pattern of amplitudes changed. Offers where only the dummy received a low share reached the highest amplitudes (FU; 6,34 /  $\mp$  3,73), followed by offers assigning an unfair share to both players (UU; 6,24 /  $\mp$  4,09). Smallest amplitudes were measured for equally fair offers (FF; 5,03 /  $\mp$  2,73). Offers only

unfair to the responder reached a somewhat higher measure (UF; 5,37 /  $\mp$  4,17).

ANOVA revealed a significant main effect for the factor DUMMY ( $F(1, 18) = 4,414$ ,  $p = .050$ ,  $\eta^2 = .197$ ). There were neither significant interactions nor a significant main effect for RESPONDER.

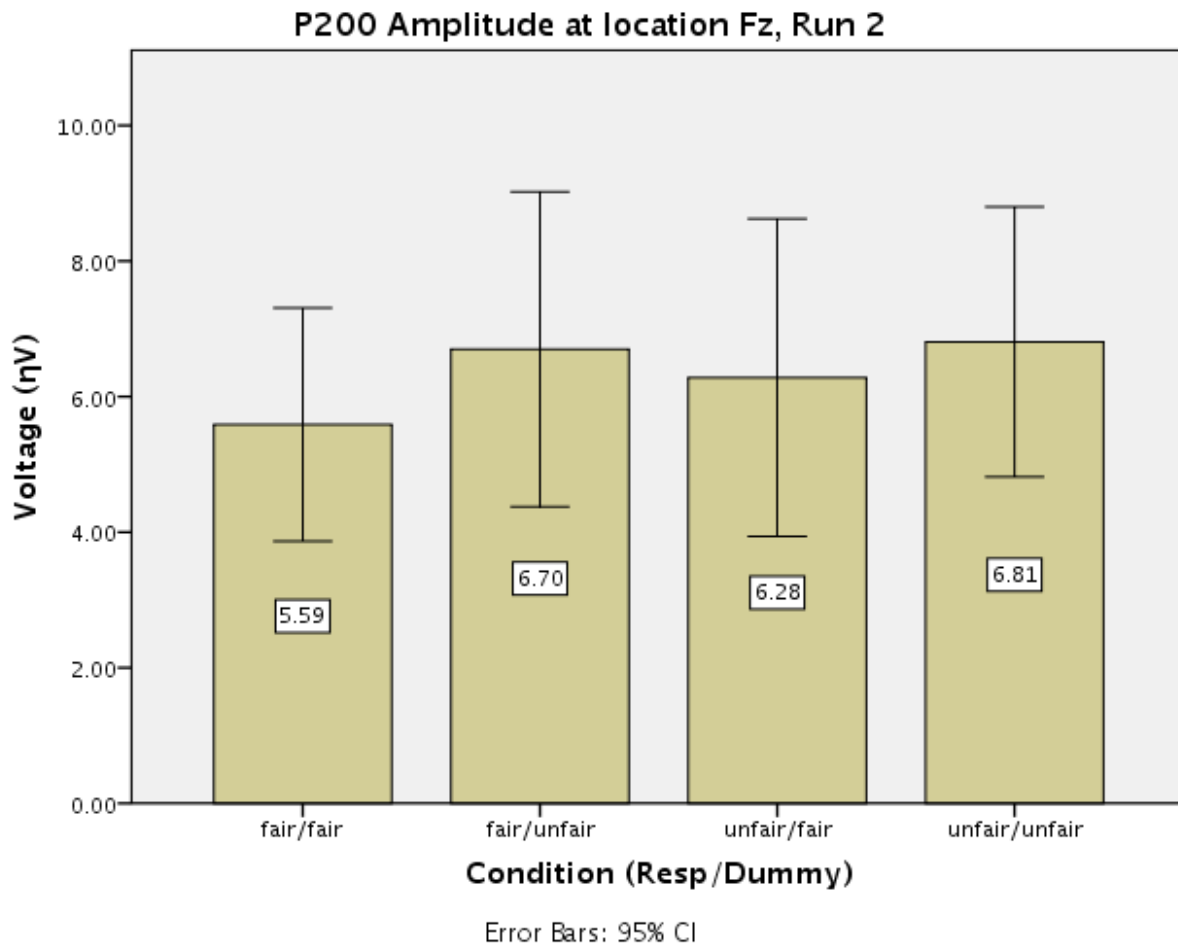


Figure 8.6: P200 Amplitudes at location Fz in Run 2

#### *Latency of P200 at Fz:*

In the first run, there were no effects of differences in P200 latency, whereas in the second run, ANOVA revealed a close-to-significance effect for the factor DUMMY ( $F(1, 18) = 3,541$ ,  $p = .076$ ,  $\eta^2 = .164$ ). Visual plot inspection showed a slightly longer latency for unfair offers to the dummy in the second run.



## 8.2.2 MFN results

The 2 x 2 x 2 ANOVA for the MFN revealed a significant main effect of the factor POWER (Run 1 vs. Run 2;  $F(1, 17) = 8,728$ ,  $p = .009$ ,  $\eta^2 = .339$ ) as well as an interaction between POWER x RESPONDER x DUMMY ( $F(1, 17) = 6,059$ ,  $p = .025$ ,  $\eta^2 = .263$ ). Separate ANOVAs for both runs revealed the results mentioned below. The between-subjects variable sex interacted significantly with RUN ( $F(1, 17) = 7,735$ ,  $p = .013$ ,  $\eta^2 = .313$ ).

### *First run:*

ANOVA did not reveal any significant main effects or interactions within the first run. Equally fair offers elicited the largest MFN amplitudes (FF;  $-8,28 / \mp 2,79$ ), but nearly similar to fair offers only to the responder (FU;  $-7,72 / \mp 3,42$ ) and unfair offers to both of the players (UU;  $-7,84 / \mp 3,25$ ). Unfair offers to the responder elicited the smallest MFN (UF;  $-7,18 / \mp 2,89$ ).

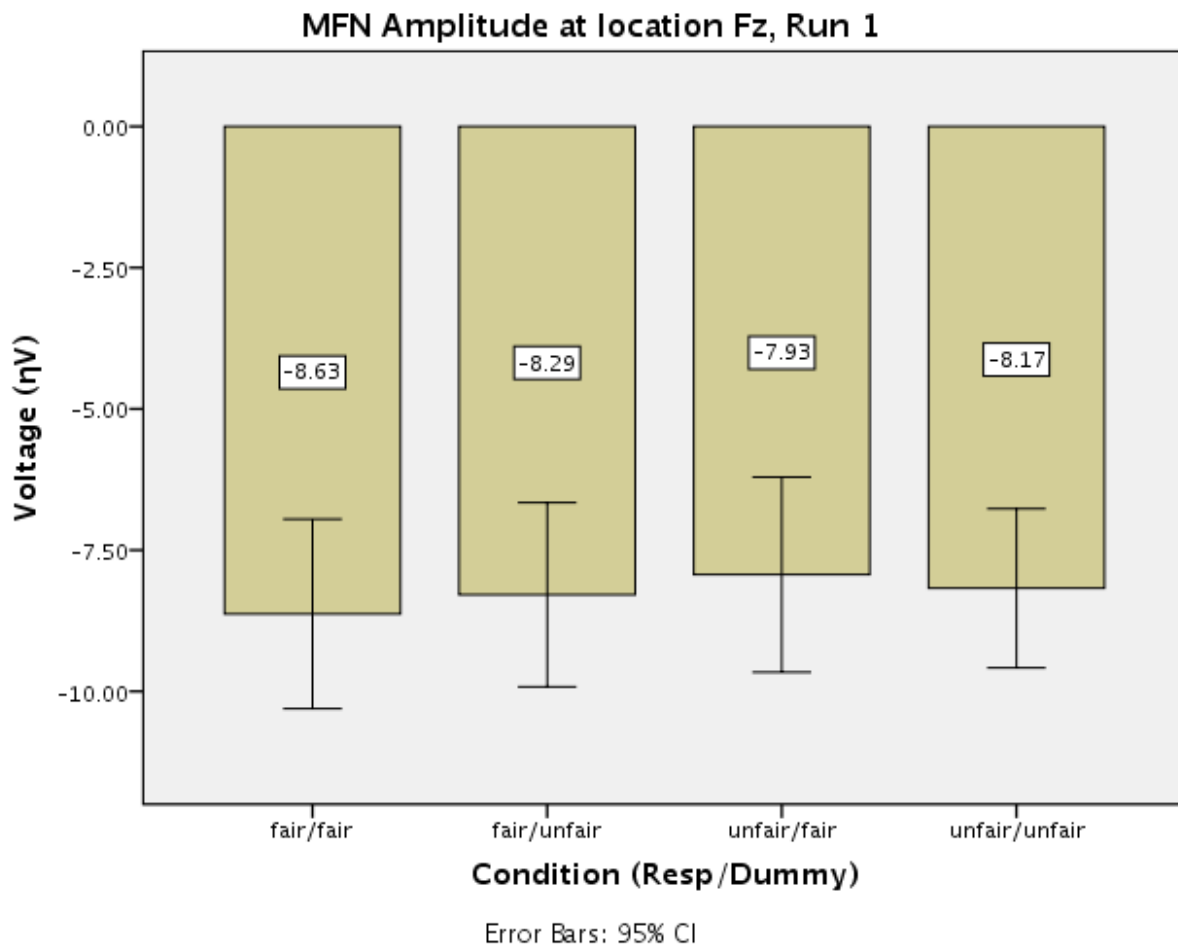


Figure 8.7: MFN Amplitudes at location Fz in Run 1

*Second run:*

In the second run, offers only fair to the responder elicited the largest MFN (FU; -7,49 /  $\mp$  2,84), followed by offers with an unfair share for both players (UU; -7,36 /  $\mp$  3,19). Offers which were unfair to the responder elicited a somewhat smaller MFN (UF; -6,56 /  $\mp$  2,96), but still greater than offers with fair shares to both players, which elicited the smallest MFN (FF; -5,69 /  $\mp$  2,90).

ANOVA did reveal a significant main effect for factor DUMMY ( $F(1, 18) = 7,096$ ,  $p = .016$ ,  $\eta^2 = .283$ ).

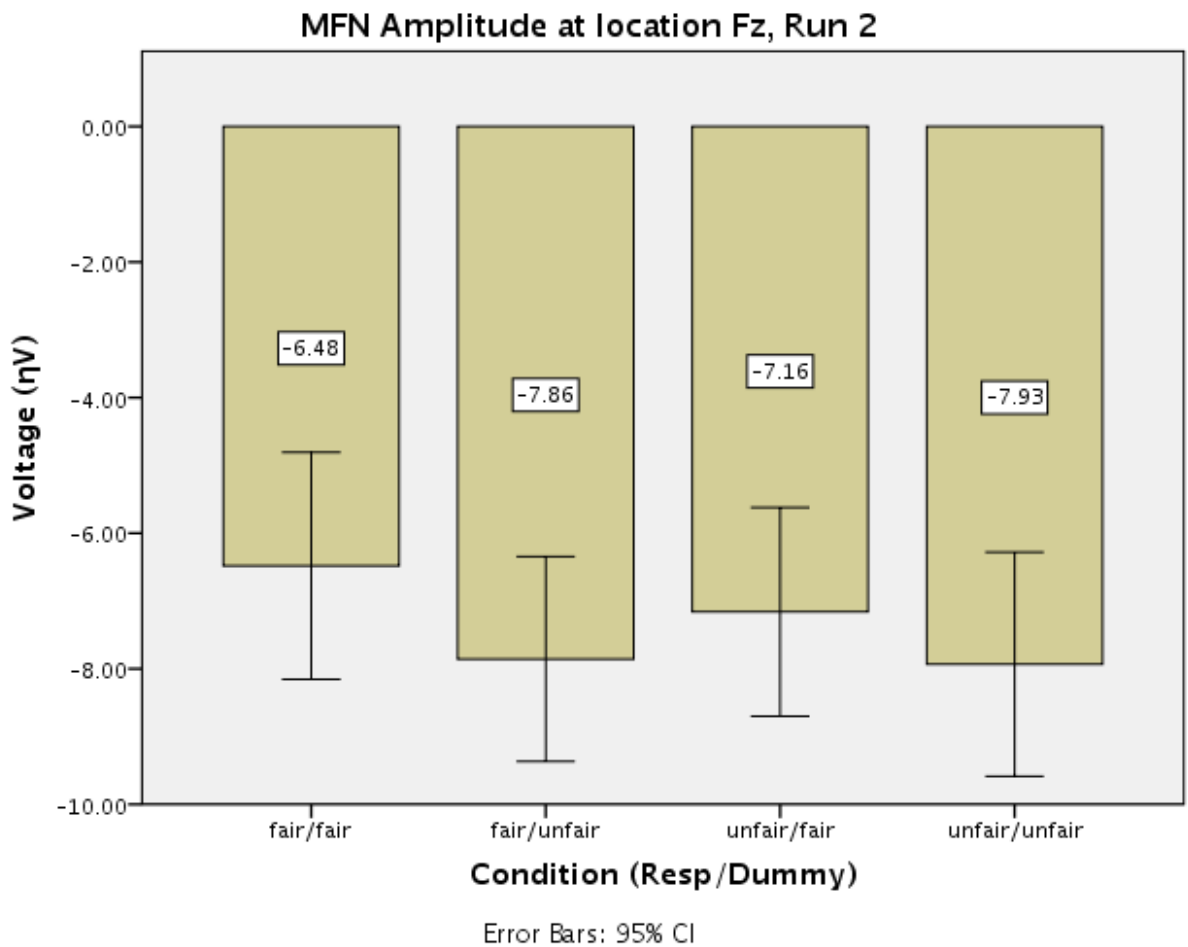


Figure 8.8: MFN Amplitudes at location Fz in Run 2

*Latency of MFN at Fz:*

Analysis of MFN latencies did not reveal any significant effects within both runs.

**8.2.3 P300 results**

The 2 x 2 x 2 ANOVA for P300 revealed a significant interaction of factors POWER x RESPONDER ( $F(1, 17) = 4,899, p = .041, \eta^2 = .224$ ) as well as an interaction between POWER x DUMMY ( $F(1, 17) = 7,280, p = .015, \eta^2 = .300$ ). There were no between-subjects differences related to gender. Separate ANOVAs for both runs revealed the results mentioned below.

*First run:*

In the first run, ANOVA showed no significant main effects or interactions for P300 amplitude. Equally fair offers (FF; 5,78 /  $\mp$  2,69) showed a much lower amplitude than offers fair to the responder (FU; 6,53 /  $\mp$  2,12), whereas equally unfair (UU; 6,41 /  $\mp$  2,49) and responder-unfair offers (UF; 6,37 /  $\mp$  2,87) were not that much lower.

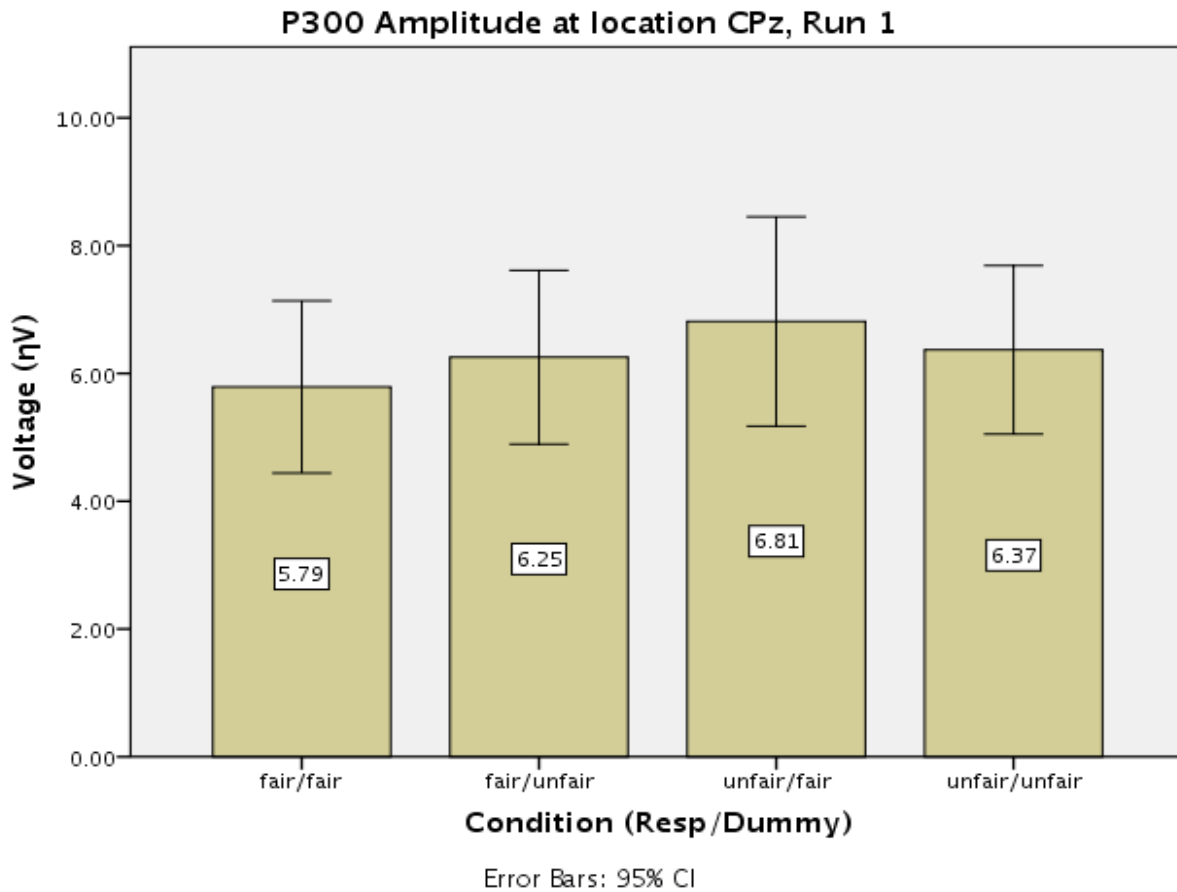


Figure 8.9: P300 Amplitudes at location CPz in Run 1

*Second run:*

The second run, on the contrary, revealed significant main effects for both RESPONDER ( $F(1, 18) = 4,574$ ,  $p = .046$ ,  $\eta^2 = .203$ ) and DUMMY ( $F(1, 18) = 6,528$ ,  $p = .020$ ,  $\eta^2 = .266$ ).

Interestingly, the pattern of amplitudes changed. Equally fair offers elicited the largest

P300 of all conditions (FF; 7,11 /  $\mp$  3,39), distancing the remaining conditions considerably. Unequal offers elicited a rather small P300 (FU; 5,44 /  $\mp$  3,22 ; UF; 5,27 /  $\mp$  3,45), whereas equally unfair offers elicited the smallest amplitudes (UU; 5,15 /  $\mp$  3,48).

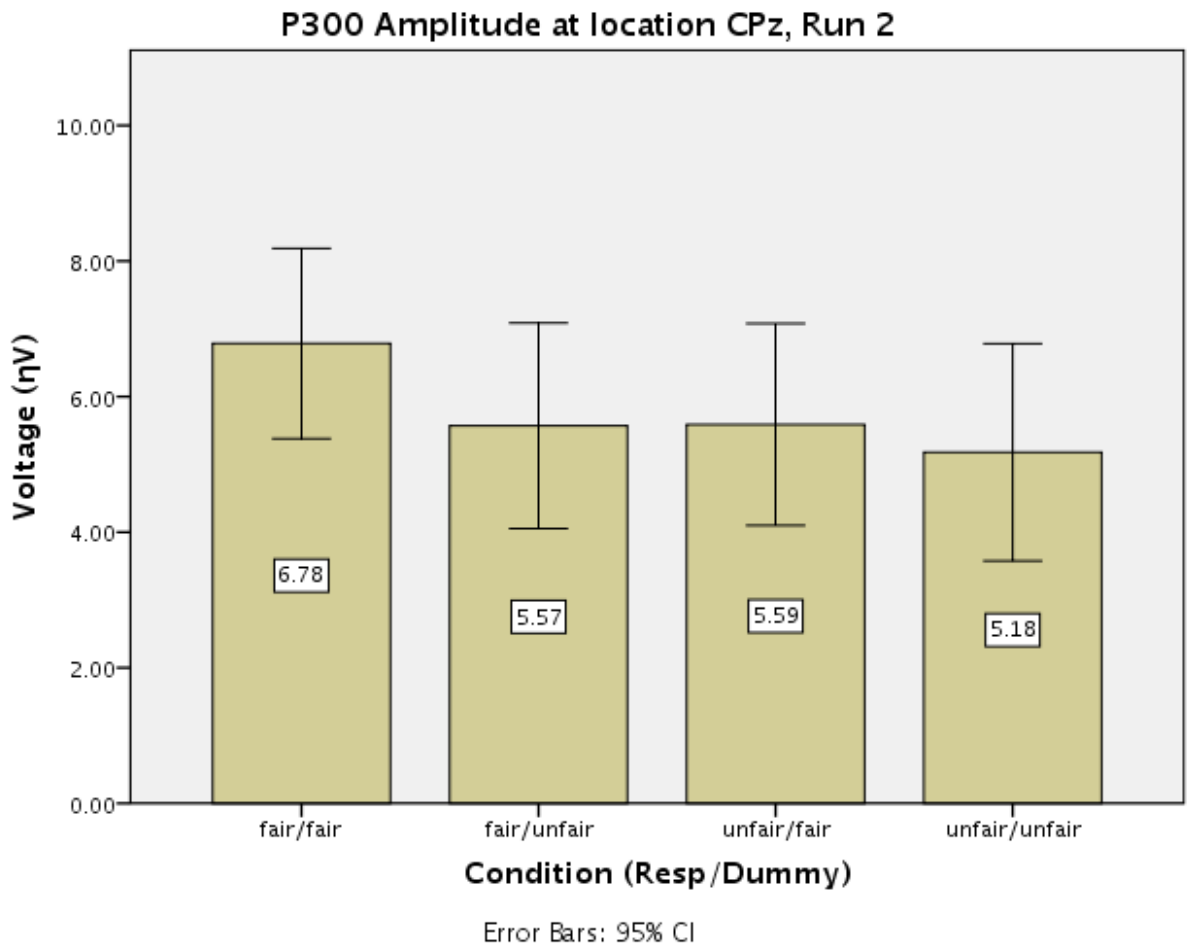


Figure 8.10: P300 Amplitudes at location CPz in Run 2

*Latency of P300 at CPz:*

Analyses of latencies did not reveal any effects in the first run. In the second run, factors RESPONDER ( $F(1, 18) = 9,678, p = .006, \eta^2 = .350$ ) and DUMMY ( $F(1, 18) = 5,042, p = .038, \eta^2 = .219$ ) reached significance. Also the interaction between RESPONDER and DUMMY was significant ( $F(1, 18) = 4,465, p = .049, \eta^2 = .199$ ).

Inspection of latency means showed a distinctly higher P300 latency for fair/fair (534,33 ms) offers in comparison to all other types of offers (FU = 475,70 ms, UF = 481,67 ms, UU = 488,00 ms)

## 9 Discussion

This thesis aimed to shed light on the representation of self-centred and other-regarding fairness in the Ultimatum Game within the human ERP and its modulation by social context. To achieve this, an extended version of the Ultimatum Game, the so called GvD game, was used and modified. Because previous research on this paradigm was concentrated on the standard Ultimatum Game, this thesis tried to explore the properties of three important ERPs (which were investigated in earlier studies) within the GvD game.

Behavioral patterns in this study were largely in accordance with earlier results (Polezzi et al., 2008), with shorter RTs for equal (FF and UU) than for unequal offers (FU and UF), a result that obviously indicates less cognitive conflict and an easier decision-making process for equal offers. So, no matter what social context subjects were in, they seemed to rather automatically accept or reject unambiguously fair or unfair offers, indicated by nearly identical RT patterns in both runs of the game.

ARs were not much different from results of other Ultimatum Game studies, with the usual high ARs for equally fair (FF) offers and low ones for equally unfair (UU) offers (Güth et al., 2007). Advantageously unequal (FU) offers showed much higher ARs than disadvantageous ones (UF). Although this pattern stayed constant between runs (with nearly exactly the same ARs for equal offers), ARs changed for unequal offers in an interesting way. While ARs for FU offers rose only slightly from first to second run (84 to 90%), which could be explained by a more egoistic (or rational) way of playing in the second run, ARs for UF offers rose steeply (from 17 to 31%). This result underlines the statement of Güth & van Damme (1998), who said that “fairness, as a social norm, seems restricted to those who have strategic influence”<sup>12</sup>. Now that the

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<sup>12</sup> Güth, W., & van Damme, E. (1998). Information, strategic behavior and fairness in ultimatum bargaining - an experimental study. *Journal of Mathematical Psychology*, 42, p. 243.

dummy himself had the power to reject offers, participants obviously tended to accept more inequitable offers to themselves, maybe to “seem fair” (Güth & van Damme, 1998) or simply because of strategy, i.e. to encourage the dummy to accept more responder-fair offers (FU). Another interesting behavioral result was provided by the self-designed Ultimatum Game Questionnaire, which revealed a correlation between self-perceived fairness of the subjects and the AR for UF offers in the second run. This result matches the results above, because it only concerns behavior in the second, but not in the first run, where the dummy had no power and did not seem to induce that many fairness concerns. Anyway, this result could have occurred due to the fact that the questionnaire was filled in after the second run.

While Fehr & Schmidt (1999) state that people only care about inequity between themselves and every single other player, but not about inequalities between other players, Bolton & Ockenfels (2000) proposed that a person's utility function decreases with a lower relative payoff in comparison to the average player's outcome. In the Fehr & Schmidt model, the utility function is affected by the payoff of every single player, whereas in the Bolton & Ockenfels model it is not. So which of the models suits the data of this experiment best? If a player is assumed to be satisfied with his outcome as soon as it approaches one third (in case of the GvD game) of the cake, as stated by Bolton & Ockenfels, players should accept every offer being fair at least for themselves and reject any other offer. This was not the case. If the Fehr & Schmidt model is applied, players should compare their outcome with every other player, so an UF offer leads to the experience of disadvantageous inequity. This model also does not fully match the results:

If one player compares his outcome with every other relevant player (and if the dummy is not a relevant player in the first, but in the second run), subjective disadvantageous inequity would rise for UF offers in the second run (two times disadvantageous inequity), leading to a lower AR, which did not happen. One possible reason could be a conflict between empathic and strategic concerns (for the more powerful dummy) on the one hand and fairness considerations in the Bolton & Ockenfels/Fehr & Schmidt-sense (inequity aversion) on the other hand.

This study's focus of interest was laid on three ERPs, the P200, the MFN, and the

P300, and their modulation by social context. Differences between offer-types within and between the two runs were expected and discovered. All of the investigated components showed differences in their amplitudes from the first to the second run, which allowed interesting insights into how they were affected by social context.

First to be mentioned, P200 results of the present study seem to be very promising. This positive component is said to either reflect an early assessment of outcomes (positive valence elicits a more positive P200; see Rigoni et al., 2010), or the allocation of attentive resources (Potts, 2004). In the first run, the P200 was expected to make a distinction between small and large gains. Thus, the component's amplitudes were expected to be highest for FF and FU offers in the first run, which only partly came true. Following Rigoni et al. (2010), who let their subjects play a gambling task in three social contexts (no social context, comparison, competition) and observed P200 effects of revealed outcomes, attentive resources should have been shifted toward social cues in the second run. Therefore, the amplitudes were expected to be less differentiated between offer types in the second run, because in Rigoni et al. (2010) differences got smaller (and insignificant) within the "social conditions".

The pattern of the P200 amplitudes for the different kinds of offers changed between runs, which indicates a major influence of social context on this component. In the first run, when the dummy had no power at all, a significant interaction between factors RESPONDER and DUMMY was observed. Equally fair (FF) or unfair (UU) offers elicited a higher P200 than unequal offers did, which supports the inequity aversion theory of Fehr & Schmidt (1999) or Bolton & Ockenfels (2000). In the second run, on the contrary, P200 differentiated between fair and unfair offers to the dummy, with significantly higher amplitudes for dummy-unfair offers (FU and UU) than for dummy-fair offers (FF and UF). Considering the fact that high amplitudes of this component seemed to indicate equal offers in the first and dummy-unfair offers in the second run, this can be interpreted in different ways.

As mentioned above, there are different theories on the functionality of the P200, with the two major ones being allocation of attentive resources (Potts, 2004) and early



assessment of outcomes (Rigoni et al., 2010). Assuming the P200 to reflect outcome assessment, showing higher amplitudes for positive valence (“gains”) than for negative valence (“losses”) (Rigoni et al., 2010), one could define equity as a “gain” in the first run (FF and UU were highest), because there was no competition between responder and dummy, but just comparison (i.e. the dummy had no influence on the player's outcome). In the second run, dummy-unfair offers (FU and UU) could be interpreted as “gains”, because the change of social context elicited a feeling of competition and any offer where the responder was better off than the dummy (or at least equally bad) was perceived as a gain.

If the P200 instead reflects allocation of attentive resources, these resources could be shifted from equity in the first run to strategic evaluations in the second run. Offers with disadvantageous inequity for the responder (UF) and FF-offers therefore would not have such a big impact on the dummy's strategy. Advantageous offers to oneself (FU), as well as UU-offers could lead to a negative attitude of the dummy, consequently causing rejections of subject-fair offers in the future.

In both cases, the valence of outcomes or the allocation of attentive resources seems to be modulated by social context. This indicates a change of perception of the dummy player by the participants. Because subjects played the same task in both runs, whereas in the second run they just rotated roles with the dummy, this change of P200 can be interpreted as an effect of social context.

The second ERP component, called MFN, is a negative component presumably generated in the ACC, which is said to reflect a distinction between unfair and fair offers in the Ultimatum Game, showing higher amplitudes for unfair offers (Boksem & De Cremer, 2009). Highest amplitudes in the present study were awaited for responder-unfair offers in general (UU and UF). A difference between runs was expected for dummy-unfair offers (UU and FU), with higher MFN amplitudes for such offers in the second run. UU offers in the second run were expected to be highest because of the strategic relevance of the dummy.

Interestingly, the MFN effects did not reach significance in the first run, whereas this component was central in some earlier Ultimatum Game experiments (Boksem & De Cremer, 2009; Polezzi et al., 2008). In the second run, the pattern of this component

was very similar to the P200 pattern in the same condition. Results were not in line with Boksem & De Cremer (2009), because unfair offers to the dummy (FU and UU) elicited the highest MFN amplitudes, significantly stronger than dummy-fair offers. The present results may indicate a lower involvement in the first run, and a perception of the dummy as an important player in the second run, seeing unfair offers to the dummy as an unfavourable outcome for oneself. This could be due to the fact, that dummy-unfair offers would lead to a rejection by the responder, which weakens the position of the responder as soon as the dummy comes to decide about an unfair offer to the responder (like for the P200). As the MFN is supposed to be elicited in the ACC (Dehaene et al., 1994), which reflects cognitive conflict (Sanfey et al., 2003), unfair offers to the dummy seem to elicit greater conflict when he has power in the game and therefore strategic (and emotional?) meaning. If the dummy had less importance to the subjects in the first run, they could make their decisions more easily, because they did not feel responsible for the powerless dummy, or at least did not have to take his outcome into consideration because of his strategic weakness, which leads to less distinguishable ACC activity.

One reason for the lower involvement in the first run could be the structure of offers in the experiment. Only clearly fair and clearly unfair offers were used in this study in order to make the experiment (which already lasted one hour with the actual design, preparation excluded) more comfortable and reasonable for the participants. This could have led to an easy behavioral scheme the participants had soon adapted to. In the second run, when roles switched all the time and subjects had to take the other player into consideration, there should have been more cognitive effort to be made. In the study of Polezzi et al. (2008), MFN did not distinguish between clearly fair and unfair either, but only between fair and mid-fair offers in the Ultimatum Game, which is in line with the present results. Fliessbach et al. (2007) reported the impact of social comparisons on reward-related neural activity within their fMRI-study. Their subjects played an estimation task against another person and showed lower activity in the ventral striatum when being worse off than the other person.

This result can be transferred to the present study, because MFN, which is thought to reflect a distinction between unfair and fair offers (reward-related; Boksem & De Cremer, 2009), was affected by social context too.

The third component investigated in this study was the P300, a positive ERP component. In a study of Yeung & Sanfey (2004), who let their subjects play a gambling task, the P300 differentiated between small and large outcomes, whereas Rigoni et al. (2010) discovered the component to be differentiating between obtained and non-obtained outcomes, being larger for the former, which was interpreted in terms of motivational significance. According to these studies, the P300 was expected to be highest for responder-fair offers, especially for FF offers in the second run (because of the dummy's greater importance). In fact, P300 did not differ much between types of offers in the first run, which could be because of the seemingly lower involvement of participants. In the second run, as expected, it reached a significantly higher value for fair/fair offers than for any other types of offers. These high amplitudes were accompanied by longer P300 latencies after such offers. As the P300 is said to vary with motivational significance (Rigoni et al., 2010) and with magnitude of outcome (Yeung & Sanfey, 2004), this is in line with recently published studies, because motivational significance seemed to have increased (the positive outcome also affects the dummy) and the dummy-part of the offer could be included into calculation of magnitude of outcome because of the dummy's strategic relevance.

Effects of gender on the MFN were expected, namely a lower MFN for dummy-unfair offers in men than in women (Fukushima & Hiraki, 2006), but could not be discovered. Nevertheless, an effect on ARs was discovered. Men accepted FU offers in the first run more often than women did. In the second run, when the dummy had power too, women nearly equalized men's AR for FU offers. Women's higher empathy for the weak dummy in the first run could be a reason for these results (Fukushima & Hiraki, 2006).

There were some limitations within this study, for example the non-existence of mid-fair offers, which could have led to less cognitive effort and lower involvement, especially in the first run. This leads to suggestions for further research: In future

designs, a more differentiated offer structure should be applied, to keep the subjects attended to the task and to strengthen their involvement. The question arising is how to keep the design reasonable for the participants. It would be of advantage if a real dummy player, who gets introduced to the responder at the beginning of the game, took part in a study. Maybe also an actor or some involved person would be sufficient for this purpose.

The differences between runs for every single ERP component seemed to reflect the change of social context and the importance of strategic power of the dummy for being included in the subject's decision-making process. When the dummy had no power, behavioral outcomes as well indicated a lower concern for the dummy's outcome and well-being. So this study emphasizes the importance of strategic power for considerations in decision-making processes. This fact is illustrated by behavioral outcomes on the one hand and is also reflected by changes within ERPs between the two social contexts.

## Appendix

### ***Appendix A – Instructions in German***

*First Run:*

“Du wirst jetzt das 3-Personen-Ultimatum-Spiel spielen.

Dieses Spiel funktioniert folgendermaßen:

Es gilt, einen Geldbetrag zwischen drei Spielern aufzuteilen (12€, 15€ oder 18€).

Es gibt in dem Spiel 3 Rollen:

- Den Proposer, der den anderen Spielern einen Vorschlag zur Aufteilung unterbreitet (Ich bekomme 6 €, Spieler 1 bekommt 6 € und Spieler2 bekommt 6€).
- Den Responder, der das Angebot entweder annehmen oder ablehnen kann.
- Den Dummy, der keine Entscheidungsgewalt hat. Er bekommt, was man ihm zugesteht.

Nimmt der Responder ein Angebot an, so wird das Geld entsprechend aufgeteilt.

Lehnt er das Angebot aber ab, so bekommt keiner von den Spielern etwas.

Du wirst im kommenden Spiel entweder der Rolle des Responder oder der des Dummy zugeteilt. Bitte bleib immer konzentriert und nimm die Angebote bewusst wahr. Bist du in der Rolle des Responder, kannst du mit den Tasten 1 und 2 der Antwortbox die Angebote annehmen oder ablehnen.

Die Angebote wurden im Vorhinein von verschiedenen Leuten eingeholt, du wirst ihre Fotos vor jedem Durchgang sehen. Diejenigen Leute, die am erfolgreichsten mit ihren Angeboten waren (d.h. diejenigen, deren Angebote von den meisten Teilnehmern dieser Untersuchung akzeptiert wurden), bekommen ebenfalls Geld ausgezahlt.

Hier noch ein Beispielangebot, damit du dir vorstellen kannst, wie das Spiel aussieht:

Bettina: 10 €  
DeinName: 1 €  
Spieler 2: 1 €

Viel Spass beim Spielen!”

*Second Run:*

### **“Informationen zum zweiten Durchgang**

Das war der Übungsdurchgang. Im kommenden Durchgang werdet ihr laufend die Rollen tauschen, das heißt du wirst mal den Responder, mal den Dummy spielen. Du wirst wiederum nach jeder Pause die Fotos der Proposer des nächsten Durchgangs sehen.

Als Neuigkeit kommt hinzu, dass vor jedem Angebot die Rollenverteilung bekannt gegeben wird:

DeinName: Responder  
Spieler 2: Dummy

Danach fixiere bitte das Kreuz und warte das gewohnte Angebot ab.

Bist du in der Rolle des Responder, kannst du das Angebot wiederum annehmen oder ablehnen.

Es gibt mehrere Pausen, deren Länge du selbst gestalten kannst. Es kann sein, dass

dein Mitspieler länger Pause machen will. Ist das der Fall, wird es am Bildschirm angezeigt und es geht weiter, sobald dein Mitspieler bereit ist.

Du wirst pro Durchgang gleich oft Dummy und Responder spielen (je 15 mal), es kann aber durchaus sein, dass du einmal mehrere Angebote hintereinander in der gleichen Rolle bist. Lass dich davon bitte nicht irritieren.

Viel Spass beim Spielen!"

## **Appendix B – Ultimatum Game Questionnaire in German**

Ultimatum Game – Fragebogen

1. Bitte beurteile die Fairness deines Mitspielers / deiner Mitspielerin auf einer Skala von 1 bis 7 (1 sehr unfair – 7 sehr fair)

sehr unfair    1 o-o-o-o-o-o-o 7    sehr fair

2. Bitte beurteile dein eigenes Verhalten (deine Fairness) gegenüber deinem Mitspieler / deiner Mitspielerin auf einer Skala von 1 bis 7 (1 sehr unfair – 7 sehr fair)

sehr unfair    1 o-o-o-o-o-o-o 7    sehr fair

3. Wie stark hast du die Anwesenheit deines Mitspielers / deiner Mitspielerin trotz der räumlichen Entfernung wahrgenommen?

sehr schwach    1 o-o-o-o-o-o-o 7    sehr stark

4. Denkst du, du hast im zweiten Durchgang mehr Rücksicht auf deinen Mitspieler / deine Mitspielerin genommen als im ersten Durchgang?

Ja

Nein

## ***Appendix C – Abstract in German***

In den meisten ökonomischen Theorien des menschlichen Entscheidungsverhaltens spielten Konstrukte wie Fairness oder soziale Beziehungen, wenn überhaupt, dann nur eine geringe Rolle. Die Bereiche der so genannten "Behavioral Economics" und der Neuroökonomie versuchen Psychologie und Ökonomie zu vereinen und betonen die Wichtigkeit psychologischer Konstrukte für ökonomische Theorien. Die vorliegende Studie versuchte den Einfluss von sozialem Kontext und Fairness (besonders gegenüber Dritten) auf das Entscheidungsverhalten und ihre Repräsentation im menschlichen ereigniskorrelierten Potential zu ergründen. Dies sollte durch das Aufzeichnen des EEG von Versuchspersonen, während diese das sogenannte Güth van Damme Spiel spielten, erreicht werden. Das Spiel wurde in zwei Kontexten vorgegeben: Im ersten Durchgang spielten die Versuchspersonen durchgehend als Responder, während sie im zweiten kontinuierlich die Rolle mit dem Dummy wechselten.

Die Ergebnisse auf Verhaltensebene zeigten einen Anstieg der Akzeptanzraten für Responder-unfaire/Dummy-faire Angebote vom ersten zum zweiten Durchgang (von 17% auf 31%). Die Analyse der ereigniskorrelierten Potentiale zeigte für die P200 eine Veränderung des Amplitudenmusters zwischen den Durchgängen, wobei im ersten Durchgang höhere Amplituden für gleiche als für ungleiche Angebote und im zweiten Durchgang für Dummy-unfaire als für Dummy-faire Angebote ausgelöst wurden. Dieses Ergebnis kann entweder als Verschiebung von Aufmerksamkeitsressourcen, die von Gleichheit im ersten Durchgang zu strategischen Erwägungen im zweiten Durchgang wanderten, interpretiert werden, oder als frühe Ergebnisbewertung, wobei in diesem Fall im ersten Durchgang Gleichheit und im zweiten Durchgang Dummy-unfaire Angebote einen „Gewinn“ darstellen würden (aufgrund der strategischen Relevanz des Dummy). Die Amplituden der MFN und der P300 zeigten nur im zweiten Durchgang signifikante Unterschiede zwischen den Angebotsarten. Die MFN wies dieselben Unterschiede wie die P200 auf, was als negative Codierung der Dummy-unfairen Angebote gedeutet wurde, da diese sich auf die späteren Entscheidungen des Dummy



auswirken konnten. Die P300 zeigte signifikant höhere Amplituden bei fair/fairen Angeboten, was die positive Wertigkeit dieser Angebotsart anzudeuten schien. Die nicht signifikanten Ergebnisse im ersten Durchgang können als Effekt der geringeren Involviertheit im ersten Durchgang und der eingeschränkten Angebotsstruktur erklärt werden. Den vorliegenden Resultaten zufolge hat der soziale Kontext einen großen Einfluss auf Fairness gegenüber Dritten und ökonomisches Entscheidungsverhalten, was sich sowohl im ereigniskorrelierten Potential als auch im Verhalten äußert.

## References

- Adams, J. S. (1963). Towards an understanding of inequity. *Journal of Abnormal and Social Psychology, 67* (5), 422–436.
- Bauer, H., & Lauber, W. (1979). Operant conditioning of brain steady potential shifts in man. *Applied Psychophysiology and Biofeedback, 4*(2), 145–154.
- Bauer, H. (1998). Slow Potential Topography. *Behavior Research Methods, Instruments & Computers, 1* (30), 20–33.
- Bewley, T. (1998). Why not cut Pay? *European Economic Review, XLII*, 459–490.
- Boksem, M.A.S., & De Cremer, D. (2010). Fairness concerns predict medial frontal negativity amplitude in ultimatum bargaining. *Social Neuroscience, 5*, 118–128.
- 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* (2), 185–192.
- Bolton, G. E., & Ockenfels, A. (1998). Strategy and Equity: An ERC-Analysis of the Güth - van Damme Game. *Journal of Mathematical Psychology, 42*, 215–226.
- Bolton, G. E., & Ockenfels, A. (2000). ERC: a theory of equity, reciprocity and competition. *American Economic Review, 90*, 166–193.
- Bolton, G. E., & Ockenfels, A. (2002). Self-centered fairness in games with more than two players. In: Plott, C., Smith, V. (Eds.), *Handbook of Experimental Economics Results*. Amsterdam, North Holland.

- Bolton, G. E., & Zwick, R. (1995). Anonymity versus punishment in ultimatum bargaining. *Games Econ Behav*, 10, 95–121.
- Botvinick, M., Nystrom, L. E., Fissell, L., Carter C. S., & Cohen, J. D. (1999). Conflict monitoring versus selection-for-action in anterior cingulate cortex. *Nature*, 402, 179–81.
- Calder, A.J., Lawrence, A.D., & Young, A.W. (2001). Neuropsychology of Fear and Loathing. *Nature Rev. Neuroscience*, 2, 352–363.
- Camerer, C. (2003). Behavioural studies of strategic thinking in games. *TRENDS in cognitive sciences*, 7, 225–231.
- Camerer, C., Loewenstein, G., & Prelec, D. (2005). Neuroeconomics: How Neuroscience Can Inform Economics. *Journal of Economic Literature*, 43, 9–64.
- Camerer, C., & Thaler, R. H. (1995). Anomalies. Ultimatums, Dictators and Manners. *Journal of Economic Perspectives*, 9 (2), 209–219.
- Carretié, L., Mercado, F., Tapia, M., & Hinojosa, J.A. (2001). Emotion, attention, and the 'negativity bias', studied through event-related potentials. *International Journal of Psychophysiology*, 41, 75–85.
- Dehaene, S., Posner, M.I., & Tucker, D.M. (1994). Localization of a neural system for error detection and compensation. *Psychological Science*, 5, 303–305.
- Delorme, A., & Makeig, S. (2004) EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics. *Journal of Neuroscience Methods*, 134, 9–21.

- Desmedt, J. E., Debecker, J., & Manil, J. (1965). Mise en evidence d'un signe électrique cerebral associée à la détection par le sujet d'un stimulus sensoriel tactile. *Bull. Acad. r. Med. Belg.* 5, 887–936.
- Fantino, E., Gaitan, S., Kennelly, A. & Stolarz-Fantino, S. (2007). How reinforcer type affects choice in economic games. *Behavioural Processes*, 75, 107–114.
- Fehr, E., & Schmidt, K. (1999). A theory of fairness, competition and cooperation. *Quarterly Journal of Economics*, 114, 817–868.
- Fehr, E., & Schmidt, K. (2005). The Economics of Fairness, Reciprocity and Altruism – Experimental Evidence and New Theories. *Handbook of Economics of giving, altruism and reciprocity*, Volume 1, Elsevier B.V.
- Festinger, L. (1954). A theory of social comparison processes. *Human Relations*, 7, 117–140.
- Fetchenhauer, D., & Huang, X. (2004). Justice sensitivity and distributive decisions in experimental games. *Personality and Individual Differences*, 36, 1015–1029.
- Fliessbach, K., Weber, B., Trautner, P., Dohmen, T., Sunde, U., Elger, C. E., & Falk, A. (2007). Social Comparison Affects Reward-Related Brain Activity in the Human Ventral Striatum. *Science*, 318, 1305–1308.
- Forsythe, R., Horowitz, J., Savin, N., & Sefton, M. (1994). Fairness in Simple Bargaining Experiments. *Games and Economic Behavior*, 6, 347–369.
- Fukushima, H., & Hiraki, K. (2006). Perceiving an opponent's loss: gender-related differences in the medial-frontal negativity. *Soc Cogn Affect Neurosci*, 1 (2), 149–157.

- Fukushima, H., & Hiraki, K. (2009) Whose loss is it? Human electrophysiological correlates of non-self reward processing. *Social Neuroscience*, 4(3), 261–275.
- Gehring, W. J., Coles, M. G. H., Meyer, D. E., & Donchin, E. (1995). A brain potential manifestation of error-related processing. In: G. Kamos, M. Molnar, V. Csepe, I. Czigler, & J. E. Desmedt (Eds.), *Perspectives of event-related potentials research* (pp. 261–272). Amsterdam: Elsevier Science B.V.
- Gehring, W.J., & Willoughby, A.R. (2002). The medial frontal cortex and the rapid processing of monetary gains and losses. *Science*, 295. 2279–2282.
- Gehring, W. J., & Willoughby, A. R. (2004). Are all medial frontal negativities created equal? Toward a richer empirical basis for theories of action monitoring. In: M. Ullsperger & M. Falkenstein (Eds.), *Errors, conflicts, and the brain: Current opinions on response monitoring* (pp. 14–20). Leipzig: MPI of Cognitive Neuroscience.
- Greenblatt, R. E., Kastner, J., Wagner, M., Hawes, S., & Ebersole, J. S. (2002). A standardized boundary element method volume conductor model. *Clin. Neurophysiol.*, 113, 702–712.
- Grosskopf, B. (2002). Reinforcement and Directional Learning in the Ultimatum Game with Responder Competition. *Experimental Economics*, 6, 141–158.
- Güth, W., & van Damme, E. (1998). Information, strategic behavior and fairness in ultimatum bargaining - an experimental study. *Journal of Mathematical Psychology* 42, 227–247.
- Güth, W., Schmidt, C., & Sutter, M. (2007). Bargaining Outside the Lab - A Newspaper Experiment of a Three Person Ultimatum Game. *Economic Journal, Royal Economic Society*, 117, 449–469.

- 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., Holroyd, C.B., & Simons, R.F. (2006). The feedback-related negativity reflects the binary evaluation of good versus bad outcomes. *Biological Psychology* 71, 148–154.
- Hoffman, E., McCabe, K., Shachat, K., & Smith, V. (1996). On Expectations and the Monetary Stakes in Ultimatum Games. *International Journal of Game Theory*, 25, 289–301.
- Holroyd, C.B., Pakzad-Vaezi, K. L., & Krigolson, O.E. (2008). The feedback correct-related positivity: Sensitivity of the event-related brain potential to unexpected positive feedback. *Psychophysiology*, 45, 688–697.
- Jasper, H. H. (1958). The ten-twenty electrode system of the International Federation. *Electroencephalography and Clinical Neurophysiology*, 10, 371–375.
- Johansson, L., & Svedsäter, H. (2009). Piece of cake? Allocating rewards to third parties when fairness is costly. *Organizational Behavior and Human Decision Processes*, 109, 107–119.
- Kagel, J., & Roth, A. (Eds.) (1995). *Handbook of Experimental Economics*. Princeton, Princeton University Press.
- Kagel, J.H., & Wolfe, K. (2000). *Tests of Difference Aversion to Explain Anomalies in Simple Bargaining Games*. Ohio State University.

- Kahneman, D., Knetsch, J. L., & Thaler, R. H. (1986). Fairness and the Assumptions of Economics. *The Journal of Business*, 59, 285–300.
- Kahneman, D. (2003). Maps of Bounded Rationality. *The American Economic Review*, 93, 1449–1475.
- Knutson, B., Rick, S., Wimmer, G., Prelec, D., & Loewenstein, G. (2007). Neural predictors of purchases. *Neuron*, 53, 147–156.
- Koenigs, M., & Tranel, D. (2007). Irrational economic decision making after ventromedial prefrontal damage: evidence from the Ultimatum Game. *Journal of Neuroscience*, 27, 951–956.
- Lamm, C., Fischmeister, F., & Bauer, H. (2005). Individual differences in brain activity during visuo-spatial processing assessed by slow cortical potentials and low resolution electromagnetic tomography. *Cognitive Brain Research*, 25, 900–912.
- Leonard, R.J. (1995). From Parlor Games to Social Science: von Neumann, Morgenstern, and the Creation of Game Theory 1928-1944. *Journal of Economic Literature*, 33, 730– 761.
- Luu, P., & Tucker D. M. (2004). Emotional Self-regulation and the Brain, Self-regulation by the medial frontal cortex: limbic representation of motive set-points. In: *Consciousness* ed: Beauregard, M. (John Benjamin, Amsterdam), 123–61.
- Ma, Q., Wang, X., Shu, L., & Dai, S. (2008). P300 and categorization in brand extension. *Neuroscience Letters*, 431, 57–61.

- MacDonald, A. W., Cohen, J. D., Stenger, V. A., & Carter, C. S. (2000). Dissociating the Role of the Dorsolateral Prefrontal and Anterior Cingulate Cortex in Cognitive Control. *Science* 288, 1835–1838.
- Marwell, G., & Ames, R. (1981). “Economicists Free Ride, Does Anyone Else?”: Experiments on the Provision of Public Goods. *Journal of Public Economics*, 15, 295–310.
- Mazziotta et al. (2001). A probabilistic atlas and reference system for human brain: International Consortium for Brain Mapping (ICBM). *Philos Trans. R. Soc. Lond. B. Biol. Sci.*, 356, 1293-1322.
- Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience*, 24. 167–202.
- Miltner, W. H. R., Braun, C. H., & Coles, M. G. H. (1997). Event-related brain potentials following incorrect feedback in a time-estimation task: evidence for a “generic” neural system for error detection. *Journal of Cognitive Neuroscience*, 9. 788–798.
- Mitzkewitz, M., & Nagel, R. (1993). Experimental Results on Ultimatum Games with Incomplete Information. *International Journal of Game Theory*, 22, 171–198.
- Nash, J. F. (1950). The Bargaining Problem. *Econometrica*, 18, 155–162.
- Nash, J. F. (1951). Non-cooperative Games. *The Annals of Mathematics*, 54, 286–295.
- Nichols, T. E., & Holmes, A. P. (2002). Nonparametric permutation tests for functional neuroimaging: a primer with examples. *Human Brain Mapping*, 15, 1–25



- Nieuwenhuis, S., Aston-Jones, G., & Cohen, J. D. (2005). Decision making, the P3, and the locus coeruleus–norepinephrine system. *Psychological Bulletin*, *131*, 510–532.
- Nieuwenhuis, S., Holroyd, C. B., Mol, N., & Coles, M. G. H. (2004). Reinforcement-related brain potentials from medial frontal cortex: Origins and functional significance. *Neuroscience and Biobehavioral Reviews*, *28*, 441–448.
- Nowak, M. Page, K. M., & Sigmund, K. (2000). Fairness Versus Reason in the Ultimatum Game. *Science*, *289*, 1773–1775.
- Oldfield, R. C. (1971). The Assessment and Analysis of Handedness: The Edinburgh Inventory. *Neuropsychologia*, *9*, 97–113.
- Orbell, J. M., Dawes, R. M., & van de Kragt, A. J. C. (1978). Explaining Discussion Induced Cooperation. *Journal of Personality and Social Psychology*, *54*, 811–819.
- Pascual-Marqui, R. D. (2002). Standardized low resolution brain electromagnetic tomography (sLORETA): technical details. *Methods & Findings in Experimental & Clinical Pharmacology*, *24*, 5–12.
- Polezzi, D., Daum, I., Rubaltelli, E., Lotto, L., Civai, C., Sartori, G., & Rumiati, R. (2008). Mentalizing in economic decision-making. *Behavioural Brain Research* *190*, 218–223.
- Polezzi, D., Lotto, L., Daum, I., Sartori, G., & Rumiati, R. (2008). Predicting outcomes of decisions in the brain. *Behavioural Brain Research*, *187*, 116–122.
- Potts, G. F. (2004). An ERP index of task relevance evaluation of visual stimuli. *Brain & Cognition*, *56*, 5–13.

- Potts, G. F., Dien, J., Hartry-Speiser, A. L., McDougal, L., & Tucker, D. M. (1998). Dense sensor array topography of the event-related potential to task-relevant auditory stimuli. *Electroencephalography and Clinical Neurophysiology*, *106* (5), 444–456.
- Potts, G. F., Martin, L. E., Burton, P., & Montague, P. R. (2006). When things are better or worse than expected: Medial frontal cortex and the allocation of processing resources. *Journal of Cognitive Neuroscience*, *18*(7), 1111–1119.
- Rabin, M. (1993). Incorporating Fairness in Game Theory and Economics. *The American Economic Review*, *83*, 1281–1302.
- Rigoni, D., Polezzi, D., Rumiati, R., Guarino, R., & Sartori, G. (2010). When people matter more than money: An ERPs study. *Brain Research Bulletin*, *81*, 445–452.
- Rilling, J. K., King-Casas, B., & Sanfey, A. G. (2008). The neurobiology of social decision-making. *Current opinion in Neurobiology*, *18*, 159–165.
- Roth, A. E. (1995). Bargaining Experiments. In: Kagel, J., Roth, A. (Eds.), *Handbook of Experimental Economics*. Princeton University Press, Princeton (253 – 342).
- Roth, A. E., Prasnikar, V., Zamir, S., & Okuno-Fujiwara, M. (1991). Bargaining and Market Behavior in Jerusalem, Ljubljana, Pittsburgh, and Tokyo: An Experimental Study. *The American Economic Review*, *81* (5), 1068–1095.
- 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.

- Sekihara, K., Sahani, M., & Nagarajan, S. S.. Localization bias and spatial resolution of adaptive and nonadaptive spatial filters for MEG source reconstruction. *Neuroimage*, 25(4), 1056–67.
- Simon, H. A. (1955). A Behavioral Model of Rational Choice. *The Quarterly Journal of Economics*, 69 (1), 99–118.
- Schmitt, M., Gollwitzer, M., Maes, J., & Arbach, D. (2005). Justice Sensitivity. Assessment and Location in the Personality Space. *European Journal of Psychological Assessment*, 21 (3), 202–211.
- Schmitt, M., Neumann, R., & Montada, L. (1995). Justice sensitivity. *Social Justice Research*, 8, 385–407.
- Suleiman, R. (1996). Expectations and fairness in a modified Ultimatum game. *Journal of Economic Psychology*, 17, 531–554.
- Sutton, S., Braren, M., Zubin, J., & John, E. R. (1965). Evoked-Potential Correlates of Stimulus Uncertainty. *Science*, 150, 1187–1188.
- van Damme, E. (1991). *Stability and Perfection of Nash Equilibria*. Berlin: Springer Verlag.
- Van Schie, H.T., Mars, R.B., Coles, M.G.H., & Bekkering, H. (2004). Modulation of activity in medial frontal and motor cortices during error observation. *Nature Neuroscience*, 7, 549–554.

- 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.
- von Neumann, J., & Morgenstern, O. Theory of games and economic behavior. Princeton, NJ: Princeton UP; 1944.
- Wagner, M., Fuchs, M., & Kastner, J., (2004). Evaluation of sLORETA in the presence of Noise and Multiple Sources. *Brain Topography*, 16, 277–280.
- Wagner, A. D., Maril, A., Bjork, R. A., & Schacter, D. L. (2001). Prefrontal Contributions to Executive Control: fMRI Evidence for Functional Distinctions within Lateral Prefrontal Cortex. *NeuroImage*, 14, 1337–1347.
- Yeung, N., & Sanfey, A.G. (2004). Independent coding of reward magnitude and valence in the human brain. *Journal of Neuroscience*, 24. 6258–6264.

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