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On second thought … the influence of a second stage in the ultimatum game on decision behavior, electro-cortical correlates and their trait interrelation

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Abstract

Previous EEG research only investigated one stage ultimatum games (UGs). We investigated the influence of a second bargaining stage in an UG concerning behavioral responses, electro-cortical correlates and their moderations by the traits altruism, anger, anxiety, and greed in 92 participants. We found that an additional stage led to more rejection in the 2-stage UG (2SUG) and that increasing offers in the second stage compared to the first stage led to more acceptance. The FRN during a trial was linked to expectance evaluation concerning the fairness of the offers, while midfrontal theta was a marker for the needed cognitive control to overcome the respective default behavioral pattern. The FRN responses to unfair offers were more negative for either low or high altruism in the UG, while high trait anxiety led to more negative FRN responses in the first stage of 2SUG, indicating higher sensitivity to unfairness. Accordingly, the mean FRN response, representing the trait-like general electrocortical reactivity to unfairness, predicted rejection in the first stage of 2SUG. Additionally, we found that high trait anger led to more rejections for unfair offer in 2SUG in general, while trait altruism led to more rejection of unimproving unfair offers in the second stage of 2SUG. In contrast, trait anxiety led to more acceptance in the second stage of 2SUG, while trait greed even led to more acceptance if the offer was worse than in the stage before. These findings suggest, that 2SUG creates a trait activation situation compared to the UG.

KEYWORDS

bargaining behavior, EEG, fairness evaluation vs. cognitive effort, midfrontal theta, reward positivity/FRN/MFN/N2, trait activation in two-stage ultimatum game, two-stage ultimatum game

1 | INTRODUCTION

The ultimatum game (UG; e.g., Güth et al., 1982) is a well-known paradigm to study socioeconomic decision-making and the electro-cortical and personality trait correlates of the respective decisions (e.g., Boksem & De Cremer, 2010; Mussel, Rodrigues, et al., 2018; Riepl et al., 2016; Thielmann et al., 2020). Traditionally, the UG has the feature of only one interaction per trial between the proposer and the receiver. In everyday life, the same

people repeatedly interact with each other, so that their reputation and the experience gained from the interaction plays a central role for decision-making (Cooper & Dutcher, 2011). In the UG, a proposer splits up an amount of money (e.g., 12 cents) as he or she likes and makes an offer to the recipient. If the receiver accepts, the money is divided accordingly, if he or she rejects, neither of them receives any money. The response to an UG offer may be confounded with the urge to get money and therefore may also be explained well with arguments based on rational choice theory (von Neumann & Morgenstern, 1944). Accordingly, a profit-maximizing proposer should offer as little money as possible, and a profit-maximizing recipient should accept all offers to achieve the most profitable monetary outcome of the game. If the UG is played in more than one stage (basically: receiving a second offer only if the first offer was rejected, Güth & Tietz, 1990), the decisions in the first stage should be less confounded with profit-maximizing. Such a game type is also called "ultimatum concession bargaining" (Felli et al., 2018). It was observed that when offers (proposer) and minimally accepted offer sizes (receiver) were determined rounds in advance, the number of rounds had no effect on the successful agreement and only in the final stage, the decisive agreement was found (Felli et al., 2018; Güth & Tietz, 1990). However, in comparison to the traditional UG, more accepted offers were observed. Following these findings, we chose to compare a traditional UG with an UG with a second stage, creating a 2-stage UG (2SUG). Thereby we aimed to disentangle the behavioral responses and electro-cortical correlates to fairness and decisions in both versions as well as their modulations by relevant personality traits. We were especially interested in the electro-cortical reactions of the responder in this case, as the reactions of the proposer have been investigated in a multi-stage ultimatum game before (Billeke et al., 2014), whereas the reactions of the responder have not been investigated so far to our knowledge. By this modification, there could also arise the default behavioral pattern of always rejecting the first offer in the hope of receiving a better one. Such strategic thinking patterns are also known as "super game strategies" (Slembeck, 1999). Here, rejecting the initial offer becomes the behavioral default to get a better offer in later stages, whereas accepting may require cognitive control to override the default (compare Botvinick, 2007; Botvinick et al., 2001). This type of behavior occurs frequently in games where not only a single interaction is given, and is executed especially by selfish persons (Slembeck, 1999). It is used to state that one is a "though" player and therefore will not tolerate a low offer in later rounds (Slembeck, 1999). Empirical evaluation of ultimatum concession gaming revealed the high prevalence of using the final round (>50% of participants) to come to an agreement, but also an influence of gender (women agreeing more) and big five personality traits, with agreeableness and conscientiousness leading to more agreement (Felli et al., 2018). Hence, we expected the rejection behavior in the first stage of 2SUG being high compared to the second stage of the 2SUG and the UG. In addition, this modification of the UG may as well interact with relevant personality traits.

1.1 | Personality traits related to ultimatum bargaining

In the past, a multitude of personality traits has been associated with decision-making behavior in UGs. For example, Kline et al. (2019) showed in their meta-analysis that among the Big Five personality factors, particularly agreeableness and openness were associated with prosocial behavior in the UG. In another recent meta-analysis, it could be shown that not only broad traits but also narrow trait constructs like altruism, greed and anger can be linked to behavioral responses in social interaction games (Thielmann et al., 2020). Thus, in the present study, for the newly developed version of 2SUG, we focused on altruism, greed, anger, and anxiety as outlined below.

In social interactions, a person can either strive for a self-maximizing benefit, i.e., act selfishly, or consider the interests of their fellow human beings and act in a prosocial way. A facet of such prosocial behavior is altruism (Carlo & Randall, 2002). In an economic context, a broad definition of altruism is often used, circumscribing any kind of selfless action that creates economic advantages for other people (Fehr & Fischbacher, 2003), including the so-called "altruistic punishment" (Fehr & Gächter, 2002; Strobel, 2016). In the UG, altruistic punishment means rejection of an unfair offer to deny the proposer his/her share while accepting to not get any money oneself. However, Brethel-Haurwitz et al. (2016) could not find a connection between altruistic behavior (i.e., kidney donations) and higher rejection rates in the UG (i.e., "altruistic" punishment), but they revealed a relationship between self-reported normative altruism scores and rejection rates. Thus, punishment in the UG does not seems to be driven by altruism in a narrow sense (e.g., Rodrigues et al., 2018, 2020; Rodrigues & Hewig, 2021). Therefore, this kind of punishment should be labeled more cautiously as "costly punishment". Likewise, Mothes et al. (2016) found no influence of trait altruism on punishment behavior in the UG. In summary, we expected high cooperative behavior in case of high trait altruism, especially if cooperation was not mandatory, for instance in the first stage of 2SUG and in case of unfair offers. This "altruistic acceptance" of unfair offers would be in line with the benevolence aspect of

altruism definitions (Rodrigues et al., 2020) in the context of UG and 2SUG.

An important personality trait driving the punishing character of costly punishment is trait anger. Trait anger stands for the disposition to react with anger in relevant situations. Anger has been defined as: "the response to interference with our pursuit of a goal we care about. Anger can also be triggered by someone attempting to harm us (physically or psychologically) or someone we care about. In addition to removing the obstacle or stopping the harm, anger often involves the wish to hurt the target." (Ekman & Cordaro, 2011, p. 365). Concerning anger and UG behavior, there is already a variety of findings. First of all, Fehr and Gächter (2002) showed that those situations, in which altruistic punishment appears, increasingly evoke negative emotions such as anger. Jordan et al. (2016) were also able to show that altruistic punishment was associated with subjective feelings of state anger. Seip et al. (2009) pointed out that anger is a mediator of altruistic punishment and is even a better predictor than the perceived unfairness (Pillutla & Murnighan, 1996). Finally, shifting the focus from state anger to trait anger, Rodrigues et al. (2018) revealed that trait anger resulted in increased costly punishment in a third-party dictator game, whereas trait altruism was related to increased altruistic compensation. Hence, we proposed that higher trait anger would lead to more rejection in the traditional UG and in the second stage of 2SUG. However, as the rejection would be a default in the first stage of 2SUG, there should be no difference for higher trait anger in this condition.

In contrast to approach-related behavior such as anger (Carver & Harmon-Jones, 2009), anxiety is considered an emotion related to avoidance or conflict (Gray & McNaughton, 2000). Trait anxiety is hereby defined as the disposition to react with state anxiety in uncertain or ambiguous situations. Anxiety has been linked to uncertain and conflicting situations as a mechanism to rise arousal and an orienting response, accompanied by behavioral inhibition (Gray & McNaughton, 2000) and passive avoidance (Gray & McNaughton, 1996). High levels of trait anxiety have a strong influence on the social life of affected persons, which leads to avoidance as a coping strategy in social behavior (Raffety et al., 1997). Accordingly, anxiety undermines the willingness to communicate, which leads to avoidance of social interactions (Turner, 1988). In terms of the UG, Wu et al. (2013) showed that high-trait anxious participants with low self-esteem accept more unfair offers from human proposers. Also, unfair offers were perceived more unfair by persons with high trait anxiety (Wu et al., 2013). Additionally, computer-generated offers were more likely to be accepted by highly anxious people than by low anxious subjects (Luo et al., 2014). In a sample of clinically diagnosed anxiety patients, anxiety was associated with a higher acceptance rate for unfair offers in comparison to the control group (Grecucci et al., 2013). Following these examples, we proposed that anxiety would lead to higher acceptance rates, especially in the first round of 2SUG, as further interactions in a second round can be avoided, even by the costs of accepting possibly unfair offers.

Finally, greed serves as a possible antipole to altruistic behavior. Greed depicts egoistic behavior in the economic context and is defined "as desire to get more at all costs, including the excessive striving for desired goods and the willingness to accept that such striving may be at the expense of others." (Mussel et al., 2015, p. 126). With regard to the UG, Seuntjens et al. (2015) and Mussel and Hewig (2016) were able to show that greedy individuals maximize their profit and thus, as providers in the UG, keep more money for themselves. However as receivers, they reject more often, indicating that the offer was not enough (Seuntjens et al., 2019). In addition, the results of an experiment with the Balloon Analogue Risk Task (BART; Lejuez et al., 2002) suggest that greedy people take a higher risk in order to maximize their profit (Mussel et al., 2015). Hence, we hypothesized that in the traditional UG and in the first stage of 2SUG, persons with high greed would reject unfair offers more often. In the second stage 2SUG, however, we expected the participants with high trait greed to maximize their profit, hence accepting more "final" offers.

Besides the influences of the traits on behavior, we were also interested in the electro-cortical correlates of the behavior and fairness in 2SUG compared to the traditional UG to shed light on the underlying cognitive processes of bargaining behavior in the UG and its´ variants.

1.2 | Electro-cortical correlates

In order to examine electrocortical correlates of social decision-making behavior in economic decision games, we used the feedback-related negativity (FRN), which is sometimes called the N2 component to offers (as no real "feedback" but information is given, although this N2 component has the expectancy evaluation aspect like the FRN or RewP, Baker & Holroyd, 2011) or medial frontal negativity (MFN, Boksem & De Cremer, 2010). We use the term N2 in the "classical" sense of a second negative peak after seeing an offer. This should not to be confused with the functional definition of the N200, which is more specifically linked to conflict, see e.g., Baker and Holroyd (2011). In the context of the UG, MFN is probably the most precise term, yet FRN having the closest theoretical link to the evaluation aspect of the component. Therefore, we will only use the term FRN in the context

of our findings in the UG and 2SUG, yet also mentioning the specific component name if other research is cited. Another component from the frequency domain often used to explore brain activation in relation to the observed behavior is midfrontal theta band activation. Both neural markers, the FRN and midfrontal theta band activation were linked to the evaluation of expectations (Hewig et al., 2011; Holroyd & Coles, 2002) and have their respective maxima/minima in the time window between 200 and 400 ms after stimulus/feedback onset (Holroyd et al., 2008). However, in the UG, the components tend to have a slightly later onset in general (e.g., Boksem & De Cremer, 2010; Riepl et al., 2016). Originally, the FRN was understood as a negative deflection, which is more pronounced when an outcome is worse than expected (Holroyd & Coles, 2002). This framework was used in the context of feedback and reinforcement learning theory, depicting the negative temporal difference error and error-based learning signal (Holroyd & Coles, 2002). However, recent research interprets this component as reward positivity (Baker & Holroyd, 2011), which is elicited for outcomes that are better than expected. Hence, the context of the learning process has been shifted from the negative consequences to the positive outcomes. This shift in perspective on the learning process offered new insights yet leaving the original concept of error-learning processes in principle untouched. Although there is still a controversial debate about this component, the original assumption that the FRN is a marker for outcomes that are worse than expected (Holroyd & Coles, 2002) has been modified to understand the FRN as a global evaluation process (Kujawa et al., 2013). Regarding the UG, the FRN was often examined in relation to the offer itself. It could be shown that unfair offers evoke a greater degree of negativity at frontocentral electrodes than fair offers (Hewig et al., 2011; Polezzi, Daum, et al., 2008). This effect was even stronger if the subjects had higher fairness-concerns (Boksem & De Cremer, 2010). Sun et al. (2015) and Mothes et al. (2016) were using the third party dictator game and therefore were able to show that if the monetary outcome for the participants was not linked to the offers directly as in the UG, there was still a higher FRN for unfair offers. Thus, the FRN is an independent marker for a fairness evaluation process. In addition to the evaluation of certain outcomes or feedback signals, the FRN was also used as a predictor of subsequent decision-making behavior. For example, Cohen and Ranganath (2007) showed that in a strategic economic game, the FRN was able to predict, after a loss to the computer, whether participants would change their strategy in the next trial. Following these findings, we hypothesized that a more unfair offer in our paradigms would lead to higher FRN. This effect should be smaller in the first stage of the 2SUG compared to the traditional UG, as there is an additional stage to get a final offer and also the majority of the participants using a super game strategy may expect a less favorable offer in trials that are not final (Billeke et al., 2014; Felli et al., 2018; Güth & Tietz, 1990).

Concerning midfrontal theta, Rodrigues et al. (2020) showed that midfrontal theta predicted less punishment in a third-party dictator game. This led to the assumption, that higher midfrontal theta would result in a higher acceptance rate, possibly due to the higher cognitive control (Cavanagh & Frank, 2014; Cohen, 2011) that is needed in order to overcome a quick or "default" behavioral option (Rodrigues et al., 2020). However, as it was also shown, that midfrontal theta used to behave similarly to the FRN in tasks similar to the UG (e.g., Rodrigues et al., 2015), we chose to hypothesize that midfrontal theta shows similar properties to the FRN component in this task. Nevertheless, it can be expected to be related to cognitive control and especially occur if a cognitive default is to be overcome.

1.3 | Personality traits and electro-cortical correlates

We now briefly address possible interactions between receiver traits and their electro-cortical correlates, starting with altruism. In the third party dictator game, on one hand, higher altruism was related to a lower (less negative) FRN amplitude following unfair offers (Mothes et al., 2016). On the other hand, higher altruism led to higher (more negative) FRN amplitudes following unfair offers (Sun et al., 2015). Accordingly, we investigated the relation between altruism and neural correlates exploratorily, although in the preregistration we chose to expect high altruism leading to a lower FRN, as we were not aware of the divergent findings at this moment.

Concerning greed, Mussel et al. (2015) could show that the FRN serves as a predictor of risky behavior in the BART, with differences in the FRN between favorable and unfavorable outcomes predicting higher risk behavior. This difference score was negatively related to greed, with high greed leading to a lower difference in FRN response. However, this effect could not be shown in a common good task for the FRN (Mussel & Hewig, 2019). Nevertheless, we expected a lower (less negative) FRN for high trait greed participants in response to unfavorable events (i.e., unfair offers in the UG). However, we did not expect this effect to be prevalent in the first stage of the 2SUG, because the offer might not be seen as a final negative event but more as a step toward the final offer (compare Billeke et al., 2014; Felli et al., 2018; Güth & Tietz, 1990).

For anxiety, it could be shown in a gambling task that a smaller FRN was found for negative outcomes in highly as compared to lowly anxious individuals (Gu et al., 2010). Similar finding could be shown in a negative outcome avoidance learning task (Andreatta et al., 2017). For ambiguous outcomes, on the other hand, the FRN was higher in anxious individuals. Thus, the FRN following negative outcomes indicates the pessimistic outcome expectations of anxious individuals (Mitte, 2007), whereas the FRN in the ambiguous situation reflects the intolerance toward insecurity in anxious individuals (Polezzi, Lotto, et al., 2008). For the UG, there is evidence that high trait anxiety leads to higher FRN following unfair offers (Luo et al., 2014). This led to the hypothesis, that high trait anxiety would elicit higher FRN amplitudes in any stage of the present UG modifications.

In terms of trait anger, Rodrigues et al. (2020) found a higher FRN to unfair offers in the third-party dictator game. Hence, we hypothesized that higher trait anger would lead to a higher FRN to unfair offers in the present study. Also, Tsypes et al. (2019) have shown that in the Doors Task, a monetary gambling task, higher levels of trait anger correlate positively with more positive FRN amplitudes following gains versus loss. The authors conclude that approach orientation rather than positive affect is responsible for the occurrence of the reward positivity. According to this finding more positive amplitudes (lower FRN) for fair offers might be expected in high trait anger or greater difference between FRN in unfair versus fair offers.

To sum up our attempts in this study, we have added a second round to the classic UG in case an offer was rejected in the first round. With this procedure, we wanted to decouple the initial decision from the default accept strategy in the classic game. Furthermore, we were interested in the influence of the personality traits altruism, greed, anger, and anxiety on the decision behavior. Finally, we investigated the electro-cortical correlates of decision-making using FRN and midfrontal theta oscillations and we evaluated their predictive value for the behavior in the UG as well as their interactions with the fairness of the offers and relevant traits, as altruism, greed, anger, and anxiety have been linked to the neural processing of outcomes in economic game. A summary of the hypotheses for the receiver in the UG and the present variations is shown in Table 1.

2 | METHOD

2.1 | Ethical statement

The study was carried out in accordance with the recommendations of "Ethical guidelines, The Association of German Professional Psychologists" ("Berufsethische Richtlinien, Berufsverband Deutscher Psychologinnen und Psychologen") with written informed consent from all subjects. All subjects gave written informed consent in accordance with the Declaration of Helsinki before they participated in the experiment. The protocol was approved by the local ethics committee of the department of psychology of the Julius-Maximilians-University of Würzburg (Ethikkommission des Institutes für Psychologie der Humanwissenschaftlichen Fakultät der Julius-Maximilians-Universität Würzburg).

2.2 | Preregistration

The pre-registration of the study is given here: https://osf.io/h6e3p. As the pre-registration is for an entire

TABLE 1 Hypotheses of the present study

	Behavior and traits	Electro-cortical correlates
General	Higher rejection rates in first stage of 2SUG compared to the traditional UG	Unfair offers lead to higher midfrontal theta and FRN. This effect is less pronounced in the first stage of 2SUG
Altruism	Higher acceptance rates especially in the first round of 2SUG	Lower FRN and midfrontal theta to unfair offers
Anger	Higher rejection rates in the second stage of 2SUG and the traditional UG	Higher FRN and midfrontal theta to unfair offers
Anxiety	Higher acceptance rates, especially in the first round of 2SUG	Higher FRN and midfrontal theta to unfair offers
Greed	Higher rejection rates, especially in the first round of 2SUG	Diminished FRN/midline theta response to unfair compared to fair offers
	In the second round of 2SUG, greed leads to higher acceptance rates	This effect is not that pronounced in the first stage of 2SUG

project, not every hypothesis stated therein will be tested and not every analysis will be performed in the current manuscript. All hypotheses concerning the proposer and structural equation modeling are not applicable in this manuscript, as the required sampling size as well as the perspective of the proposer was not used in this data set.

2.3 | Participants

An a-priory sampling size calculation was performed using an effect of $r = .3$ as the desired effect size, the calculation with G-power with alpha = .05 and power(1-beta) = .8 leads to at least 82 participants per sample (https://osf.io/h6e3p). In the final sample, 92 participants were recruited through advertisements in experiment online portals of the University of Würzburg, as well as via a free online portal and local advertisement on campus. Participants were given course credits or a monetary compensation of 10€. All participants were at least 18 years old, right-handers, non-color blind and without a history of a psychiatric disorder. The mean age was 24.07 ($SD = 4.08$) and 67 were female.

2.4 | Paradigm

The paradigm used in this study was a 2SUG and a traditional UG. The participants first had to give one hypothetical offer in the UG. In addition, they gave a hypothetical offer and a follow up offer in 2SUG. After these hypothetical offers, they experienced the paradigms in the role of the receiver. The traditional UG consists of a fixation cross (300–500 ms), a display of the offer (with max duration of 3 s and stop as soon as a reaction is made via keypress of the key left/right to accept or decline the offer) and a feedback screen (1 s) with the credits that were gained during this trial by the other player and oneself. The offer display consists of a pie depicting the offer to the participant in red, and the amount that the fictive player keeps for him/herself in blue. The pie chart has a diameter of 4.2 cm. At the top of the screen, it is indicated that this is the offer. If the participant were reacting to slow to the offer, they were reminded that they were to slow and should be faster the next time. Also, they were informed that the offer was automatically rejected. The 2SUG was identical to the traditional UG, if the offer was accepted. But if the offer was rejected, instead of having feedback that neither the other player nor the participant gained any credits in this trial, the participants were informed that they had rejected the offer and another offer would come up (this information was shown for 1 s). After this information, a second fixation cross was shown (with the same parameters as the first fixation cross) and a second offer display was shown with similar parameter settings as the first offer display. The only difference of the second offer display to the first display was that during the second display, the short note at the top of the screen indicated that this would be the second offer. The offers in the traditional UG were splits of 12 Credits (each Credit was worth 1 Cent) and ranged from 1–7 Cent. Every offer was repeated 20 times during the block, leading to 140 trials. In the 2SUG, the offers in the first stage ranged from 2–4 Credits. The second offers were +1 Credit, +0 Credits or −1 Credit for receivers compared to the first offer. As every combination of offers was also repeated 20 times, 2SUG had 180 trials that could have two stages or only one stage, if the first offer was accepted. The number of trials was chosen to get a reliable FRN (Marco-Pallares et al., 2011), although the analysis was made on single trial basis (see method section below). The participants were instructed that all trials were "one-shot" trials, meaning that they play against other persons that have given their offers previously and will receive the money after the experiment finishes (identical to the offer they had given at the beginning of the task). A schematic display of the trials is shown in Figure 1.[1]

2.5 | Procedure

Before coming to the laboratory, the participants filled in a web-based questionnaire to assess relevant traits (see trait measurement section). Also, demographical data were collected (gender, age and handedness). The online questionnaire was presented with the online questionnaire platform SoSci Survey (Leiner, 2020).

In the lab, participants were first given (semi) informed consent (not revealing the cover story). Then they were seated in front of a 61 cm (24″) widescreen monitor in 50–60 cm distance and an EEG was placed on their head. After that, a first state measurement was taken and the participants experienced a resting EEG period consisting of eight minutes with four minutes

[1]One limitation in the paradigm was concerning the feedback slide at the end of the trials, where the participants could see the final outcome of the trials. Due to a technical error, there was a display error which displayed wrong numbers (one number too high in 2SUG) in this final feedback. However, this error was only spotted after 90 participants by a rather conscientious participant. After having corrected for this error and comparing the last (four) participants with the previous ones and finding no difference in behavior or in FRN response, we are confident, that this technical error was not realized by the participants. Probably, this written information about the final outcome was ignored by most participants, because they already knew what they had chosen, to reject or to accept the offer and knew what the proposer had offered, since they had seen the display of the money before and only a limited distribution of offers had been used.

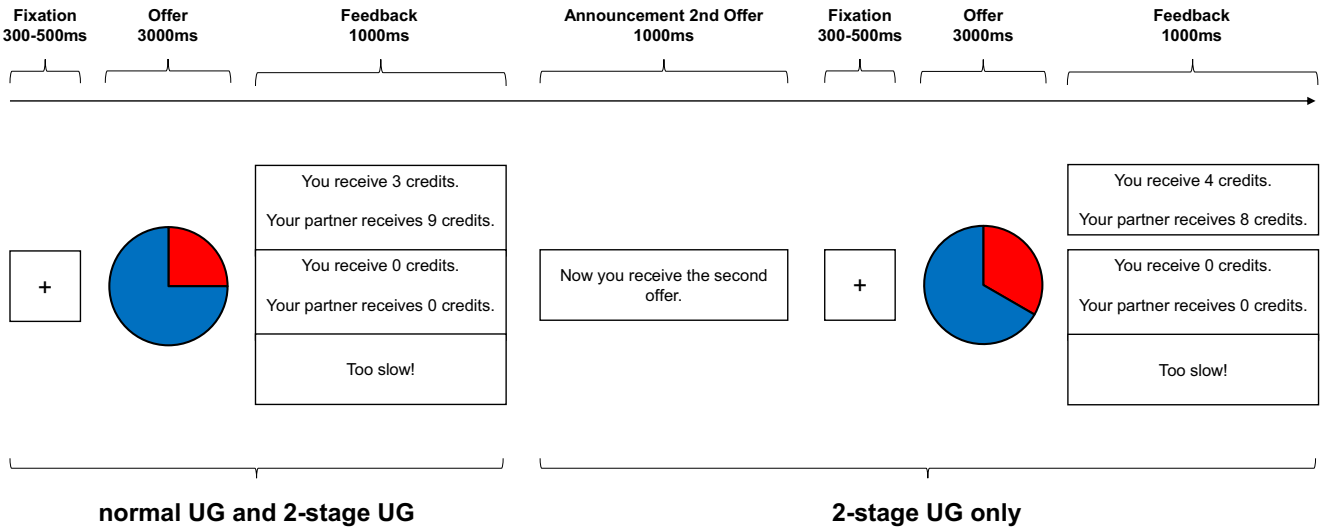


FIGURE 1 Time course of one trial for both the normal UG and 2SUG. Each trial began with a jittered fixation cross (300–500 ms), followed by the presentation of the offer (3000 ms). Afterward, the feedback was presented, which indicated the monetary outcome or a reminder that the answer was given too slowly. Additionally, in the 2-Stage block an announcement for the second offer was displayed for 1000 ms

of closed eyes and four minutes of open eyes in total and a change of open or closed eyes every 60 s. After the resting EEG, they were asked to give a hypothetical offer to other players in the UG. Subsequently, they were asked about a first and a second offer in 2SUG if the first offer would be rejected. Then, they experienced the traditional UG and 2SUG after a short training phase, where they could make themselves familiar with the task. The order of the two types of the ultimatum game was randomized between the participants. Following each block, state questionnaires were measured. After the experiment, the participants were freed from all measurement apparatus and debriefed.

2.6 | Apparatus

2.6.1 | EEG

The EEG was measured by Ag/AgCl-electrodes located in an electrode cap in the following 32 positions: Fp1, Fp2, F3, F4, C3, C4, P3, P4, O1, O2, F7, F8, T7, T8, P7, P8, Fz, Pz, FC1, FC2, CP1, CP2, FC5, FC6, F9, F10, TP9, TP10, PO9, PO10, FCz, and Cz (according to the international 10–10 system). Ground electrode was located on AFz position, the reference electrode was Cz.

For the elimination or correction of artifacts caused by eye movements, an additional electrode to register eye movements and blinks was put below the left eye. Electrode impedances were kept below 5 kOhm for the EEG. Data were recorded with a sampling rate of 500 Hz with BrainVision BrainAmp Standard (Brain Products GmbH, Gilching, Germany) and BrainVision Recorder 1.20 software (Brain Products GmbH). For further computation, MATLAB and EEGLAB toolbox (Delorme & Makeig, 2004) was used and a variant of the EPOS pipeline was used (Rodrigues, Weiß, et al., 2021). Raw data were filtered with a 1 Hz Butterworth high-pass filter after statistical channel selection (z-value threshold 3.29) for frequency [1125 Hz], joint probability and kurtosis. Deleted channels were spline-extrapolated. The segmentation of the data was done from −1 s before an event to 2 s after the event with a baseline form −500 ms to the event onset. Following the segmentation, a first ICA was performed, then artifact-corrupted segments were detected and deleted statistically (z-value threshold 3.29), targeting all components for probability and kurtosis of the signal. Additional artifact correction for muscle activity and ocular correction was made with a second ICA (Makeig et al., 2004), removing all components associated with muscular activity or eye movement and blink activity by using the program SASICA (Chaumon et al., 2015) for selection with input from ADJUST (Mognon et al., 2011) and MARA (Winkler et al., 2011). After that, CSD transformation was applied, using a script provided by Cohen (2014).

Theta frequency from 4–8 Hz was extracted using morlet wavelets during the event period to see the temporal function of theta. The theta peaks were detected via automatic peak detection for the mean frequency response for all conditions on the electrode FCz in the same time window as the FRN (250–550 ms). A matching peak for FRN was detected after applying a 40 Hz Butterworth low-pass filter via the time course of the

ERPs on the electrode position FCz in the time window from 250–550 ms for the mean signal of all conditions. A 40 ms peak detection window was used to quantify the peak in theta frequency and FRN signals to avoid biases based on latency shifts of the different conditions. The ERP was built via grand means for the participants and conditions.

Changes to the preregistration can be found in supplemental materials S1.

2.6.2 | Trait measurement

Several traits were assessed with online questionnaires on the SoSci Survey portal (Leiner, 2020). For the assessment of greed, the GR€€D scale (Mussel & Hewig, 2016) was used. For the measurement of trait altruism and prosocial tendencies, the prosocial tendencies measure (Carlo et al., 2003; Carlo & Randall, 2002; Rodrigues et al., 2017) was used. To assess anger on a trait level, the German version of the State- Trait – Anger – Expression – Inventory (Schwenkmezger & Hodapp, 1991; Spielberger, 1988) was administered. To assess trait anxiety, the German version of the State – Trait anxiety inventory (STAI; Laux et al., 1981) was used.

2.7 | Statistics

2.7.1 | Behavior as criterion

The behavior in the UG was analyzed with a hierarchical single trial multi-level logistic regression model for each stage and variant of the UG separately. The model included different random effects: A random slope for trials for each person, random intercept for the position of the acceptance button (left/right), random intercept for the order of the UG types (traditional UG first/2SUG first). The fixed effects of offer and the EEG signals FRN per trial and midfrontal theta per trial were inserted on level 1. The participants were the cluster variable constituting the level 2. On level 2 with the fixed effects of the traits altruism, anger, anxiety, and greed along with the mean FRN activation per person and mean midfrontal theta activation per person were entered. The metric predictors on level 1 were centered within the participants, while the variables on level 2 were grand-mean centered.

Exceeding the pre-registration of the analysis, for the second stage of 2SUG, the additional factor of the difference to the previous stage was inserted to explore the influence of a better, identical or worse offer.

The best model for each variant of the UG was chosen using the corrected Akaike Information Criterion (AICc) and the probability of information loss (Burnham et al., 2002 see Tables S1–S3 in Supporting Information).

All *p*-values were Bonferroni adjusted for each single fixed effect term (excluding the intercept) in the respective target model (see Tables S1–S3).

2.7.2 | EEG as criterion

The FRN/midfrontal theta was analyzed as the dependent variable in a multilevel mixed model for each variant and stage of the UG with only the random intercept for each participant. The fixed effect offer was inserted at level 1, and the participants constituted the cluster for level 2. On level 2, the fixed effects of the traits altruism, anger, anxiety and greed were entered. The metric predictors on level 1 were centered within the participants, while the variables on level 2 were grand-mean centered.

Exceeding the pre-registration of the analysis, for the second stage of 2SUG, the additional factor of the difference to the previous stage was inserted to explore the influence of a better, identical or worse offer.

The best model for each variant and stage of the UG as well as for the midfrontal theta was chosen using the AICc and the probability of information loss (see Tables S4–S6 in supplemental materials).

All *p*-values were Bonferroni adjusted for each single fixed effect term (excluding the intercept) in the respective target model (see Tables S4–S6). This led to no correction for the models for the traditional UG except predicting FRN (3 terms) and all models predicting midfrontal theta, a correction for 3 terms in the case of the first stage of 2SUG for predicting behavior or FRN and a correction for 70 terms for the prediction of the behavior in the second stage of 2SUG.

The reason to use multi-level modeling in the preregistration and the present analysis was the opportunity to account for single trial analysis and therefore for individual slopes and intercepts as well as identify the source of variance on person level versus trial level. All statistical analyses were carried out using R software (R Core Team, 2020) with the packages "glmmTMB" (Brooks et al., 2017). For graphical illustration, the package "ggplot2" (Wickham, 2016) was used.

2.7.3 | Exploratory analyses

On behalf of the reviewers, we added gender to the best model of all previous analysis and conducted the analysis of theta with induced and evoked power and delta frequency as a predictor and criterion. However, in this manuscript we report only significant effects while the rest of the analyses can be found in the supplemental materials.

3 | RESULTS

3.1 | Descriptive results

The interrelation of the traits can be seen in Table S7 in supplement. The rejection and acceptance in the different types of the UG for the respective offers are shown in Table S8 in supplement. The correlation of midfrontal theta activation and FRN activation in UG and 2SUG are shown in Table S9.

3.2 | Behavior as criterion

3.2.1 | Ultimatum game

The logistic mixed model for the UG with the behavior as criterion and the offer as fixed predictors and a random slope for the side on which the rejection button was, the order of the stages as well as the trials per subjects led to significant main effect for the offer ($\beta = 2.256$, $z = 44.32$, $p < .001$, see Figure 2), with higher offer leading to more acceptance. All other variables did not succeed in increasing the information and therefore were not considered (see Table S1).

3.2.2 | First stage 2-stage ultimatum game

For the first stage of 2SUG, the best model was the model including the offer, and trait anger as a predictor (Table S2).

A significant main effect was found for the offer ($\beta = 2.211$, $z = 57.9$, $p < .001$, see Figure 2), with higher offers leading to more acceptance. The effect of the offer additionally interacted with trait anger ($\beta = .522$, $z = 5.60$, $p < .001$, Figure 3a), leading to higher acceptance of the highest offer, while lower offers were more often rejected.

All other variables did not succeed in increasing the information and therefore were not considered (see Table S2).

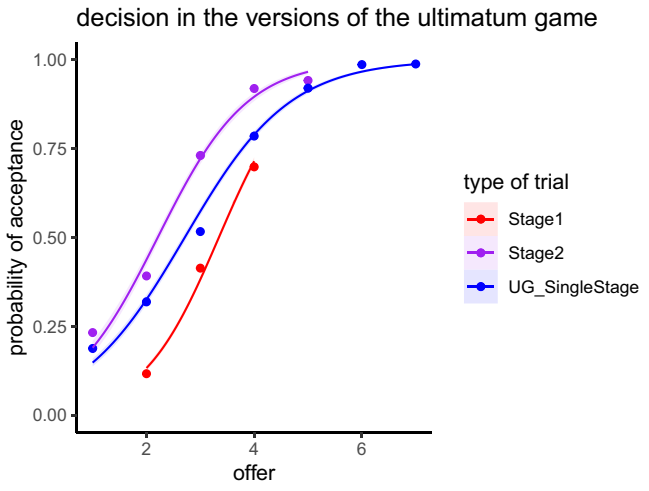


FIGURE 2 Probability of acceptance in the different versions and stages of the ultimatum game. Shaded error-bars represent 95% confidence intervals

3.2.3 | Second stage 2-stage ultimatum game

For the second stage of 2SUG, the best model was the model including the offer, all traits, and the difference to the previous stage as a predictor (Table S3).

A significant main effect was present for the offer ($\beta = 1.057$, $z = 17.92$, $p < .001$, see Figure 2), with higher offers leading to more acceptance. This effect interacted with the trait anger, leading to an amplification of the offer effect ($\beta = .869$, $z = 5.196$, $p < .001$, see Figure 3b), meaning that low offers were accepted less for high trait anger and high offers being accepted more for high trait anger. Also, it interacted with trait anxiety leading to a dampening of the offer effect ($\beta = -.444$, $z = -3.748$, $p < .001$, see Figure 3c) for low compared to high anxiety due to less acceptance of higher offers. Additionally, the effect of offer was moderated by the mean amplitude of the FRN response of the person ($\beta = -.033$, $z = -4.663$, $p < .001$, see Figure 3d) with relatively large (highly negative) mean FRN amplitude leading to more rejection behavior to more fair offers.

Exploratory effect: Difference to the previous stage

The difference to the previous stage led also to a significant effect with a higher second offer compared to the first offer leading to more acceptance ($\beta = 6.645$, $z = 11.940$, $p < .001$). This effect interacted with the effect of offer, leading to a higher offer effect if the present offer was being higher than in the previous stage ($\beta = 3.603$, $z = 4.375$, $p < .001$, see Figure 3e). The difference to the previous offer also interacted with greed ($\beta = .421$, $z = 4.479$, $p < .001$, see Figure 3f), with high trait greed leading to more acceptance of offers that are worse than the previous one. Additionally, the mean FRN response amplitude of the person interacted with this difference effect of the previous to the present offer ($\beta = .164$, $z = 3.746$, $p < .05$, $\beta = .056$, $z = 5.129$, $p < .001$ see Figure 3g) with relatively large (highly negative) mean FRN amplitudes even inversing the offer effect and leading to more rejection if the offer was higher, while the "normal" offer effect of accepting more generous offers was amplified if the mean FRN amplitude was relatively small (highly positive). Also, trait altruism interacted with the difference to the previous offer and the offer itself ($\beta = .164$, $z = 3.746$, $p < .05$, $\beta = .056$, $z = 5.129$, $p < .001$ see

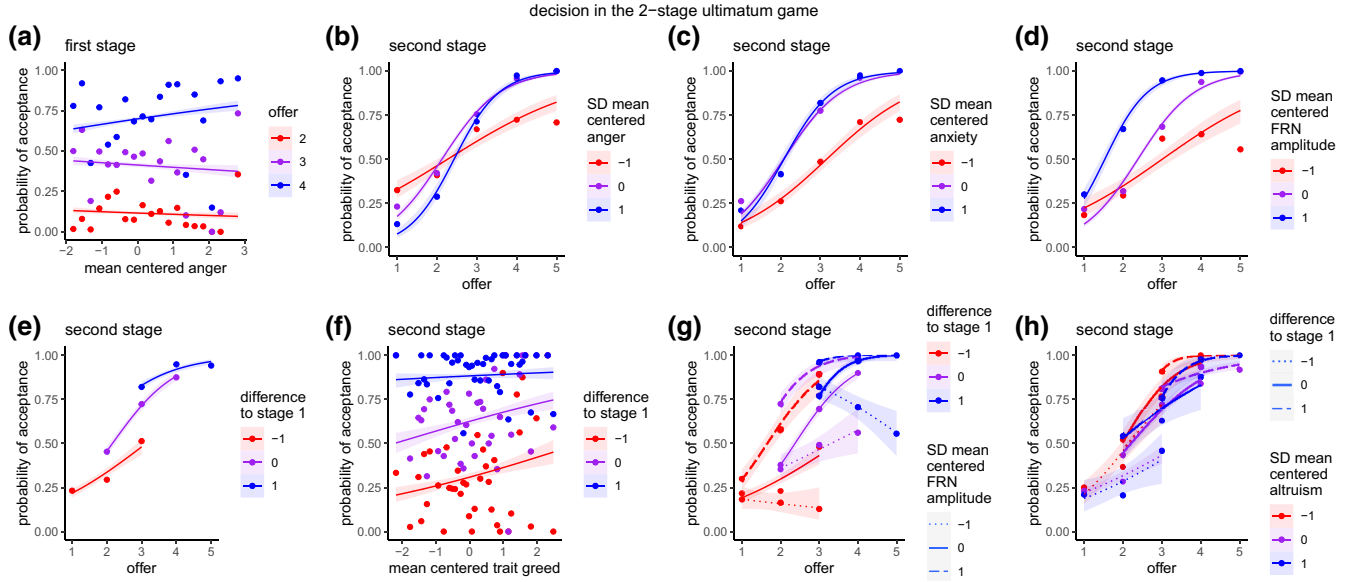


FIGURE 3 Probability of acceptance in the first and second stage of the 2SUG, moderated by trait altruism, trait anger, trait anxiety, trait greed, trait FRN responsiveness and the difference to the previous stage. Shaded error-bars represent 95% confidence intervals

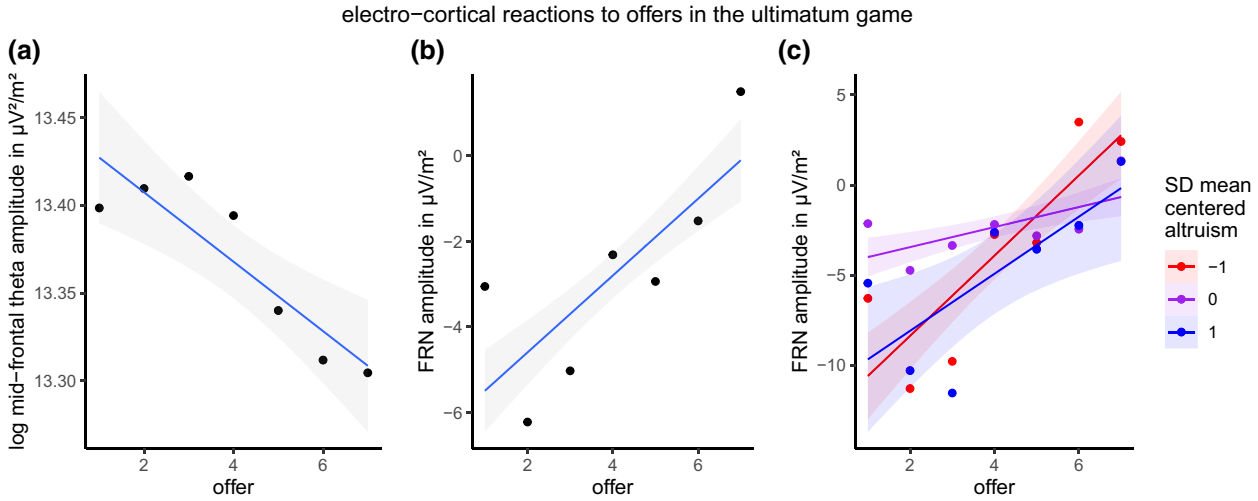


FIGURE 4 Midfrontal theta activation and FRN activation to the offers, moderated by altruism in the ultimatum game. Shaded error-bars represent 95% confidence intervals

Figure 3h) with low altruism leading to more acceptance of unfair offers in this final stage, except the offer was better than the previous offer.

All other variables did not succeed in increasing the information and therefore were not considered (see Table S6).

3.3 | EEG as criterion

The automatic peak-detection led to two different peaks for the FRN component: 276 ms (window 256–296 ms) and for the midfrontal theta activation: 472 ms (window 452–492 ms).

3.3.1 | Ultimatum game

For the traditional UG and the midfrontal theta band activation, the offer was the only significant predictor ($\beta = -.019$, $z = 4.47$, $p < .001$, see Figures 4a and 5), with higher offers leading to less midfrontal theta. The FRN in the traditional UG was also predicted by offer, with a higher offer leading to a lower (less negative) FRN amplitude ($\beta = .882$, $z = 6.971$, $p < .001$, see Figures 4b and 6). This effect was moderated by altruism, with low and high, compared to average altruism leading to a higher (more negative) FRN amplitude for unfair offers ($\beta = -.606$, $z = 2.394$, $p < .05$, see Figure 4c).

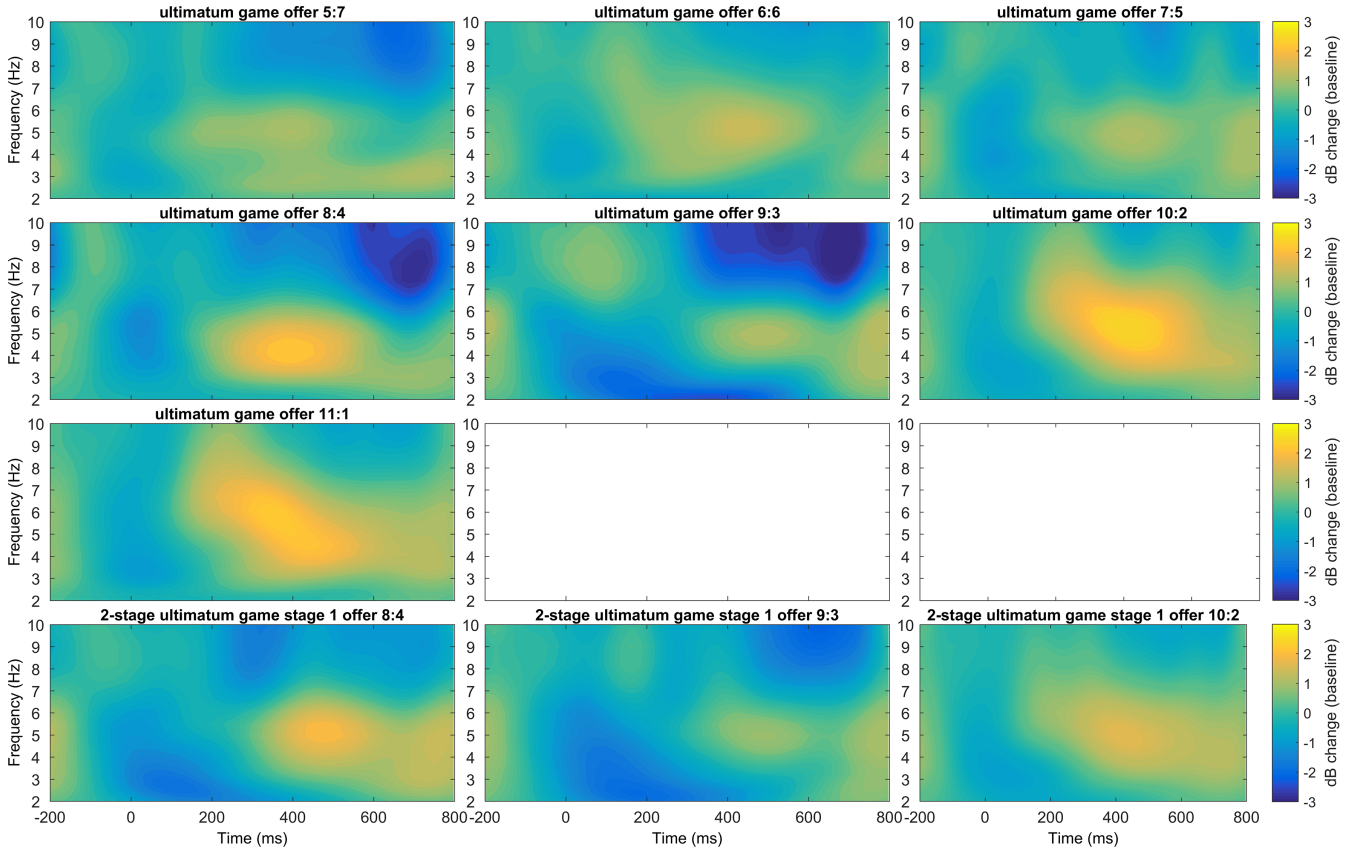
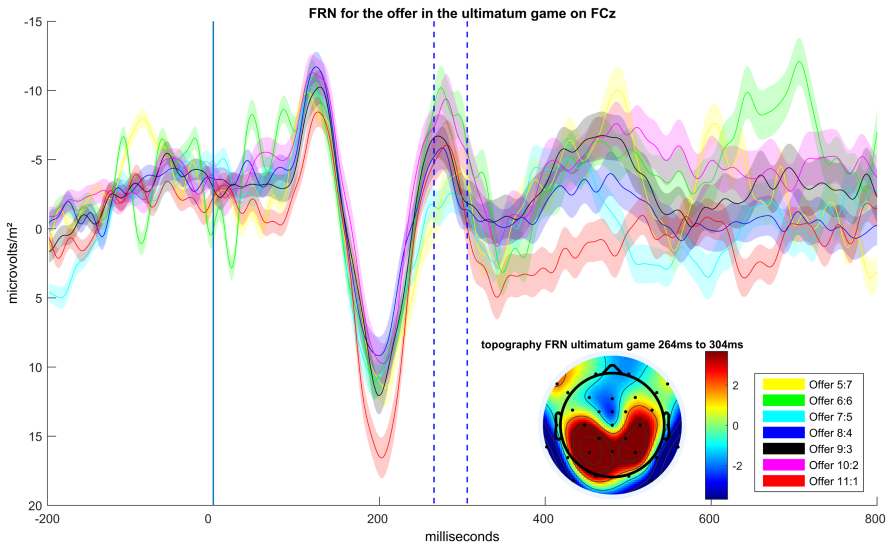


FIGURE 5 Mean frequency activation during the trials for different offers, stages and paradigm types for midfrontal theta

FIGURE 6 ERP for the different offers in the ultimatum game. Shaded areas depict the between SE



3.3.2 | First stage 2-stage ultimatum game

For the first stage of 2SUG, the midfrontal theta band activation could only be predicted by the offer ($\beta = .050$, $z = 5.33$, $p < .001$, see Figures 5 and 7a), with higher offers leading to more midfrontal theta, thus a reversed effect compared to the UG. For the FRN, the offer effect was significant with a higher offer leading to a lower (less negative) FRN amplitude ($\beta = 1.635$, $z = 6.366$, $p < .001$, see Figures 7b and 8). Also, this offer effect was moderated by trait anxiety ($\beta = 1.505$, $z = 3.161$, $p < .01$, see Figure 7c), with a diminished or even reversed offer effect for low compared to average and high trait anxiety.

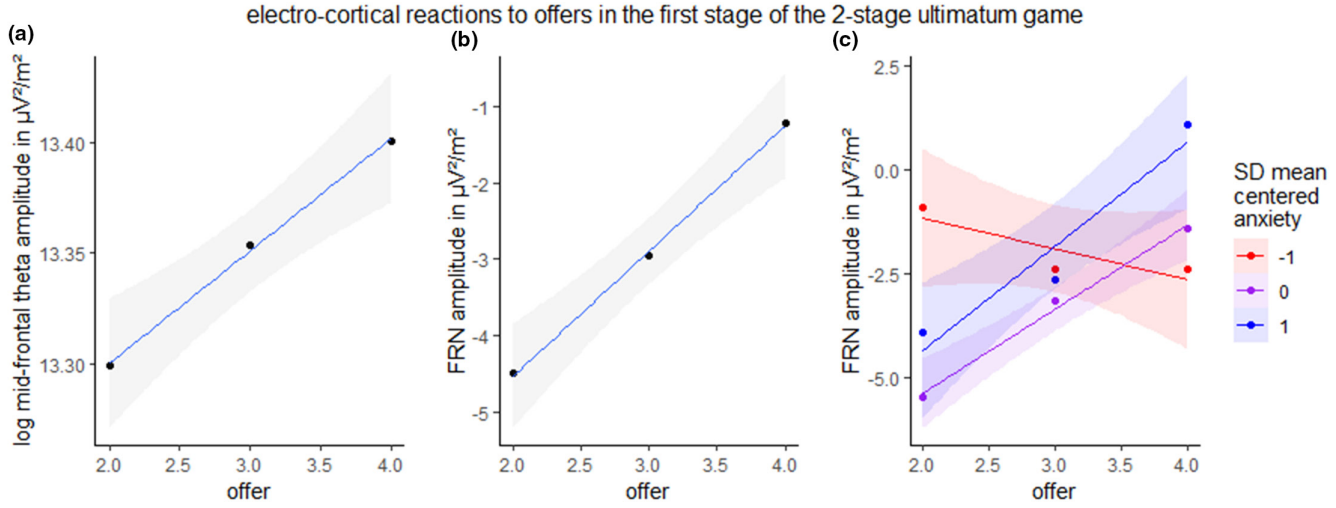


FIGURE 7 Midfrontal theta activation and FRN activation to the offers in the first stage of the 2-stage ultimatum game. Shaded error-bars represent 95% confidence intervals

3.3.3 | Second stage 2-stage ultimatum game

In the second stage of 2SUG, midfrontal theta band activation could not be predicted at all. Also, for the FRN, no prediction could be made at all.

3.4 | Exploratory analyses

3.4.1 | Significant gender effects

Behavior as criterion

Concerning behavior, there were no significant effects in the traditional UG and the first stage of the 2SUG (see Tables S12 and S12). In the second stage of the 2SUG, there was a significant gender effect, leading to a slightly more predictive model (AICc = 2871.2, $p_{\text{information loss}} = .029$). While no direct effect of gender was given ($\beta = 1.139$, $z = 1.142$, $p = .254$), there was an interaction of gender with offer ($\beta = 1.186$, $z = 2.923$, $p < .01$), leading to a higher acceptance for higher offers in women, as well as a higher acceptance if the offer in this phase was higher than before ($\beta = 1.700$, $z = 2.727$, $p < .01$), but also more rejection if the offer was worse than in the stage before ($\beta = -1.201$, $z = -3.157$, $p < .01$). For all non-gender related effects, see Table S12.

EEG as criterion

Midfrontal theta band activation was strongly influenced by gender in all stages and variants of the paradigm. While there was no main effect of gender in the traditional UG ($\beta = .252$, $z = 1.58$, $p = .113$), an interaction with the offer was given ($\beta = -.024$, $z = -2.63$, $p < .01$). We found lower theta responses for women if the offer was higher, while for men, this effect was absent. For the first stage ($\beta = .337$, $z = 2.13$, $p < .05$) and the second stage ($\beta = .324$, $z = 2.01$, $p < .05$) of the 2SUG, a generally higher midfrontal theta band response for women could be found. For further details, see Table S13.

The FRN however, was not influenced by gender effects (see Table S14).

3.4.2 | Influence of induced and evoked theta power

Behavior as criterion

An influence of the different aspects of induced and evoked theta frequency responses in the traditional UG is not present as for the mean theta response (see Table S1).

For the first stage of the 2SUG however, decibel (dB) change to baseline of evoked theta as an additional predictor could contribute significantly to the previous model including trait anger and the offer as predictors (see Table S2). The influence of the offer and the interaction with anger are preserved (see Table S15), yet it was additionally moderated by the evoked theta response ($\beta = .086$, $z = 2.24$, $p < .05$), with even higher acceptance rates if the theta during the trial was high, given a high trait anger and a high offer. However, there are additional interactions of the evoked theta per person and offer, leading to a higher acceptance rate for persons with a generally higher dB evoked theta ($\beta = .380$, $z = 4.73$, $p < .001$) for better offers (see Figure 9). This effect was dampened by the theta given during the trials ($\beta = -.046$, $z = -2.08$, $p < .05$), with lower dB evoked theta responses during the trial leading to exceptionally high acceptance for the best available offer (see Figure 9). This leads to the interpretation of one part of the participants showing high evoked theta responses in general seem to show less midfrontal theta in the FRN timeframe during the trial for not choosing the default to

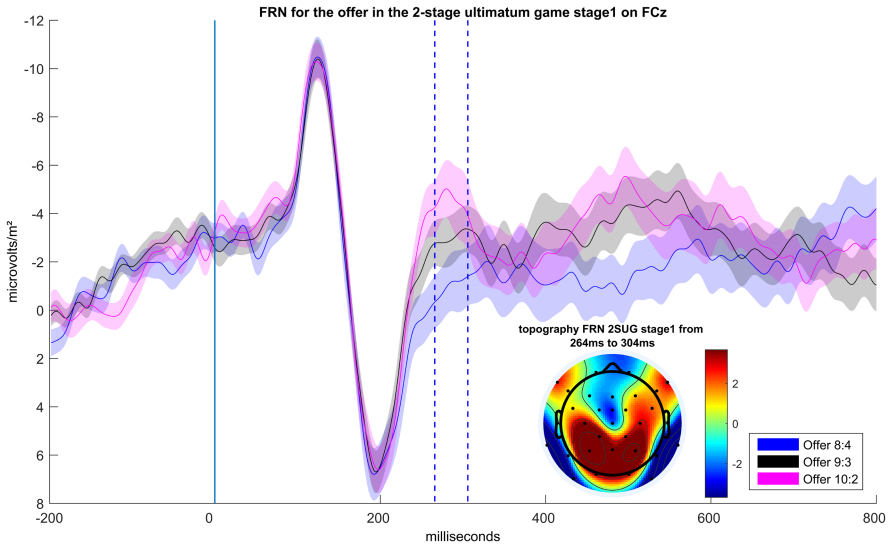


FIGURE 8 ERP for the different offers in the first stage of the 2-stage ultimatum game. Shaded areas depict the between SE

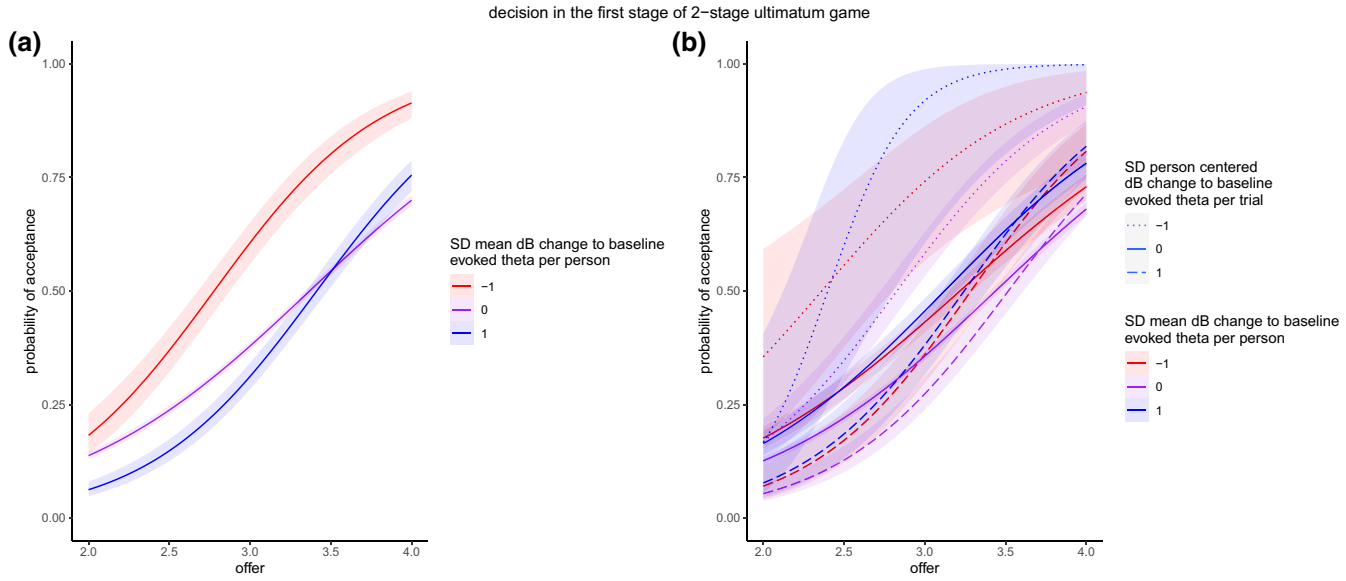


FIGURE 9 Probability of acceptance in the first stage of 2SUG, dependent on offer and evoked midfrontal theta responses

reject in this task. However, one must keep in mind that this evoked potential here is based on the residual FRN response, not the theta peak response. Hence, we see that a lower negative evaluative response leads to acceptance, which is in line with previous findings.

For the second stage of the 2SUG, no additional information is provided by evoked or induced theta power to predict behavior (see Table S3).

EEG as criterion

For the traditional UG, the differentiation for all variants of midfrontal dB change to baseline theta reactions, only offer was a significant predictor (see Table S4) as for the log theta response. The effects for dB change to baseline total theta was $\beta = -.085$, $z = -3.332$, $p < .001$, for induced dB change to baseline induced theta $\beta = -.081$, $z = -3.169$, $p < .01$ and for the evoked dB change to baseline $\beta = -.026$, $z = -2.871$, $p < .01$, all pointing to less theta reactions if there is a higher offer.

In the first stage of the 2SUG, total dB theta changes to baseline ($\beta = .272$, $z = 4.999$, $p < .001$) and induced dB theta change to baseline ($\beta = .288$, $z = 5.303$, $p < .001$) could be predicted by the offer and led to the same effect with higher offers leading to a higher theta response, as the log theta reaction, while the evoked dB theta change to baseline could not be predicted (see Table S5).

In the second stage of the 2SUG, no frequency response could be predicted at all (see Table S6).

3.4.3 | Influence of total delta power

Behavior as criterion

Total delta power has no additional influence concerning the prediction of the behavior in any stage or variant, neither UG or 2SUG (see Tables S1–S3).

EEG as criterion

Total delta power in the traditional UG was predicted by the interaction of the offer of the proposer and trait anxiety ($\beta = -.022$, $z = -3.59$, $p < .001$, see also Table S4), leading to higher delta responses for higher offers in persons with low trait anxiety, while the opposite was true for high anxiety (see Figure 10).

In the first stage of the 2SUG, only the offer could predict log delta band activation ($\beta = .047$, $z = 6.690$, $p < .001$) with higher offers leading to higher delta responses (see also Table S5).

In the second stage of the 2SUG, no frequency response could be predicted at all (see Table S6).

4 | DISCUSSION

In this work, we investigated the influence of a second stage in the UG on the acceptance behavior and the rejection behavior, as well as the electro-cortical correlates to fairness and their relation to the resulting behavior. We hypothesized that having a second stage available would lead to a higher threshold for acceptance than in the traditional UG in the first stage and that the electro-cortical correlates to unfair offers would be dampened if a second stage were still available. Additionally, we hypothesized that traits and their moderation of the behavior and electro-cortical responses during the trials would interact differently with the paradigms and their stages.

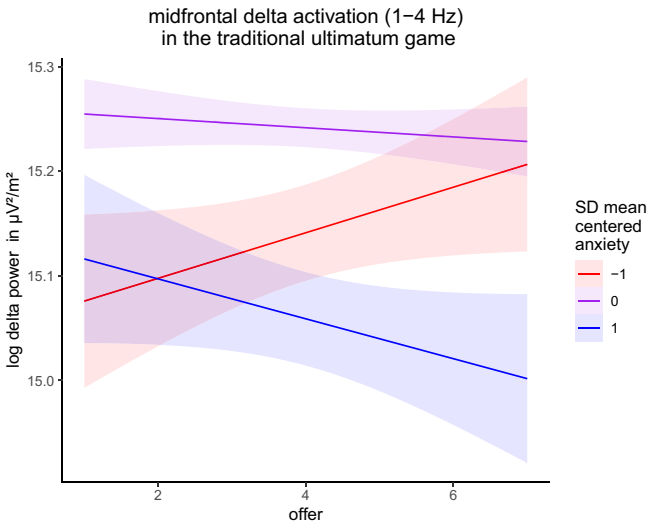


FIGURE 10 Midfrontal delta responses in the traditional ultimatum game

The data confirm our expectation of having the second stage available leading to higher rejection rates in the 2-stage ultimatum game for unfair offers and in general. This is in line with previous findings (Billeke et al., 2014;Felli et al., 2018; Güth & Tietz, 1990), confirming the negotiation character of this 2-stage UG. However, the acceptance in the second stage of 2SUG was not as high as predicted (see Figure 2), somewhat missing the effect of the "final" stage (Felli et al., 2018; Güth & Tietz, 1990). The predicted effect of the final stage would have been, that participants would be more prone to accept the "final" offer, as has been found in other concession ultimatum games (Felli et al., 2018; Güth & Tietz, 1990). Nevertheless, traits took a great influence on this second stage in 2SUG. These behavioral results stress the already known difference between a single stage UG and a multiple stages approach, with the multiple stages being more realistic than the artificial one-shot interaction situations, which we might encounter less frequently in our daily lives. Hence, multistage UGs can be more useful to get more insight into human behavior of negotiation than the traditional UG, stressing the influence of traits on resulting behavior. Additionally, the electro-cortical correlates during the trials give information about the perception and processing of the respective situations. Despite our expectations, we did not find a dampened (less negative) FRN response to unfair offers if a second stage is available. Hence, despite the second chance for an offer, the perception of the unfair offer might not be different to the traditional UG. In fact, the processes for evaluation might be similar, but the perception of the tasks may be independent from each other, as the expected global evaluation was not present (see Kujawa et al., 2013). If the global evaluation would have been prevalent, the FRN would not have been as pronounced in the first part of the 2SUG as in the second part, the most negative event of the task would have to be expected. Also in the traditional UG, there was globally seen the worst offer, with 11:1 for the proposer. Hence, the two variants of the UG might have been seen and evaluated as different tasks altogether, yet with similar processing of the offers. Yet, another explanation for the lack of a global evaluation could be the different instructions for the task and the division in different blocks. This suggests a different task and therefore might encourage a different reference frame. Hence, independent of whether the same task or another would have been used, the reference frame may have been prone to be different for the blocks anyway.

Concerning midfrontal theta, we found an offer effect with higher midfrontal theta band activation for lower offers in the UG, being in line with the FRN effect. Although maybe being influenced also by the fairness consideration,

this finding may hint to the cognitive control to overcome the default action of accepting the offer (see also Table S8) in the traditional UG. As the offer gets more unfair, the cognitive control to overcome the acceptance default and leading to rejection is seen in the midfrontal theta band activation. Interestingly, an opposite effect was found for the first stage of 2SUG, with more theta band activation to higher compared to lower offers. As in the 2SUG there is a second stage in which a better offer may be hoped for, the behavioral default in the first stage of the 2SUG might be to reject the offer. Thus, this leads to the conclusion that midfrontal theta is linked to cognitive control needed to overcome the behavioral default action of rejection the offer (see also Table S8) in the first stage of 2SUG in case of a rather generous offer. These results for midfrontal theta and the FRN stress the position, that midfrontal theta band activation and the FRN component might display different processes (Cavanagh & Frank, 2014; Cohen, 2011). In particular, later midfrontal theta band activation may reflect cognitive control and conflict (Cavanagh & Frank, 2014; Cohen, 2011) to overcome the respective behavioral "default" actions, while the earlier FRN component shows the fairness evaluation and discrepancy from the (fairness or reward) expectation in economic decision games (see e.g., Boksem & De Cremer, 2010; Rodrigues et al., 2020). Interestingly, we find a corresponding pattern in the data, with the FRN component having its peak around 276 ms while the midfrontal theta band activation has its peak around 472 ms. Knowing that the N2 has theta band activation components (Cavanagh et al., 2012), we detect in Figure 5 small corresponding theta band activations in this time frame, especially if the offers are rather unfair. However, a much bigger theta peak is to be found later, especially if a rather fair offer is given. Similarly, as we show in Figures 6 and 8, there is an FRN component in its typical timeframe and an additional "component like" pattern around 480 ms which is not as time logged as the N2 component. We refer to this theta band frequency-induced pattern as N3 (being the third negative "peak" although not that precisely aligned, yet clearly to be found in the theta band spectrum) in this context, possibly being an ERP signature of the underlying process of cognitive control in decision-making in this paradigm. This N3 might be driven by the theta band activation that is associated with cognitive control (Cavanagh & Frank, 2014; Cohen, 2011).

As we were trying to account for relevant inter-individual differences, we investigated the influence of altruism, anger, anxiety, and greed on the behavior and the electro-cortical correlates of behavior and perception in the present paradigms. Concerning the prediction of behavior, we additionally found an interesting effect concerning the trait-like tendency to react with a higher FRN compared to other participants. This tendency of generally having a higher FRN (which is not linked to the actual trial but is given for the person) predicted the rejection behavior in the first stage of 2SUG. Following the idea of the FRN being a marker of fairness evaluation, participants with this high FRN reactivity may perceive the offers more unfair compared to other participants and therefore reject the offers more often (cmp. Luo et al., 2014; Wu et al., 2013 for anxiety). Possibly being indirectly linked to this effect was the effect of low trait anxiety leading to a lower (less negative) FRN response in this first stage of 2SUG, indicating the expected higher FRN for trait anxiety and the sensitivity to unfair offers for persons with high trait anxiety (see Luo et al., 2014; Wu et al., 2013). However, this finding is not in line with the evidence for lower (more positive) FRN amplitudes for high trait anxiety for negative outcomes in gambling tasks (Gu et al., 2010), or in context conditioning (Andreatta et al., 2017). As the 2SUG is neither a context conditioning (Andreatta et al., 2017) nor a gambling task (Gu et al., 2010) with very clear cut outcomes without social dependence, the results may be as they are because of the social relevance of the decision and the ambiguous character of the decision (Andreatta et al., 2017; Gu et al., 2010). Nevertheless, the finding is in line with previous research about the influence of trait anxiety on the FRN in the ultimatum game concerning the fairness of the offers (see Luo et al., 2014; Wu et al., 2013). Interestingly, there was no amplification of the midfrontal theta band activation by trait anxiety that could be expected (see e.g., Osinsky et al., 2017; Schmidt et al., 2018). This may be due to the gender effect that this modulation was predominantly present in women (Osinsky et al., 2017), which our sample favored with 72%, yet it was not an entirely female sample. Another expected effect concerning anxiety was the higher acceptance of offers linked to trait anxiety (see Grecucci et al., 2013; Luo et al., 2014; Wu et al., 2013), which we only found in the second stage of 2SUG. This finding may be due to the social pressure persons with high anxiety might feel themselves under and the avoidance of social conflict (Raffety et al., 1997; Turner, 1988). However, it was only found in the second stage of 2SUG, which might hint to the stronger perception of interaction and social closeness or commitment to the interaction partner and therefore social obligation to them in this 2-round interaction. Hence, the 2SUG situation provides a situational activation context for trait anxiety that is more intensive and possibly more similar to real world interactions than the UG (cmp. e.g., Rodrigues, Allen, et al., 2021 for trait activation and strength of situational context, see also limitation section below).

Another trait influence activated by 2SUG is trait greed. As expected for maximizing their profit (Mussel & Hewig, 2016), in the final stage of 2SUG, trait greed led to

accepting more offers, especially if they were lower than the first offer. Contrary, the expected higher rejection in the UG and the first stage of 2SUG could not be found. Partly, this is due to the rather high rejection default in the first stage of 2SUG (see Table S8), but also due to the high acceptance default in the traditional UG (see Table S8) as well as the situational activation context of the offers. A lack of situational trait activation (see e.g., Mussel et al., 2015; Rodrigues, Allen, et al., 2021) may have arisen in the UG due to a wide variety of offers including fair and more than fair offers, while in the 2SUG there were only offers below an even split. This may have led to the effect that in the traditional UG, none of the traits led to any behavioral modulation.

Confirming our expectations, high trait anger led to higher rejection rates for unfair offers in 2SUG. This fits the idea of anger leading to a rejection, that we have already referred to as "costly punishment" (Rodrigues et al., 2020). Researchers could already show the strong relation of anger with this kind of behavior in various paradigms (e.g., Gilam et al., 2019; Nelissen & Zeelenberg, 2009; Pedersen et al., 2013; Pillutla & Murnighan, 1996; Pohling et al., 2019; Rodrigues et al., 2018; Seip et al., 2009, 2014). This corroborates the findings about trait anger leading to more costly punishment (Rodrigues et al., 2018) and challenges the term "altruistic" for this kind of punishment and would suggest it being rather "costly punishment". Interestingly, trait anger did not moderate the traditional UG responses. This may be due to the previously mentioned lack of situational trait activation (see e.g., Rodrigues, Allen, et al. 2021) in the traditional UG due to the variety of offers, while in the 2SUG there were only offers below an even split.

Negatively linked to trait anger in the third-party dictator game was trait altruism (e.g., Rodrigues et al., 2018, 2020). However, our hypothesis about trait altruism leading to more acceptance, which arose from the altruistic compensation seen in the third-party dictator game was not supported. In fact, we found support for a higher rejection of unfair offers in 2SUG that were not corrected in the second stage. This is in line with altruism leading to a norm reinforcement (Fehr et al., 2002; Fehr & Gächter, 2002; Strobel, 2016), especially if no error in providing an offer can be assumed as no correction is given in the second stage. Hence, in the context of UG and 2SUG, on a behavioral level, as there is no compensation or similar act possible, the rejection of an unfair offer and therefore social and fairness norm reinforcement seems to be linked to altruism as only possible prosocial act, yet confound with other motivational aspects like anger (cmp. Rodrigues et al., 2018). Nevertheless, we found that low or high trait altruism led to higher (more negative) FRN reactions to unfair offers in the traditional UG. This is a surprising support to the mixed evidence findings of Mothes et al. (2016) and Sun et al. (2015) which may have assessed only one part of the respective distribution in their sample. The finding supports the idea of two different sub-groups in persons with high altruism. One subgroup with a weaker negative evaluation of unfair offers or an empathy for norm violating behavior (see Mothes et al., 2016) and therefore also less intend to punish unfair behavior. This lack of negative evaluation may eventually lead to more acceptance of unfair offers and would be in line with the idea of benevolent altruism (see Rodrigues & Hewig, 2021), yet we were not able to find this on the behavioral level in our study. The other subgroup may have a higher negative evaluation of the unfair offers and less empathy for norm violation (see Sun et al., 2015) leading to the behavioral rejection found in the second stage of 2SUG if the unfair offer was not corrected. This difference in these two subgroups of altruism may be responsible for the mixed findings concerning the FRN, but also for the mixed findings concerning punishment and trait altruism (see e.g., Rodrigues et al., 2018, 2020) and future research may deepen the understanding of those different subgroups in different contexts and experimental settings. However, although some evidence is given that altruism may lead to rejection behavior in the 2SUG, we want to conclude, that not altruism alone, but anger also involved in the rejection and therefore the punishment behavior. Hence, the term "altruistic punishment" is not accurate, and the more cautions and neutral term "costly punishment" is advisable.

The explorative analyses concerning gender revealed additional interesting findings, that may be used to confirmatory research in future studies: Concerning behavior, the only influence we could detect was given in the second stage of the 2SUG, leading to the effect that women seem to be more sensitive to higher offers in general concerning acceptance. They accept more if they get better offers, but they also punish and reject more if the offer is worse. The latter finding of women rejecting more in the 2SUG is in line with previous findings of women generally rejecting more in the traditional UG (García-Gallego et al., 2012), yet the interpretation in this case may be different, as they are also more prone to accept a better offer. Hence, women may simply reward and punish their counterpart for acting more socially agreeable. However, a different explanation would be that they behave more impulsive and might follow their urge to retaliate for even worse offers and accept offers that are rewarding. Yet, no definite conclusion can be drawn from this data set and further research is needed. Concerning midfrontal theta band activation, in the traditional UG, the effect of higher theta responses for lower offers was only present in women. This may represent the difference in cognitive control needed to come to

a decision, as men tend to make their decision partly more "on principle" while women adjust their decisions more to the circumstances (Eckel & Grossman, 1996). This may also be an explanation for the generally higher midfrontal theta band activation in the first and second stage of the 2SUG.

Exploratory analyses of the dB change to baseline of the total, induced and evoked theta responses revealed that while there are no structural differences in the effects of the theta responses in the traditional UG and in the second stage of the 2SUG, in the first stage of the 2SUG, the evoked theta responses of the FRN response may add additional value to predict behavior. Here, the evoked theta responses were higher in participants with high trait anger, if the best offer in the first stage of the 2SUG was given. One possible interpretation would be that this is caused by the default to reject, as this punishment response may also be preferred by persons with high trait anger (Rodrigues et al., 2020) and now additional cognitive control is needed in case of a good offer. The interpretation of this evoked theta response being a marker of cognitive control to overcome the default of rejection is partly strengthened, as persons showing higher evoked theta responses in general also accept more if higher offers are given. However, this effect was dampened by the person-centered evoked theta response per trial. In the first interpretation, this indicates two different processes still confound here, even in the evoked responses. One process seems to display the evaluative component as the FRN on trial by trial basis (Holroyd & Coles, 2002), while the other aspect here given by the personal tendency to show high midfrontal evoked theta responses seem to display the cognitive control (Cavanagh & Frank, 2014). Yet, one must keep in mind that the evoked response is based on the residual FRN response and not the theta peak response. Hence, we see that a lower negative evaluation response in a trial leads to acceptance, which is in line with previous findings, while the tendency of showing a higher evaluative response in general leads to more acceptance, which has also been found in the traditional UG in clinical context (Grecucci et al., 2013). The problem in interpretation arising from the evoked theta response in this case is the potential that has been used to create this reaction. As the FRN was the dominant component in the timeframe, the evoked theta response is bound to be related to the FRN response. However, looking at Figure 8, there are two different peaks visible, one being prevalent over all offer conditions, but the second one being specific to the offers and with different latencies. Looking at the two "not worst" conditions, we see two peaks, one early or midst the time-window and a second one at the end or even shortly after the FRN time-window. This second "component" might be the N3 as argued above, displaying the needed cognitive control and therefore also the respective second theta response that we have seen to be linked to the cognitive control needed to overcome the default of rejection. In order to create a comparable evoked theta response in this N3 window, one needs to alter the paradigm and only include 2 conditions with more repetitions, that the N3 may clearly be seen, and the evoked response may be calculated to this N3 component, showing the amplificated cognitive control responses in this case in our study.

The exploratory analyses concerning the influence of delta activity revealed that delta was not relevant for altering behavioral decisions, but it could be predicted differentially in an interaction of the offer with trait anxiety in the traditional UG. In persons with low trait anxiety, high delta responses were linked to higher offers, while persons with high trait anxiety showed lower delta responses being linked to higher offers. These findings are in line with the link of delta frequency having also part in evaluative processes of the reward positivity (Bernat et al., 2011; Cavanagh, 2015; Holroyd et al., 2008) and being higher for persons with high anxiety or showing social anxiety symptoms (Cavanagh et al., 2019; Jin et al., 2019). While the low anxious persons might simply enjoy the higher offers and show the higher delta driven reward positivity, persons with high trait anxiety may show the higher delta response because of their anxious arousal in case of lower offers. However, this effect is only present when there is only one stage to play as in the traditional UG, as the effect of anxiety is not present in the first stage of the 2SUG, where only the higher delta response for higher offers is shown. Hence, the trait anxiety in a finite decision paradigm seem to influence the delta response heavily and the respective delta responses should be seen in the context of trait anxiety, or the paradigm may be altered from a finite game to a game with additional rounds. Yet, this may not only change the delta response, but also other important features as discussed above.

Altogether, the present findings further stress the influence of traits like anxiety, greed, anger, and altruism in economic games context, which we hoped to enhance by adding an additional stage to the UG. Additionally, gender seems to play a major role concerning economic decision-making, while the evaluation of fairness seems independent of gender effects.

4.1 | Limitations

The lack of significance for some of the expected findings may be due to several reasons. First, the modification of the paradigm and the UG paradigm as used in this study may have led to a suboptimal situation in order to activate

the traits sufficiently. As it has been shown that the intensity of a situation may have an influence on behavioral responses as well as relevant electro-cortical correlates (e.g., Mussel et al., 2015; Rodrigues, Allen, et al., 2021) it may be that this situation is not sufficiently strong to show an activation of the respective trait and a significant interaction with electro-cortical measurement taken. Second, the paradigms were not conducted with real proposers in a live repeated game, but the participants were instructed that they were playing repeated one-shots against persons that already have given their offers. Hence, a final rejection cannot be used to gain a direct advantage in the next trial, as it cannot be used to communicate ones expectations (e.g., Mussel, Hewig, & Weiß, 2018; Weiß, Mussel, & Hewig, 2020). This may lead to a smaller influence of the traits, as the situational reinforcement of punishment behavior or acceptance is not directly experienced. Additionally, the participants were not playing with real proposers, but with fictive proposers, which was revealed to the participants after the game. This led to a specific "full design" matrix, as any combination of offer could be given and repeated. However, in real life, if a greedy person interacts repeatedly with anxious proposers for example, he or she might influence the decisions of the counterpart while gathering more money and executing social dominance (compare Weiß, Rodrigues, et al., 2020). Hence, the interaction of real persons in a repeated scenario may lead to "unbalanced" design matrices, but it has the advantage to possibly enhance trait interactions given by the interaction partners. Thus, a more trait-activating situation might arise from playing with real persons. However, this has serious shortcomings for electrophysiological analyses as such a confound will have a strong impact on ERPs. A third limitation is that the preregistration of this manuscript did also suggest slightly different pre-processing of the data and other analysis had been planned. However, as the manuscript is already very large and we wanted to make use of more recent developments that emerged since the pre-registration (Rodrigues, Weiß, et al., 2021), we changed the pre-processing accordingly. Furthermore, we reported the changes to the preregistration in the method section and specifically state, that not all suggested analyses of the preregistration were included in this manuscript, especially as some analyses were thought to be executed with a far bigger sample size (e.g., structural equation modeling, for details see https://osf.io/h6e3p).

4.2 | Conclusion

We tested the influence of a second bargaining stage in an UG compared to the traditional UG on behavioral responses, electro-cortical correlates and their moderations by altruism, anger, anxiety and greed. We found that an additional stage led to more rejection in the 2SUG. The FRN during a trial was linked to expectance evaluation and fairness of the offers in UG and the first stage of 2SUG, while midfrontal theta was a marker for the needed cognitive control to overcome the default behavioral pattern. The mean FRN response, representing the trait-like general electrocortical reactivity to unfairness, predicted rejection in the first stage of 2SUG. Additionally, we found the expected trait influences for anxiety, greed, and anger in 2SUG, partly being only present when taking into account the difference to the previous stage. This reveals the potential of 2SUG as a trait-activating paradigm. The findings concerning trait altruism indicated two subgroups, one with high sensitivity and low empathy for norm violation and one with high empathy for norm violation which may be the cause of mixed findings for behavioral outcomes and physiological parameters in economic decision games.

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CONFLICT OF INTERESTS

No potential conflicting interests exist.

AUTHOR CONTRIBUTIONS

Johannes Rodrigues: Conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; project administration; validation; visualization; writing – original draft; writing – review and editing. **Martin Weiss:** Writing – original draft; writing – review and editing. **Patrick Mussel:** Validation; writing – review and editing. **Johannes Hewig:** Resources; software; supervision; writing – review and editing.

PREREGISTRATION

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DATA AVAILABILITY STATEMENT

The processed EEG data with the behavioral data, trait data, materials and the statistical analyses are available on the OSF repository (non-frozen version of the project: https://osf.io/baz7r/). The EEG processing pipeline is available here: (https://osf.io/cw5qv/). For further interest beyond these scripts and data contact the first author.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

TABLE S1 Fit indices (AICc) and p-information loss for the computed models with rejection/acceptance behavior as dependent variable for the ultimatum game

TABLE S2 Fit indices (AICc) and p-information loss for the computed models with rejection/acceptance behavior as dependent variable for the first stage of the 2-stage ultimatum game

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TABLE S4 Fit indices (AICc) and p-information loss for the electrocortical responses as dependent variable for the ultimatum game

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