The Role of Emotion Regulation and Choice Repetition Bias in the Ultimatum Game

Justin Cheuk Yin Chung*[1], Raj Seraya Bhatoa[2], Ruth Kirkpatrick[3], and Kate Anne Woodcock*[4]

[1]School of Psychology, University of Birmingham, UK

[2]Cerebra Centre for Neurodevelopmental Disorders, School of Psychology, University of Birmingham, UK

[3]School of Psychology, Queen's University Belfast, UK

[4]Centre for Applied Psychology and the Institute for Mental Health, School of Psychology, University of Birmingham, UK

*Correspondence about this article should be addressed to Justin Chung (justincychung@googlemail.com) or Kate Woodcock (papers@katewoodcock.com), School of Psychology, University of Birmingham, Birmingham, UK, B15 2SA.

The data and computer code used to generate the results are publicly available at https://osf.io/uygpq/

Acknowledgements

We acknowledge the contributions of: Emma Catterson, Eavan Hennessey, Clare Howie, and Hannah Kee in assisting with data collection; Alex Perry and Glenda Preston in assisting with data collection and designing the modifications for the Comments paradigm of the Ultimatum Game; Mahmoud Elsherif in providing statistical guidance. The modified

Ultimatum Game paradigm was piloted as a part of a Marie Curie Fellowship awarded to KAW under the European Commission's seventh framework programme (PIOF- GA-2009-252877) and supported with work by RSB and Eleanor Callaghan. This funding had no role in the conceptualization, design, data collection, analysis, decision to publish, or preparation of the manuscript.

Competing Interests

The authors declare no competing financial or non-financial interests.

Author Note

The data and computer code used to generate the results are publicly available at https://osf.io/uygpq/ (Chung et al., 2021).

Abstract

Social decision-making is commonly explored in the context of adult responder behaviour in the Ultimatum Game. Responder behaviour in the game has been proposed to be the consequence of two competing systems that control behaviour: an affective system, which promotes an emotional response to unfair offers; and a deliberative system, which instead encourages a rational response to maximise in-game gains. In a secondary analysis of Ultimatum Game data in children and adolescents (*N* = 429), the present study demonstrated that trial-level metrics of responder behaviour were reflective of a dual systems framework. However, no consistent relationship was found between responder behaviour and trait-level measures of emotion regulation. Choice history was found to influence all measures of responder behaviour in the game. These results support a dual systems account of social decision-making in children and adolescents and highlight choice repetition bias as an additional factor influencing decision-making within the Ultimatum Game.

Keywords

Social decision-making; Ultimatum Game; emotion regulation; choice repetition bias

The Ultimatum Game is commonly used to study processes involved in social decision-making (Güth et al., 1982; Güth & Kocher, 2014). The original paradigm involves the interaction between two players: a proposer determines how a monetary sum (stake) should be split between themself and a responder, who in turn chooses whether to accept or reject this offer. Acceptance of the offer results in both parties gaining their split of the stake according to the offer of the proposer, whereas rejection of the offer results in no gain for either party.

In the face of offers that are unfavourable (unfair) to the responder, the "rational" choice for the responder would be to accept these offers in order to maximise their gains within the game. However, studies of responder behaviour in the game have consistently reported an increased likelihood of rejecting unfair offers (e.g., Sanfey et al., 2003). Multiple frameworks have been proposed to explain this pattern of responder behaviour (for reviews, see Hallsson et al., 2018; Zheng et al., 2017). Whilst a large number of processes contribute to decision-making in the Ultimatum Game (for a review of contemporary theories of social decision-making, see Murray et al., 2021), the scope of the present study focuses on one such account: the *dual-process theory*, which describes an affective (emotional) system and a deliberative (rational) system that operate in parallel and compete to determine the decision of the responder (Alós-Ferrer & Strack, 2014; Loewenstein & O'Donoghue, 2004; Sanfey & Chang, 2008; but see Pfeifer & Allen, 2012, 2016 for critiques on the dual-process theory). In the context of decision-making, the affective system is considered to be fast, automatic, and responsible for immediate reactions; whereas the deliberative system is slower, demands effortful control, and has the potential to modulate the affective response (Sanfey & Chang, 2008). According to this framework, an unfair offer presents conflict between the two systems, as a responder may reject the offer as an

immediate, emotional response, whereas the responder may accept the unfair offer if they are able to successfully regulate their emotions through the top-down control via the deliberative system, which would necessitate a longer response time (Alós-Ferrer & Strack, 2014; Sanfey & Chang, 2008). The ability to regulate one's emotions can be considered both as a trait, which represents a stable pattern of regulation tendencies; and as momentary states, which are variable and context-dependent (Colombo et al., 2020; McMahon & Naragon-Gainey, 2020).

The involvement of an emotional component in response to unfair offers in the Ultimatum Game has been demonstrated in prior research, as unfair offers can evoke anger, sadness, and contempt in adult responders (Gilam et al., 2019; Kravitz & Gunto, 1992; Pillutla & Murnighan, 1996; Tabibnia et al., 2008). The feeling of anger in adult responders could be accentuated by comments supposedly made by the proposer that emphasised the inequity of the offer, consequently decreasing the acceptance rate of unfair offers (Kravitz & Gunto, 1992). However, when comments were designed to specifically elicit anger in adult responders using threats and insults, the acceptance rate of unfair offers and the feeling towards offers were not affected, suggesting that perhaps the emphasis on inequity was important in altering responder behaviour (Gilam et al., 2019).

Studies involving manipulations of the ability for a responder to regulate their emotions further support the role of top-down control in decision-making within the Ultimatum Game. For example, the acceptance rate of unfair offers increased when adult responders were instructed to employ the emotion regulation strategy of reappraisal to interpret unfair offers as less negative (Grecucci et al., 2013, 2020; van 't Wout et al., 2010). On the other hand, inducing sadness in adult responders prior to the game decreased the acceptance rate

of unfair offers (Harlé & Sanfey, 2007). Consistent with the different temporal characteristics of the two systems proposed by the dual-process theory, adult responders rejected unfair offers more quickly and accepted unfair offers more slowly when compared to evenly split (fair) offers (Lin et al., 2020).

In conjunction with the two systems, the history of past decisions may further influence responder behaviour in the Ultimatum Game. Indeed, in the wider literature of perceptual and value-based decision-making, there is a robust tendency for individuals to repeat their recent choices (Akaishi et al., 2014; Alós-Ferrer et al., 2016; Bosch et al., 2020; Senftleben et al., 2019). In social decision-making paradigms involving repeated interactions with the same partner, studies have mainly explored the influence of previous actions of the partner on the subsequent actions of a player (e.g., Alós-Ferrer & Farolfi, 2019; Hilbe et al., 2018). The effect of one's past decisions on one's subsequent decision-making has received less attention, but studies with variants of the Prisoner's Dilemma, in which players were required to reciprocally cooperate to maximise overall gains, found that players had the tendency to repeat their previous decisions to cooperate, which was further influenced by the actions of their partners (Blake et al., 2015; Grujic et al., 2010; Grujić & Lenaerts, 2020).

In the context of the Ultimatum Game, the behaviour of the proposer has been found to be influenced by whether their previous offer was accepted or rejected (Achtziger et al., 2016, 2018). However, it remains unclear whether the decision history of a responder has bearing on their own subsequent choices. Whilst it is conceivable that across repeated rounds of the Ultimatum Game, past decisions of the responder may affect their subsequent decision-making with the same proposer, the extent to which past decisions could similarly influence responder behaviour in encounters with new proposers is unknown. If past decisions are

indeed influential in the decision-making of subsequent interactions with new partners, this may necessitate a shift in how data from "one-shot" paradigms should be analysed and interpreted, as each round of interaction is typically regarded as independent from the outcome of the previous round (e.g., van 't Wout & Sanfey, 2008).

As much of the research on the Ultimatum Game has focused on the behaviour of adults, the literature on responder behaviour in children and adolescents has been less comprehensive. Developmental evidence suggests that the affective and deliberative systems follow different developmental trajectories over childhood and adolescence, with the affective system being favoured especially during adolescence (e.g., Shulman et al., 2016). However, it is currently unclear whether these developmental differences may influence the decision-making of children and adolescents in the Ultimatum Game to produce differing patterns of behaviour compared to adult responders. Consistent with the literature on adult responder behaviour, unfair offers were more likely to be rejected by children and adolescents compared to fair offers (Sally & Hill, 2006; Steinbeis et al., 2012; Sutter, 2007). However, the affective system appeared to be more dominant in influencing the responder behaviour of children and adolescents, as they were more likely to reject unfair offers compared to adult responders (Murnighan & Saxon, 1998; Sutter, 2007). Critically, there is a lack of research on the other metrics of responder behaviour in children and adolescents, in terms of the temporal dynamics of offer acceptance and rejection and the emotions elicited by unfair offers. Investigation into these aspects of responder behaviour in children and adolescents could provide further insight as to whether the dual-process theory might be applicable for children and adolescents as it appears to be for adults, or whether there might be developmental differences that could alter such an account.

This study investigated how the responder behaviour of children and adolescents in the Ultimatum Game might be affected at a trial-level by the following: 1) the addition of proposer comments; 2) trait emotion regulation; and 3) the decision history of the responder. It was hypothesised that negative comments displayed in conjunction with unfair offers might provoke a heightened emotional response, which would be reflected by a lower acceptance rate, longer response time to accept, and the experience of more negative emotions. With regards to unfair offers in general, it was expected that trait-level emotion regulation in children and adolescents would influence the relationship between momentary emotional states and decision-making, such that greater trait emotion regulation would predict increased acceptance rate, decreased response time to accept, and decreased experience of negative emotions. Previous decisions were expected to affect subsequent decisions in response to unfair offers in children and adolescents but given that this factor had rarely been considered in previous social decision-making research, no specific pattern of results was hypothesised.

Methods

This study involved the secondary analysis of data collected as part of an unpublished postgraduate dissertation (Shields, 2015). Participant informed assent and parental informed consent were obtained for individuals taking part in the original study, which was approved by the School of Psychology Research Ethics Committee at Queen's University Belfast. A subset of the data was previously used as age-matched controls in a study assessing social decision-making in autistic adolescents (Woodcock et al., 2020).

Participants

Overall, 482 children and adolescents were recruited through convenience sampling from classes within primary and secondary schools in Northern Ireland and the Republic of Ireland. Sample availability in the original study was pragmatically constrained by the number of schools able to take part in the research, and by the class sizes within those schools. Data regarding gender and Ultimatum Game performance were missing for 24 children and adolescents, who were consequently excluded from analysis. Further exclusions were applied based on responder behaviour in the Ultimatum Game (see below), such that the final analysis involved 429 participants. The final sample consisted of 201 males (46.9%) and 228 females (53.1%), with a mean age of 10.5 years (standard deviation = 3.1; range = 6–17).

Measures

Ultimatum Game

The details of the computerised Ultimatum Game paradigm have previously been reported in a separate article (Woodcock et al., 2020). In brief, participants were presented with offers perceived to be proposed by another player, when in fact these offers were predetermined by the researchers. Each offer involved a monetary sum being divided either fairly or unfairly, with 20% of the monetary value being offered to the participant. Participants responded by pressing one of two keys on the keyboard to accept or reject each offer. The response mappings between the keys and the decisions were counterbalanced across participants. Following their decision, participants were asked to rate the degree of negative valence associated with the offer on a 5-point Likert-like scale (1 – *Completely calm and relaxed* to 5 – *Very annoyed*). The task utilised visual stimuli and pre-recorded verbal instructions throughout. Participants completed a total of 36 trials divided into two blocks.

Each trial involved a different proposer that the participant had not yet encountered. Twelve of the trials involved fair offers, whilst the remaining 24 trials involved unfair offers.

Three versions of the computerised paradigm with different modifications were used (Supplementary Table 1). In the original study, these modifications were intended to impose regulatory demands on participants to evaluate the use of the Ultimatum Game as an index of emotion regulation. In the Two-stakes paradigm, offers involved one of two stake sizes (£100 and £1). In the Four-stakes paradigm, four possible stake sizes (£100, £10, £1, £0.10) were included to maintain engagement to the task for older participants. The Comments paradigm utilised two stake sizes (£100 and £1) and the addition of a comment when the proposer was introduced. In 18 of the unfair trials, the comments were associated with negative intent (e.g., 'Did you really expect half?') and the remainder of unfair trials and all fair trials included neutral comments (e.g., 'Here is my offer…'). There were more negative comments than neutral comments in the unfair trials as the negative comments were assumed to evoke greater regulatory demands. The comments were unique across trials (Supplementary Table 1). A range of stake sizes were included in all three paradigms as a pragmatic consideration to increase the potential sensitivity of the paradigms in capturing emotion regulation in responders who may be more inclined to reject unfair offers (e.g., due to impaired emotion regulation), as higher monetary values may incentivise acceptance of unfair offers (Tabibnia et al., 2008; Van Der Veen & Sahibdin, 2011).

Children's Emotion Management Scales

The Children's Emotion Management Scales (CEMS) comprise of 33 items distributed across three scales pertaining to children's general ability to regulate feelings of anger, sadness, and anxiety (Zeman et al., 2001, 2002, 2010). Each item is scored on a 3-point Likert scale (1

– *Hardly ever;* 2 – *Sometimes*; 3 – *Often*). Each of the emotion management scales is further divided into subscales of Inhibition, Coping, and Dysregulation related to the corresponding emotion. The scales demonstrated acceptable to good internal consistency and test-retest reliability (Zeman et al., 2001, 2002, 2010). The CEMS were administered on the computer with verbal instructions and visual aids to indicate possible response options. A trait measure of emotion regulation was used, as it was expected to provide an indication of how responders might regulate their emotional states within the Ultimatum Game. Eight participants in the final sample had missing CEMS data.

Procedure

Participants were informed of potential prizes based on performance in the Ultimatum Game. Prior to the game, participants completed a computerised version of the CEMS. To simulate the social component of the Ultimatum Game, participants entered their name and the name of a preferred cartoon character. Participants were assigned to one of the three paradigms. Children and adolescents first acted as the proposer and decided whether they would propose fair or unfair offers. Individuals in the Comments paradigm were required to input a comment that accompanied their proposed offer. The data related to the offers proposed by participants have not been included in the present analysis. Participants completed a practice session as the responder, followed by two further sessions. Participants were led to believe that each offer in these two sessions were selected from offers made by previous participants from the study. Upon completion of the study, participants were informed of the harmless deception involved, which had been approved by the School of Psychology Research Ethics Committee at Queen's University Belfast, and 10% of participants were randomly selected to receive £5 in Amazon vouchers as their prize.

Prior to analysis, additional exclusion criteria were applied to the data to ensure that participants sufficiently understood and attended to the game. Seventeen participants were excluded if they accepted <66% of fair offers associated with the larger stake sizes (£100 in Two-stakes and Comments; £100 and £10 in Four-stakes), or if they accepted <66% of all fair offers regardless of stake size, as these conditions indicated insufficient understanding of the game. Trials with response time (RT) < 0.5 seconds or RT > upper quartile + 2 * interquartile range were excluded as outliers[1]. Twelve participants were excluded as more than half of their trials were removed based on RT. The characteristics of the participants retained after exclusion are presented in Table 1.

Table 1 Characteristics of participants assigned to each Ultimatum Game paradigm.

Variable	Paradigm		
	Two-stakes	Four-Stakes	Comments
Age (*n*)			
6	8	-	11
7	22	-	27
8	22	19	33
9	-	46	26
10	-	17	30
11	-	6	10

[1] This criterion was used in a previous study that analysed a subset of the same data (Woodcock et al., 2020). A rerun of the analysis with the commonly used criterion of RT > Q3 + 1.5*IQR found no changes to significance in the main findings, apart from the interaction effect of fairness and decision on RT in the two between-paradigm comparisons decreasing in level of significance from $p < 0.05$ to $p \geq 0.05$.

12	-	25	-
13	-	23	-
14	-	27	-
15	-	35	-
16	-	38	-
17	-	4	-
Total	52	240	137
Mean	7.3	12.4	8.5
SD	0.7	2.8	1.4
Range	6–8	8–17	6–11
Gender (%)			
Male	48.1	44.2	51.1
Female	51.9	55.8	48.9

Statistical Analyses

The data were analysed at the trial-level using a series of generalised linear mixed-effects models with random individual and trial intercepts, using the lme4 package (Bates et al., 2015) in R 4.0.2 (R Core Team, 2021). General recommendations for mixed-effects models suggest a minimum number of 10-40 trials per participant, so this type of analysis is appropriate for the present data (Bolker et al., 2009; Brysbaert & Stevens, 2018). Each set of analyses involved three separate univariate models, each with a different response variable corresponding to responder behaviour characteristics that were of interest: decision, RT, and negative valence rating. Logistic mixed-effects models were used to analyse decision,

with the significance of coefficients evaluated using Wald z-tests. Linear mixed-effects models were used for RT and negative valence rating, with the significance of coefficients evaluated using t-tests with Satterthwaite's approximation implemented in the lmerTest package (Kuznetsova et al., 2017). RTs in seconds were log-transformed and continuous predictor variables were centred around the means within each paradigm. Stake size was coded as a categorical variable with the stakes arranged in descending order. The effect sizes of main effects and interaction terms are reported in terms of unstandardised *b* coefficient estimates and 95% confidence intervals (CIs). To aid interpretation, significant main effects and interaction terms are further elaborated in terms of estimates of percent change in odds, percent change in RT, and change in arbitrary units for negative valence rating, as derived from the unstandardised *b* coefficients.

Direct comparisons between paradigms were carried out to explore the potential effects of paradigm modifications. These comparisons used subsets of participants of overlapping or similar age to limit the confounding potential of age. To investigate the effect of varying the number of stake sizes, responder behaviour was compared between 7- and 8-year-olds from the Two-stakes paradigm and 8- and 9-year-olds from the Four-stakes paradigm (n = 44 and 65, respectively; total number of trials = 3,604). The effect of the presence of comments was analysed by comparing data from 6- to 8-year-olds from the Two-stakes and Comments paradigms (n = 52 and 71, respectively; total number of trials = 4,008). Each model in both sets of comparisons included main effects of gender, fairness, paradigm, and the interaction between fairness and paradigm. Models with RT or negative valence rating as the response variable additionally included decision of the current trial as a main effect and the two- and three-way interactions between decision, fairness, and paradigm. For the comparisons

between Two-stakes and Four-stakes, age was included as a main effect to account for the different age ranges of the two subsets.

The effects of trait emotion regulation and decision history on responder behaviour were subsequently analysed within each paradigm, as there were methodological differences between the paradigms that precluded aggregation of the data. Trials from children that were analysed in the between-paradigm comparisons were included in this set of analyses. Separate models were estimated for each paradigm, to identify consistent effects that were robust to differences in paradigm and sample characteristics. As unfair offers were of particular interest in relation to emotion regulation and decision history, trials involving fair offers were excluded from these analyses (total number of unfair trials in Two-stakes = 1,051; Four-stakes = 5,454; Comments = 3,100). These models included main effects of age, gender, decision from previous trial, stake size, and the nine subscales of the CEMS. Models with RT or negative valence rating as the response variable additionally included decision of the current trial as a main effect and the two-way interactions between decision of the current trial and: age, decision from previous trial, and stake size. Models for the Comments paradigm additionally included the main effect of nature of the comment (neutral or negative) and the interaction between decision of the current trial and the nature of the comment.

Transparency and Openness

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study. The data and computer code used to generate the results are publicly available at https://osf.io/uygpq/ (Chung et al., 2021). Data were processed and analysed in R 4.0.2 (R Core Team, 2021) with the packages dplyr (Wickham et

al., 2020), lme4 (Bates et al., 2015) and lmerTest (Kuznetsova et al., 2017); and visualised with the packages ggplot2 (Wickham, 2016), ggsignif (Ahlmann-Eltze, 2019), and patchwork (Pedersen, 2020). This study's design and its analysis were not pre-registered.

Results

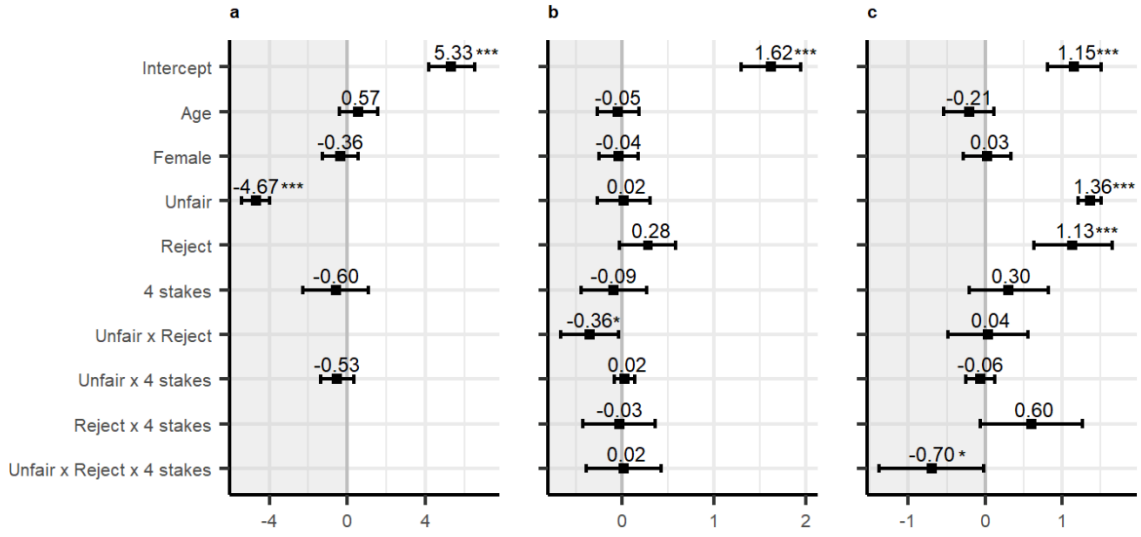
Effect of Modifications on Responder Behaviour

Number of Stake Sizes

The comparison between subsets of data from the Two-stakes and Four-stakes paradigms are presented in Figure 1. The main effect of fairness was significant (z = -12.893, p < 0.001), such that compared to fair trials, unfair trials reduced odds of acceptance by 99.1% and 99.4% in the Two-stakes and Four-stakes paradigms, respectively. There was a significant interaction between fairness and decision on RT (t = -2.219, p = 0.027), such that compared to fair offers, RT increased when accepting unfair offers (Two-stakes: +1.5%; Four-stakes: +3.9%) and decreased when rejecting unfair offers (Two-stakes: -29.0%; Four-stakes: -26.0%). In terms of negative valence rating, there were significant main effects of fairness (t = 17.940, p < 0.001) and decision (t = 4.373, p < 0.001). Furthermore, there was a significant interaction between fairness, decision, and paradigm on negative valence rating (t = -2.004, p = 0.045). Overall, negative valence rating increased in unfair compared to fair trials (Two-stakes accept (change in rating points): +1.36; Two-stakes reject: +1.39; Four-stakes accept: +1.30; Four-stakes reject: +0.63) and in rejected compared to accepted trials (Two-stakes fair (change in rating points): +1.13; Two-stakes unfair: +1.17; Four-stakes fair: +1.73; Four-stakes unfair: +1.07). The significant interaction appeared to have been driven by the larger increase in negative valence rating when rejecting fair offers in the four-stakes paradigm.

There was no other significant main effect or interaction involving the number of stake sizes.

Figure 1 Fixed effect unstandardised coefficients from mixed-effects models with 7- and 8-year-olds from the Two-stakes paradigm and 8- and 9-year-olds from the Four-stakes paradigm. (**a**) Coefficients from the model predicting changes in log odds of an offer being accepted over being rejected by a responder. A positive value indicates an increase in the odds of an offer being accepted, whilst a negative value (in shaded area) indicates a decrease in the odds of an offer being accepted. (**b**) Coefficients from the model predicting changes in log-transformed response time. A positive value indicates an increase in response time, whilst a negative value (in shaded area) indicates a decrease in response time. (**c**) Coefficients from the model predicting changes in negative valence rating. A positive value indicates an increase in negative valence, whilst a negative value (in shaded area) indicates a decrease in negative valence.



Error bars represent 95% CIs of *b* coefficient estimates.

* $p < 0.05$, *** $p < 0.001$.

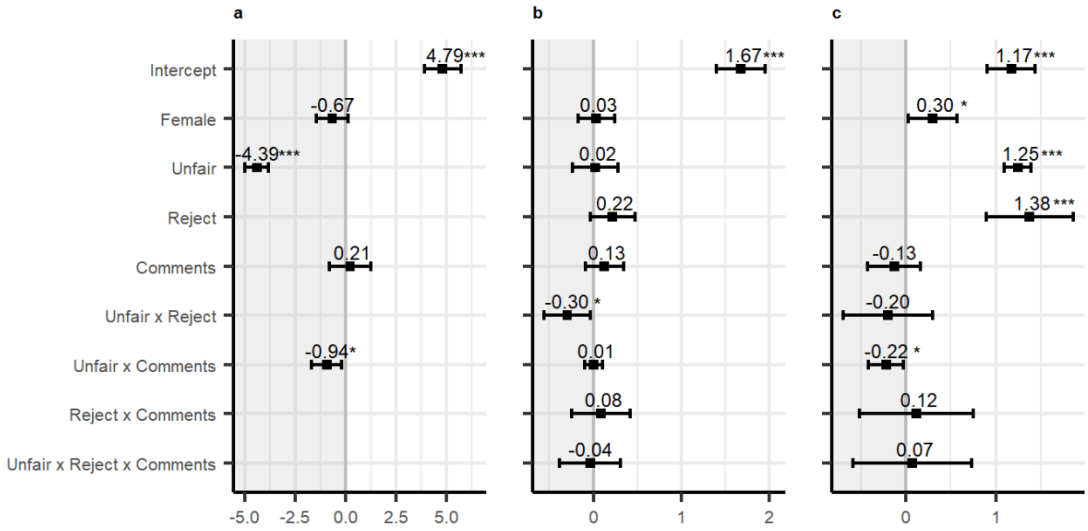
Presence of Comments

The models of the comparison between individuals of the same age from the Two-stakes and Comments paradigms are presented in Figure 2. There was a significant main effect of gender on negative valence rating, such that female participants from this subset comparison reported greater negative valence (+0.30, $t = 2.145$, $p = 0.034$). The effects of the game were generally consistent with the findings from the comparison between the Two-stakes and Four-stakes paradigms. There was a significant main effect of fairness ($z = -14.715$, $p < 0.001$) and a significant interaction between fairness and the presence of comments on decision ($z = -2.481$, $p = 0.013$), such that the odds of acceptance decreased for unfair offers by 98.8% for the Two-stakes paradigm, compared to 99.5% for the Comments paradigm. The interaction between fairness and decision on RT was significant ($t = -2.203$, $p = 0.028$), as unfair offers increased RT to accept (Two-stakes: +2.1%; Comments: +2.8%) and decreased RT to reject (Two-stakes: -24.1%; Comments: -26.3%) compared to fair offers. In terms of effects on negative valence rating, the main effects of fairness ($t = 16.358$, $p < 0.001$) and decision were significant ($t = 5.616$, $p < 0.001$), and there was a significant interaction between fairness and the presence of comments ($t = -2.222$, $p = 0.026$). Consistent with the comparison between the Two-stakes and Four-stakes paradigms, negative valence rating increased when offers were unfair compared to when offers were fair (Two-stakes accept (change in rating points): +1.25; Two-stakes reject: +1.05; Comments accept: +1.03; Comments reject: +0.90) and when offers were rejected compared to being accepted (Two-stakes fair (change in rating points): +1.38; Two-stakes unfair: +1.18;

Comments fair: +1.49; Comments unfair: +1.37). The interaction between fairness and the presence of comments appeared to stem from the larger increase in negative valence rating for unfair offers in the Two-stakes paradigm.

There was no other significant main effect or interaction involving the addition of comments in the game.

Figure 2 Fixed effect unstandardised coefficients from mixed-effects models with 6- to 8-year-olds from the Two-stakes and Comments paradigms. (**a**) Coefficients from the model predicting changes in log odds of an offer being accepted over being rejected by a responder. A positive value indicates an increase in the odds of an offer being accepted, whilst a negative value (in shaded area) indicates a decrease in the odds of an offer being accepted. (**b**) Coefficients from the model predicting changes in log-transformed response time. A positive value indicates an increase in response time, whilst a negative value (in shaded area) indicates a decrease in response time. (**c**) Coefficients from the model predicting changes in negative valence rating. A positive value indicates an increase in negative valence, whilst a negative value (in shaded area) indicates a decrease in negative valence.



Error bars represent 95% CIs of *b* coefficient estimates.

* $p < 0.05$, *** $p < 0.001$.

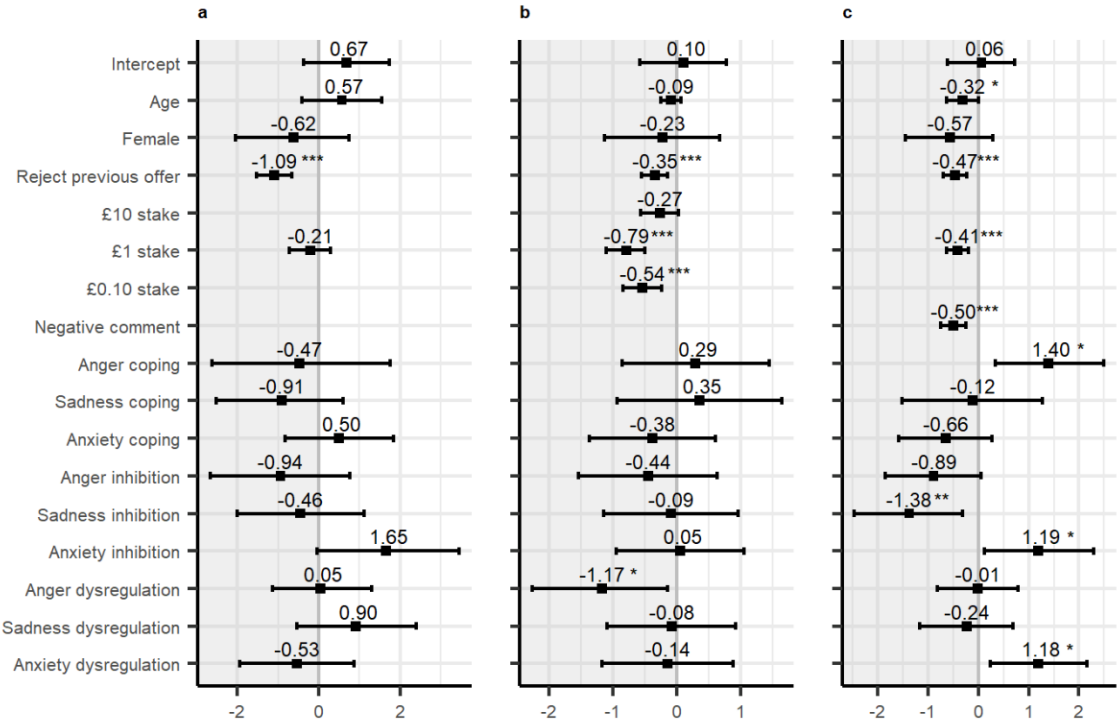
Effect of Emotion Regulation and Decision History on Responder Behaviour in Unfair Trials

Decision

The models of decision for unfair trials in each paradigm are presented in Figure 3. The odds of accepting an unfair offer in 6- to 11-year-olds decreased by 27.3% for every increase in 1 year of age in the Comments paradigm (z = -1.992, p = 0.046). Compared to offers with £100 stake, smaller stakes decreased the odds of accepting unfair offers in the Four-stakes (£1: -54.8%, z = -5.517, $p < 0.001$; £0.10: -41.5%, z = -3.810, $p < 0.001$) and Comments paradigms (£1: -33.9%, z = -3.893, $p < 0.001$). Similarly, compared to neutral comments, the presence of negative comments decreased the odds of accepting unfair offers by 39.5% in the Comments paradigm (z = -4.067, $p < 0.001$).

In terms of trait emotion regulation as measured by the CEMS, there were several significant main effects of different CEMS subscales on decision across the three models, but no effect was consistently significant across the paradigms. By contrast, the main effect of decision from the previous trial was significant across all three paradigms, as rejection of the previous trial consistently predicted reduced odds of accepting the unfair offer of the current trial (Two-stakes: -66.4%, z = -4.934; Four-stakes: -29.3%, z = -3.502; Comments: -37.2%, z = -3.890, all $p < 0.001$).

Figure 3 Fixed effect unstandardised coefficients from logistic mixed-effects models in the (**a**) Two-stakes, (**b**) Four-stakes, and (**c**) Comments paradigms. Coefficients in all three models predict changes in log odds of an offer being accepted over being rejected by a responder. A positive value indicates an increase in the odds of an offer being accepted, whilst a negative value (in shaded area) indicates a decrease in the odds of an offer being accepted.



Error bars represent 95% CIs of *b* coefficient estimates.

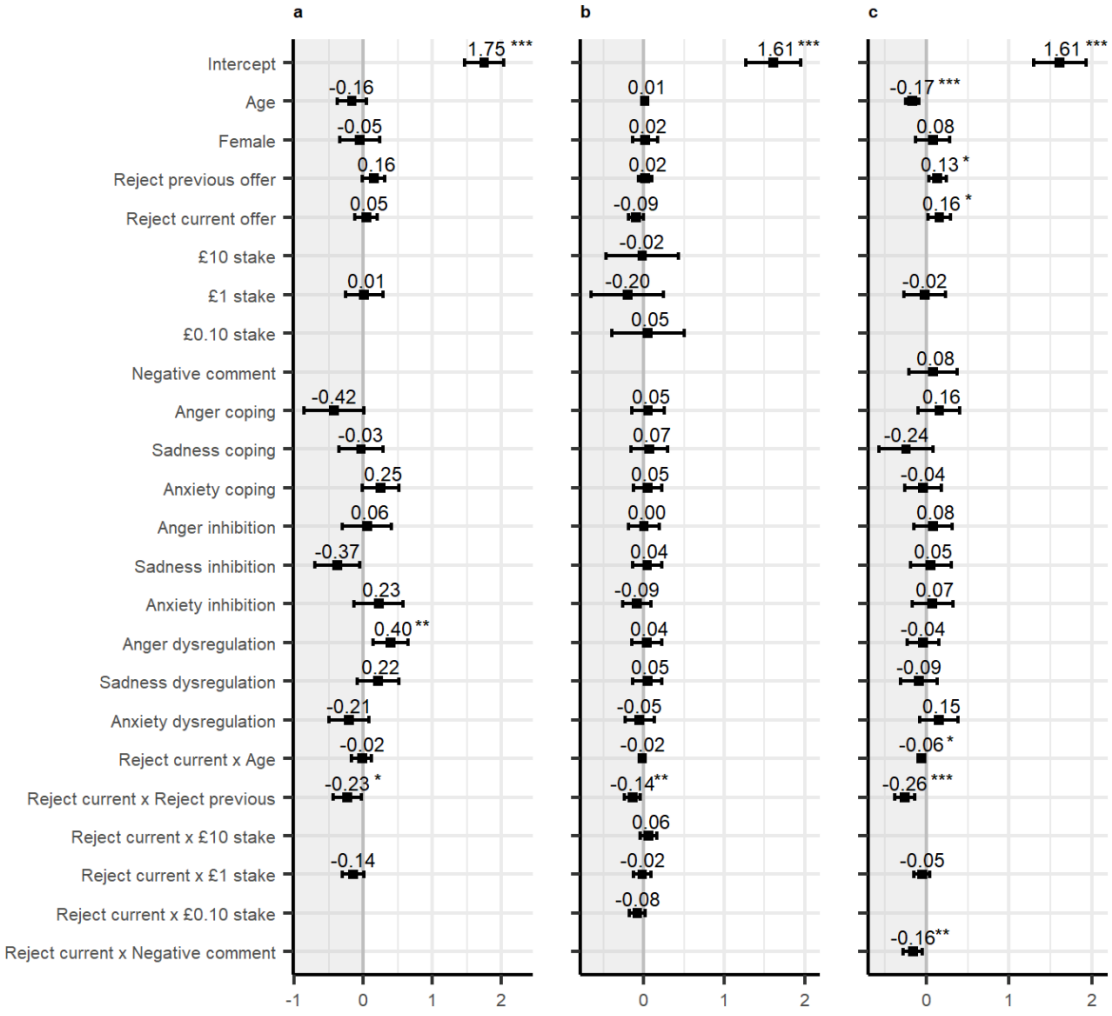
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Response Time

The models of RT for unfair trials in each paradigm are presented in Figure 4. In the Comments paradigm, there was a significant main effect of age (t = -4.010, $p < 0.001$) and an interaction effect between age and decision (t = -2.575, p = 0.010), such that for every increase of 1 year from the mean age, RT decreased by 15.8% and 20.6% in 6- to 11-year-olds when accepting and rejecting offers, respectively. The interaction between decision and the nature of the comment in unfair trials of the Comments paradigm was significant (t = -2.809, p = 0.005), as unfair offers with negative comments increased RT to accept by 8.6% and decreased RT to reject by 7.6% compared to unfair offers with neutral comments.

The effects of trait emotion regulation on RT were similar to the effects reported on decision, as several different CEMS subscales were significant, but there was no consistent effect across the paradigms. In the Comments paradigm, the main effects of decisions from the previous (t = 2.478, p = 0.013) and current trial were significant (t = 2.271, p = 0.023). A consistent interaction between previous and current decisions was observed across all three paradigms (Two-stakes: t = -2.227, p = 0.026; Four-stakes: t = -2.745, p = 0.006; Comments: t = -4.115, p < 0.001). Rejection as opposed to acceptance of the previous offer polarised the RT of the current unfair trial, such that the time taken to accept the current offer was increased (Two-stakes: +16.9%; Four-stakes: +2.2%; Comments: +14.3%) and the time taken to reject the current offer was decreased across all three paradigms (Two-stakes: -7.3%; Four-stakes: -11.0%; Comments: -11.8%).

Figure 4 Fixed effect unstandardised coefficients from linear mixed-effects models in in the (**a**) Two-stakes, (**b**) Four-stakes, and (**c**) Comments paradigms. Coefficients in all three models predict changes in log-transformed response time. A positive value indicates an increase in response time, whilst a negative value (in shaded area) indicates a decrease in response time.



Error bars represent 95% CIs of *b* coefficient estimates.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Negative Valence Rating

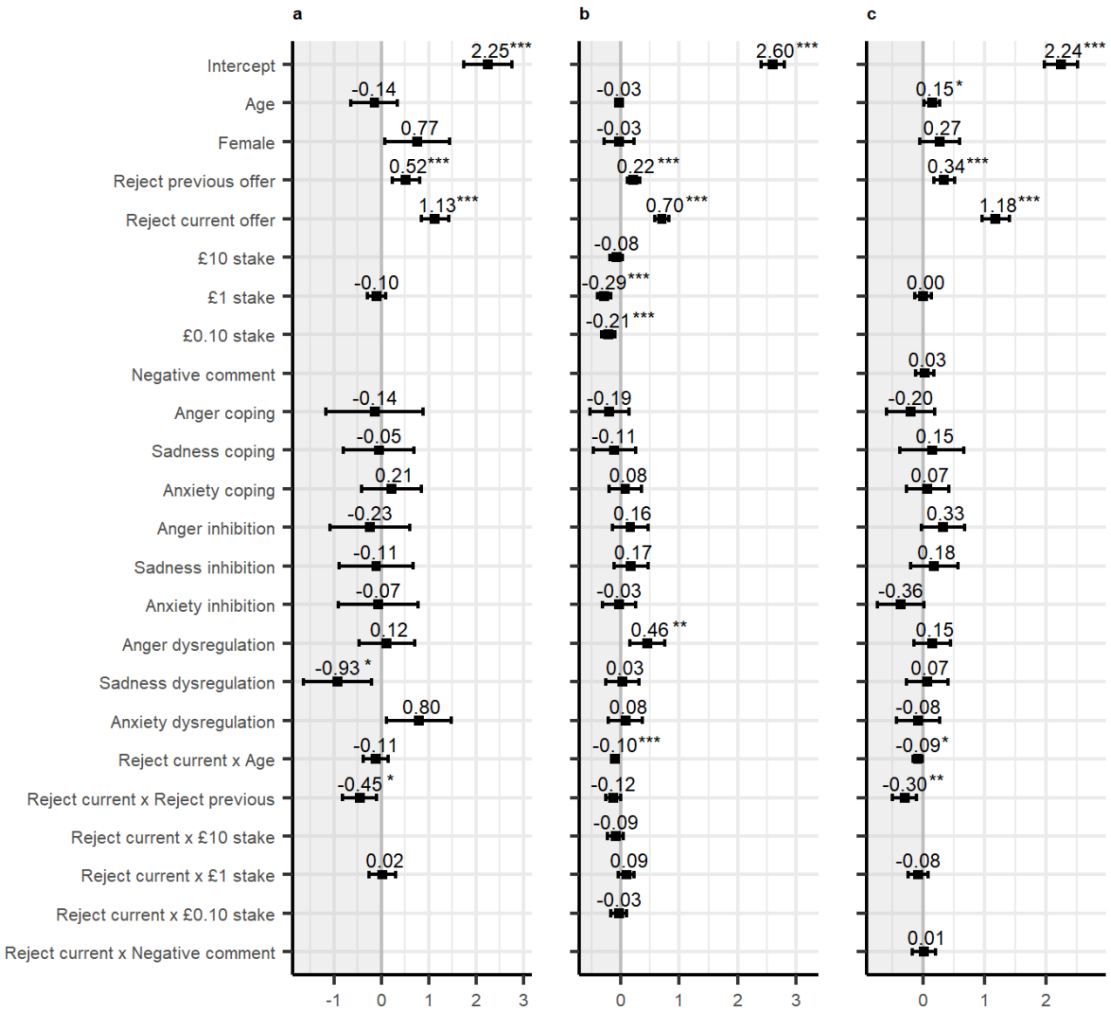
The models of negative valence rating for unfair trials in each paradigm are presented in Figure 5. There was a significant main effect of age in the Comments paradigm ($t = 2.158$, $p = 0.032$). The interaction between age and decision was significant in the Four-stakes ($t = -8.020$, $p < 0.001$) and Comments paradigms ($t = -2.282$, $p = 0.023$), such that for every

increase of 1 year from the mean age, negative valence rating in the Four-stakes paradigm decreased by 0.03 rating points when offers were accepted and negative valence rating decreased by 0.13 when offers were rejected by 8- to 17-year-olds; conversely, negative valence rating of 6- to 11-year-olds from the Comments paradigm increased by 0.15 and 0.06 for every increase of 1 year from the mean age when offers were accepted and rejected, respectively. Unfair offers of smaller stakes in the Four-stakes paradigm elicited lower levels of negative valence compared to offers with £100 stake (£1: t = -4.778, p < 0.001; £0.10: t = -3.646, p < 0.001) when accepting (£1 (change in rating points): -0.29; £0.10: -0.21) and rejecting offers (£1 (change in rating points): -0.19; £0.10: -0.25). There was no significant main effect or interaction involving the nature of comments in the Comments paradigm.

As with the effects of trait emotion regulation on decision and RT, no effect of any CEMS subscale was consistently observed across paradigms. Across all three paradigms, the main effects of decisions from the current (Two-stakes: t = 7.771; Four-stakes: t = 11.202; Comments: t = 10.447, all p < 0.001) and previous trials were significant (Two-stakes: t = 3.573; Four-stakes: t = 3.949; Comments: t = 3.974, all p < 0.001). The interaction between previous and current decisions was significant in the Two-stakes (t = -2.466, p = 0.014) and Comments paradigms (t = -2.931, p = 0.003). Overall, rejection as opposed to acceptance of the current offer increased negative valence rating regardless of whether the previous offer was accepted (Two-stakes (change in rating points): +1.13; Four-stakes: +0.70; Comments: +1.18) or rejected (Two-stakes (change in rating points): +0.68; Four-stakes: +0.58; Comments: +0.88). Furthermore, rejection as opposed to acceptance of the previous offer increased negative valence rating when the current offer was accepted (Two-stakes (change

in rating points): +0.52; Four-stakes: +0.22; Comments: +0.34) or rejected (Two-stakes (change in rating points): +0.07; Four-stakes: +0.09; Comments: +0.04).

Figure 5 Fixed effect unstandardised coefficients from linear mixed-effects models of in **a**) Two-stakes, (**b**) Four-stakes, and (**c**) Comments paradigms. Coefficients in all three models predict changes in negative valence rating. A positive value indicates an increase in negative valence, whilst a negative value (in shaded area) indicates a decrease in negative valence.



Error bars represent 95% CIs of *b* coefficient estimates.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Summary of Main Findings

When children of similar ages were compared between paradigms, consistent effects involving the fairness of trials were found across comparisons. Compared to fair trials, unfair trials were less likely to be accepted; were rejected more quickly and accepted more slowly; and were associated with increased negative valence rating.

Analysis of the unfair trials within each paradigm revealed that previous rejection consistently influenced subsequent decision-making: the odds of acceptance decreased; the RT for acceptance increased whilst the RT for rejection decreased; and negative valence rating increased.

In terms of modifications to the Ultimatum Game, negative responder comments decreased both the odds of offer acceptance and the RT for rejection, whilst the RT for acceptance increased. Unfair offers involving smaller stakes decreased the odds of acceptance in the Four-stakes and Comments paradigms and elicited lower negative valence rating in the Four-stakes paradigm.

Lastly, no effect of trait emotion regulation as measured by the CEMS was found to be consistently significant across paradigms or across metrics of responder behaviour.

Discussion

This article examined the responder behaviour of children and adolescents in the Ultimatum Game at the trial level within the context of the dual-process theory to specifically explore how paradigm modifications, trait emotion regulation, and decision history may influence

social decision-making. By conducting separate models on responder behaviour from each paradigm in parallel, effects that were robust to differences in paradigm and sample characteristics could be identified. Whilst the convergence of results from the models demonstrated support for the replicability of the claims in the present study, attention should nevertheless be drawn to the potential limitation of the sample size at the trial level (Chen et al., 2022).

The general effects of the game were significant across comparisons involving children and adolescents, and consistent with previous studies on adult responder behaviour, as unfair offers: 1) were more likely to be rejected; 2) evoked more negative valence; and were linked to an 3) increased RT when being accepted and decreased RT when being rejected (e.g., Kravitz & Gunto, 1992; Lin et al., 2020). These findings establish support that the responder behaviour of children and adolescents in the Ultimatum Game follows the dual-process account, which may provide the theoretical basis for future work in social decision-making to utilise this paradigm and framework to investigate longitudinal differences and differences in atypically developing populations. This could help to address the gap that has been identified in the context of understanding atypical social decision in a number of neurodiverse populations, where such dynamic assessments have been lacking (e.g., Woodcock et al., 2020).

Despite the expectation of a consistent age effect due to the differing developmental trajectories of the affective and deliberative systems, the effect of age was only found across response variables in the Comments paradigm, and this could not be consistently replicated across paradigms, suggesting that the significant effects related to age may instead be due to differences in paradigm. Furthermore, a previous study using the standard

Ultimatum Game paradigm with responders of a similar age range (*M* = 9.5, *SD* = 2.6) found no correlation between age and acceptance rate of unfair offers (Wang et al., 2019). Therefore, it is possible that the effects of age from the Comments paradigm may reflect developmental differences in theory of mind and reading comprehension, such that older participants were more able to identify the intent behind the proposer comments and respond accordingly (Dore et al., 2018).

In relation to modifications of the paradigm, the addition of comments decreased the likelihood of accepting unfair offers and increased the level of negative valence associated with unfair offers. Specifically, negative comments in unfair trials appeared to drive the decreased odds of acceptance and accentuated the polarising nature of decision on RT. The reduced acceptance rate in the present study is consistent with the findings from a study on adult responder behaviour using similar comments that emphasised the inequity of unfair offers (Kravitz & Gunto, 1992). These results lend support to the hypothesis that negative comments may introduce more conflict between the affective and deliberative systems by provoking a heightened emotional response from responders. However, negative comments did not have the predicted effect on the rating of negative valence in relation to unfair offers, which could be due to insufficient measurement sensitivity with the rating scale or potential ceiling effects elicited by unfair offers.

Although the variation in the stake size was introduced primarily for pragmatic reasons, the analysis revealed that unfair offers of smaller stake sizes decreased the likelihood of acceptance (Four-stakes and Comments paradigms) and the level of negative valence (Four-stakes). The former is consistent with previous work demonstrating that substantial increases in the stake size of unfair offers incentivised responders to accept (Andersen et al.,

2011), whilst the latter contrasted a study reporting no effect of stake size on feelings of contempt or happiness (Tabibnia et al., 2008). However, as these effects were not presently replicated across all three paradigms, caution should be drawn to potential interpretations.

As the pattern of responder behaviour was found to be consistent with the dual-process theory, the present findings provide support for the role of emotion regulation in decision-making for unfair offers in the Ultimatum Game. However, in contrast to the hypothesised relationship between trait emotion regulation and responder behaviour in the game, this study demonstrated no consistent effect of any CEMS subscales on responder behaviour across and within paradigms. This absence of a consistent effect of trait emotion regulation could reflect a limitation of self-report trait measures, which are less able to account for the variability introduced by contexts in daily life (McMahon & Naragon-Gainey, 2020). For example, social processes may affect responder behaviour in the Ultimatum Game, such as the potential motivations for accepting or rejecting an unfair offer (e.g., Yamagishi et al., 2012), which may consequently influence the regulation of momentary emotional states during the game (Aldao et al., 2015; Colombo et al., 2020). Furthermore, the division of the CEMS into their respective subscales according to emotion (anger, sadness, and worry) and type of emotion regulation (inhibition, coping, and dysregulated expression) may be unsuitable for the present study design, as responders in the Ultimatum Game may instead utilise a combination of strategies to regulate general negative affect, as opposed to using individual emotion-specific strategies (Brans et al., 2013; McMahon & Naragon-Gainey, 2020). In the wider context of the construct of self-regulation, which encompasses emotion regulation, evidence appears to suggest that self-report and behavioural measures share low correlation and potentially capture different latent constructs, which may be pertinent to the present study (Eisenberg et al., 2019; Zeynep Enkavi et al., 2019).

With regards to the effect of the previous decision on responder behaviour in the current unfair trial, consistent effects were observed across paradigms for the three response variables of interest. In line with the choice repetition biases observed in other decision-making paradigms (e.g., Senftleben et al., 2019), responders in the Ultimatum Game were more likely to repeat their previous choice when faced with an unfair offer. Furthermore, the temporal dynamics of decisions in unfair trials were influenced in a similar fashion (e.g., Alós-Ferrer et al., 2016), such that responders were quicker to reach a decision if it was congruent with their previous choice, but they were slower when it conflicted with their previous decision. The choice history of responders also affected the valence associated with subsequent unfair offers, as responders indicated greater levels of negative valence if they had rejected the previous offer. These effects on RT and negative valence rating in child responders are consistent with the conceptualisation of choice history as an additional process that can conflict with the affective and deliberative systems in decision-making (Alós-Ferrer et al., 2016).

Although the paradigms in the present study followed the “one-shot” design of the Ultimatum Game, such that a new proposer was introduced for each offer, the influence of decision history was nevertheless robust across the samples. The persistent bias of choice history has been demonstrated in other domains of decision-making. For example, in a perceptual task, where the presentation of the target stimulus was random and independent across trials, the choice and outcome of the previous trial influenced decision-making of participants in the subsequent trial (Abrahamyan et al., 2016). Similar to the effects of choice history in the Prisoner’s Dilemma (Blake et al., 2015; Grujic et al., 2010; Grujić & Lenaerts, 2020), it is possible that decision history may interact with offer history to influence the degree of reciprocity shown by the responder across repeated rounds of the

Ultimatum Game with the same proposer. Therefore, subsequent research should examine whether this choice repetition bias influences repeated play of the Ultimatum Game, in addition to whether this effect is present in adult responders to verify that it is developmentally persistent.

In this article, the responder behaviour of children and adolescents in the Ultimatum Game was demonstrated to follow predictions based on the dual-process theory. Furthermore, the paradigm was conducive to modification, such that the addition of proposer comments influenced some aspects of responder behaviour. Whilst trait emotion regulation appeared to have no clear effect on responder behaviour, a robust choice repetition effect was observed, which is consistent with the view that decision history may interact with the two systems to influence social decision-making.

References

Abrahamyan, A., Silva, L. L., Dakin, S. C., Carandini, M., & Gardner, J. L. (2016). Adaptable history biases in human perceptual decisions. *Proceedings of the National Academy of Sciences of the United States of America*, *113*(25), E3548–E3557. https://doi.org/10.1073/pnas.1518786113

Achtziger, A., Alós-Ferrer, C., & Wagner, A. K. (2016). The impact of self-control depletion on social preferences in the ultimatum game. *Journal of Economic Psychology*, *53*, 1–16. https://doi.org/10.1016/j.joep.2015.12.005

Achtziger, A., Alós-Ferrer, C., & Wagner, A. K. (2018). Social preferences and self-control. *Journal of Behavioral and Experimental Economics*, *74*, 161–166. https://doi.org/10.1016/j.socec.2018.04.009

Ahlmann-Eltze, C. (2019). *ggsignif: Significance Brackets for "ggplot2."* https://cran.r-project.org/package=ggsignif

Akaishi, R., Umeda, K., Nagase, A., & Sakai, K. (2014). Autonomous Mechanism of Internal Choice Estimate Underlies Decision Inertia. *Neuron*, *81*(1), 195–206. https://doi.org/10.1016/j.neuron.2013.10.018

Aldao, A., Sheppes, G., & Gross, J. J. (2015). Emotion Regulation Flexibility. *Cognitive Therapy and Research*, *39*(3), 263–278. https://doi.org/10.1007/s10608-014-9662-4

Alós-Ferrer, C., & Farolfi, F. (2019). Trust Games and Beyond. *Frontiers in Neuroscience*, *13*, 887. https://doi.org/10.3389/fnins.2019.00887

Alós-Ferrer, C., Hügelschäfer, S., & Li, J. (2016). Inertia and Decision Making. *Frontiers in Psychology*, *7*, 169. https://doi.org/10.3389/fpsyg.2016.00169

Alós-Ferrer, C., & Strack, F. (2014). From dual processes to multiple selves: Implications for economic behavior. *Journal of Economic Psychology*, *41*, 1–11. https://doi.org/10.1016/j.joep.2013.12.005

Andersen, S., Ertaç, S., Gneezy, U., Hoffman, M., & List, J. A. (2011). Stakes matter in ultimatum games. *American Economic Review*, *101*(7), 3427–3439. https://doi.org/10.1257/aer.101.7.3427

Bates, D., Mächler, M., Bolker, B. M., & Walker, S. C. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*(1), 1–48. https://doi.org/10.18637/jss.v067.i01

Blake, P. R., Rand, D. G., Tingley, D., & Warneken, F. (2015). The shadow of the future promotes cooperation in a repeated prisoner's dilemma for children. *Scientific Reports*, *5*(1), 14559. https://doi.org/10.1038/srep14559

Bolker, B. M., Brooks, M. E., Clark, C. J., Geange, S. W., Poulsen, J. R., Henry, M., Stevens, H., & White, J.-S. S. (2009). Generalized linear mixed models: a practical guide for ecology and evolution. *Trends in Ecology & Evolution*, *24*(3), 127–135. https://doi.org/10.1016/j.tree.2008.10.008

Bosch, E., Fritsche, M., Ehinger, B. V., & de Lange, F. P. (2020). Opposite effects of choice history and evidence history resolve a paradox of sequential choice bias. *Journal of Vision*, *20*(12), 1–13. https://doi.org/10.1167/jov.20.12.9

Brans, K., Koval, P., Verduyn, P., Lim, Y. L., & Kuppens, P. (2013). The regulation of negative and positive affect in daily life. *Emotion*, *13*(5), 926–939. https://doi.org/10.1037/a0032400

Brysbaert, M., & Stevens, M. (2018). Power Analysis and Effect Size in Mixed Effects Models: A Tutorial. *Journal of Cognition*, *1*(1). https://doi.org/10.5334/joc.10

Chen, G., Pine, D. S., Brotman, M. A., Smith, A. R., Cox, R. W., Taylor, P. A., & Haller, S. P. (2022). Hyperbolic trade-off: The importance of balancing trial and subject sample sizes in neuroimaging. *NeuroImage*, *247*, 118786. https://doi.org/10.1016/j.neuroimage.2021.118786

Chung, J. C. Y., Bhatoa, R. S., Kirkpatrick, R., & Woodcock, K. A. (2021). *Data and code for The Role of Emotion Regulation and Choice Repetition Bias in the Ultimatum Game*. osf.io/uygpq

Colombo, D., Fernández-Álvarez, J., Suso-Ribera, C., Cipresso, P., Valev, H., Leufkens, T., Sas, C., Garcia-Palacios, A., Riva, G., & Botella, C. (2020). The need for change: Understanding emotion regulation antecedents and consequences using ecological momentary assessment. *Emotion*, *20*(1), 30–36. https://doi.org/10.1037/emo0000671

Dore, R. A., Amendum, S. J., Golinkoff, R. M., & Hirsh-Pasek, K. (2018). Theory of Mind: a Hidden Factor in Reading Comprehension? *Educational Psychology Review*, *30*(3), 1067–1089. https://doi.org/10.1007/s10648-018-9443-9

Eisenberg, I. W., Bissett, P. G., Zeynep Enkavi, A., Li, J., MacKinnon, D. P., Marsch, L. A., & Poldrack, R. A. (2019). Uncovering the structure of self-regulation through data-driven ontology discovery. *Nature Communications*, *10*(1), 1–13. https://doi.org/10.1038/s41467-019-10301-1

Gilam, G., Abend, R., Shani, H., Ben-Zion, Z., & Hendler, T. (2019). The Anger-Infused Ultimatum Game: A Reliable and Valid Paradigm to Induce and Assess Anger. *Emotion*,

19(1), 84–96. https://doi.org/10.1037/emo0000435

Grecucci, A., Giorgetta, C., Lorandini, S., Sanfey, A. G., & Bonini, N. (2020). Changing decisions by changing emotions: Behavioral and physiological evidence of two emotion regulation strategies. *Journal of Neuroscience, Psychology, and Economics*, *13*(3), 178–189. https://doi.org/10.1037/npe0000130

Grecucci, A., Giorgetta, C., Van't Wout, M., Bonini, N., & Sanfey, A. G. (2013). Reappraising the ultimatum: An fMRI study of emotion regulation and decision making. *Cerebral Cortex*, *23*(2), 399–410. https://doi.org/10.1093/cercor/bhs028

Grujic, J., Fosco, C., Araujo, L., Cuesta, J. A., & Sanchez, A. (2010). Social experiments in the mesoscale: Humans playing a spatial prisoner's dilemma. *PLoS ONE*, *5*(11), e13749. https://doi.org/10.1371/journal.pone.0013749

Grujić, J., & Lenaerts, T. (2020). Do people imitate when making decisions? Evidence from a spatial Prisoner's Dilemma experiment: Do people imitate when making decisions. *Royal Society Open Science*, *7*(7). https://doi.org/10.1098/rsos.200618

Güth, W., & Kocher, M. G. (2014). More than thirty years of ultimatum bargaining experiments: Motives, variations, and a survey of the recent literature. *Journal of Economic Behavior and Organization*, *108*, 396–409. https://doi.org/10.1016/j.jebo.2014.06.006

Güth, W., Schmittberger, R., & Schwarze, B. (1982). An experimental analysis of ultimatum bargaining. *Journal of Economic Behavior and Organization*, *3*(4), 367–388. https://doi.org/10.1016/0167-2681(82)90011-7

Hallsson, B. G., Siebner, H. R., & Hulme, O. J. (2018). Fairness, fast and slow: A review of dual

process models of fairness. *Neuroscience and Biobehavioral Reviews*, *89*, 49–60. https://doi.org/10.1016/j.neubiorev.2018.02.016

Harlé, K. M., & Sanfey, A. G. (2007). Incidental Sadness Biases Social Economic Decisions in the Ultimatum Game. *Emotion*, *7*(4), 876–881. https://doi.org/10.1037/1528-3542.7.4.876

Hilbe, C., Chatterjee, K., & Nowak, M. A. (2018). Partners and rivals in direct reciprocity. *Nature Human Behaviour*, *2*(7), 469–477. https://doi.org/10.1038/s41562-018-0320-9

Kravitz, D. A., & Gunto, S. (1992). Decisions and perceptions of recipients in ultimatum bargaining games. *Journal of Socio-Economics*, *21*(1), 65–84. https://doi.org/10.1016/1053-5357(92)90026-4

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2017). lmerTest Package: Tests in Linear Mixed Effects Models. *Journal of Statistical Software*, *82*(13), 1–26. https://doi.org/10.18637/jss.v082.i13

Lin, P. H., Brown, A. L., Imai, T., Wang, J. T. yi, Wang, S. W., & Camerer, C. F. (2020). Evidence of general economic principles of bargaining and trade from 2,000 classroom experiments. *Nature Human Behaviour*, *4*(9), 917–927. https://doi.org/10.1038/s41562-020-0916-8

Loewenstein, G. F., & O'Donoghue, T. (2004). Animal Spirits: Affective and Deliberative Processes in Economic Behavior. *SSRN*. https://doi.org/10.2139/ssrn.539843

McMahon, T. P., & Naragon-Gainey, K. (2020). Ecological validity of trait emotion regulation strategy measures. *Psychological Assessment*, *32*(8), 796–802. https://doi.org/10.1037/pas0000827

Murnighan, J. K., & Saxon, M. S. (1998). Ultimatum bargaining by children and adults. *Journal of Economic Psychology*, *19*(4), 415–445. https://doi.org/10.1016/S0167-4870(98)00017-8

Murray, A. L., Hafetz Mirman, J., Carter, L., & Eisner, M. (2021). Individual and developmental differences in delinquency: Can they be explained by adolescent risk-taking models? *Developmental Review*, *62*, 100985. https://doi.org/10.1016/j.dr.2021.100985

Pedersen, T. L. (2020). *patchwork: The Composer of Plots*. https://cran.r-project.org/package=patchwork

Pfeifer, J. H., & Allen, N. B. (2012). Arrested development? Reconsidering dual-systems models of brain function in adolescence and disorders. *Trends in Cognitive Sciences*, *16*(6), 322–329. https://doi.org/10.1016/j.tics.2012.04.011

Pfeifer, J. H., & Allen, N. B. (2016). The audacity of specificity: Moving adolescent developmental neuroscience towards more powerful scientific paradigms and translatable models. *Developmental Cognitive Neuroscience*, *17*, 131–137. https://doi.org/10.1016/j.dcn.2015.12.012

Pillutla, M. M., & Murnighan, J. K. (1996). Unfairness, anger, and spite: Emotional rejections of ultimatum offers. *Organizational Behavior and Human Decision Processes*, *68*(3), 208–224. https://doi.org/10.1006/obhd.1996.0100

R Core Team. (2021). *R: A Language and Environment for Statistical Computing*. https://www.r-project.org/

Sally, D., & Hill, E. (2006). The development of interpersonal strategy: Autism, theory-of-

mind, cooperation and fairness. *Journal of Economic Psychology*, *27*(1), 73–97. https://doi.org/10.1016/j.joep.2005.06.015

Sanfey, A. G., & Chang, L. J. (2008). Multiple systems in decision making. *Annals of the New York Academy of Sciences*, *1128*, 53–62. https://doi.org/10.1196/annals.1399.007

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*(5626), 1755–1758. https://doi.org/10.1126/science.1082976

Senftleben, U., Schoemann, M., Schwenke, D., Richter, S., Dshemuchadse, M., & Scherbaum, S. (2019). Choice perseveration in value-based decision making: The impact of inter-trial interval and mood. *Acta Psychologica*, *198*. https://doi.org/10.1016/j.actpsy.2019.102876

Shields, R. (2015). *Measuring Emotion Regulation in Children and Adolescents and Examining its Changes with Age*. Unpublished dissertation, Queen's University Belfast, Northern Ireland, UK.

Shulman, E. P., Smith, A. R., Silva, K., Icenogle, G., Duell, N., Chein, J., & Steinberg, L. (2016). The dual systems model: Review, reappraisal, and reaffirmation. *Developmental Cognitive Neuroscience*, *17*, 103–117. https://doi.org/10.1016/j.dcn.2015.12.010

Steinbeis, N., Bernhardt, B. C., & Singer, T. (2012). Impulse Control and Underlying Functions of the Left DLPFC Mediate Age-Related and Age-Independent Individual Differences in Strategic Social Behavior. *Neuron*, *73*(5), 1040–1051. https://doi.org/10.1016/j.neuron.2011.12.027

Sutter, M. (2007). Outcomes versus intentions: On the nature of fair behavior and its

development with age. *Journal of Economic Psychology*, *28*(1), 69–78. https://doi.org/10.1016/j.joep.2006.09.001

Tabibnia, G., Satpute, A. B., & Lieberman, M. D. (2008). The sunny side of fairness: Preference for fairness activates reward circuitry (and disregarding unfairness activates self-control circuitry): Research article. *Psychological Science*, *19*(4), 339–347. https://doi.org/10.1111/j.1467-9280.2008.02091.x

van ’t Wout, M., Chang, L. J., & Sanfey, A. G. (2010). The Influence of Emotion Regulation on Social Interactive Decision-Making. *Emotion*, *10*(6), 815–821. https://doi.org/10.1037/a0020069

van ’t Wout, M., & Sanfey, A. G. (2008). Friend or foe: The effect of implicit trustworthiness judgments in social decision-making. *Cognition*, *108*(3), 796–803. https://doi.org/10.1016/j.cognition.2008.07.002

Van Der Veen, F. M., & Sahibdin, P. P. (2011). Dissociation between medial frontal negativity and cardiac responses in the ultimatum game: Effects of offer size and fairness. *Cognitive, Affective and Behavioral Neuroscience*, *11*(4), 516–525. https://doi.org/10.3758/s13415-011-0050-1

Wang, Y., Xiao, Y., Li, Y., Chu, K., Feng, M., Li, C., Qiu, N., Weng, J., & Ke, X. (2019). Exploring the relationship between fairness and ‘brain types’ in children with high-functioning autism spectrum disorder. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *88*, 151–158. https://doi.org/10.1016/j.pnpbp.2018.07.008

Wickham, H. (2016). *ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag New York. https://ggplot2.tidyverse.org

Wickham, H., François, R., Henry, L., & Müller, K. (2020). *dplyr: A Grammar of Data Manipulation*. https://cran.r-project.org/package=dplyr

Woodcock, K. A., Cheung, C., González Marx, D., & Mandy, W. (2020). Social Decision Making in Autistic Adolescents: The Role of Theory of Mind, Executive Functioning and Emotion Regulation. *Journal of Autism and Developmental Disorders*, *50*(7), 2501–2512. https://doi.org/10.1007/s10803-019-03975-5

Yamagishi, T., Horita, Y., Mifune, N., Hashimoto, H., Li, Y., Shinada, M., Miura, A., Inukai, K., Takagishi, H., & Simunovic, D. (2012). Rejection of unfair offers in the ultimatum game is no evidence of strong reciprocity. *Proceedings of the National Academy of Sciences of the United States of America*, *109*(50), 20364–20368. https://doi.org/10.1073/pnas.1212126109

Zeman, J. L., Cassano, M., Suveg, C., & Shipman, K. (2010). Initial validation of the children's worry management scale. *Journal of Child and Family Studies*, *19*(4), 381–392. https://doi.org/10.1007/s10826-009-9308-4

Zeman, J. L., Shipman, K., & Penza-Clyve, S. (2001). Development and initial validation of the children's sadness management scale. *Journal of Nonverbal Behavior*, *25*(3), 187–205. https://doi.org/10.1023/A:1010623226626

Zeman, J. L., Shipman, K., & Suveg, C. (2002). Anger and Sadness Regulation: Predictions to Internalizing and Externalizing Symptoms in Children. *Journal of Clinical Child and Adolescent Psychology*, *31*(3), 393–398. https://doi.org/10.1207/S15374424JCCP3103_11

Zeynep Enkavi, A., Eisenberg, I. W., Bissett, P. G., Mazza, G. L., MacKinnon, D. P., Marsch, L.

A., & Poldrack, R. A. (2019). Large-scale analysis of test–retest reliabilities of self-regulation measures. *Proceedings of the National Academy of Sciences of the United States of America*, *116*(12), 5472–5477. https://doi.org/10.1073/pnas.1818430116

Zheng, Y., Yang, Z., Jin, C., Qi, Y., & Liu, X. (2017). The influence of emotion on fairness-related decision making: A critical review of theories and evidence. *Frontiers in Psychology*, *8*(SEP), 1592. https://doi.org/10.3389/fpsyg.2017.01592