Endogenous testosterone correlates with parochial altruism depending on decision strategy in relation to costly punishment

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Luise Reimers[1,*], Eli Kappo[1], Lucas Stadler[1], Mostafa Yaqubi[1], **Esther K. Diekhof[1,*]**

[1]*Faculty of Mathematics, Informatics and Natural Sciences, Department of Biology, Institute of Zoology, Neuroendocrinology and Human Biology Unit, Universität Hamburg, Hamburg, Germany*

*These authors contributed equally

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Corresponding author:

Prof. jun. Dr. Esther Diekhof

University of Hamburg

Zoological Institute

Neuroendocrinology Unit

Martin-Luther-King Platz 3

D-20146 Hamburg/ Germany

Tel.: +49-40-42838-3931

Email: esther.diekhof@uni-hamburg.de

37 **Abstract**

39 Testosterone plays a key role in shaping human social behavior. Recent findings have linked

40 testosterone to altruistic behavior in economic decision tasks depending on group membership

41 and intergroup competition. The preferential treatment of ingroup members, while aggression

42 and discrimination is directed towards outgroup members, has been referred to as parochial

43 altruism.

44 Here we investigated in two consecutive studies, whether testosterone is associated with

45 parochial altruism depending on individual tendency for costly punishment. In the first study, 61

46 men performed a single-shot ultimatum game (UG) in a minimal group context, in which they

47 interacted with members of an ingroup and outgroup. In the second study, 34 men performed a

48 single-shot UG in a more realistic group context, in which they responded to the proposals of

49 supporters of six political parties during the German election year 2017. Political parties varied

50 in their social distance to the participants' favorite party as indicated by an individual ranking.

51 Participants of study 2 also performed a cued recall task, in which they had to decide whether

52 they had already encountered a face during the previous UG (old-new decision). In order to make

53 the UG data of study 2 most comparable to the data of study 1, the rejection rates of several

54 parties were combined according to the social distance ranking they achieved. Parties ranked 1 to

55 3 formed the relatively close and favored 'ingroup' that shared similar political values with the

56 participant (e.g., left wing parties), while the 'outgroup' consisted of parties ranked from 4 to 6

57 with more distant or even antagonistic political views (e.g., conservative to right wing parties).

58 In both studies, results showed a parochial pattern with higher rejection rates made in response to

59 outgroup compared to ingroup offers. Interestingly, across studies higher salivary testosterone

60 was associated with higher rejection rates related to unfair outgroup offers in comparison to the

61 unfair offers made by ingroup members.

62 The present findings suggest that latent intergroup biases during decision-making may be

63 positively related to endogenous testosterone. Similar to previous evidence that already indicated

64 a role of testosterone in shaping male parochial altruism in male soccer fans, these data

65 underscore the general, yet rather subtle role of male testosterone also in other social settings.

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68 **1. Introduction**

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70 Humans display a large extent of prosocial behaviors such as cooperation and altruism. At the

71 same time, the human history of conflicts and wars is unparalleled. This supposedly inconsistent

72 behavior of ingroup favoritism and outgroup hostility has recently been referred to as *parochial*

73 *altruism* (Choi and Bowles 2007). A behavior is thereby defined as altruistic if it incurs personal

74 costs without direct benefits or only minimal benefits for the actor, but happens to benefit

75 another person or a group of people (in case of parochial altruism this would be the ingroup). For

76 example, in order to protect members of the ingroup against outgroup threat individuals may

77 have to engage in hostile acts with outsiders, and are willingly to do so despite negative

78 consequences like death or mutilation. Empirical evidence for parochial altruism comes from

79 several studies that used economic decision tasks to emulate real-world situations in which

80 limited resources are unequally distributed between competing human groups (Baumgartner et

81 al. 2012; Bernhard, Fischbacher, and Fehr 2006; Diekhof, Wittmer, and Reimers 2014;

82 Fershtman and Gneezy 2001; Goette et al. 2012; Kubota et al. 2013; Reimers and Diekhof 2015).

83 For instance, members of different indigenous language groups in Papua New Guinea have been

84 shown to display a strong ingroup bias by punishing norm violators that treated members of their

85   own group unfairly more often compared to situations, in which the "victim" of the unequal

86   share was an outgroup member (Bernhard, Fischbacher, and Fehr 2006). In addition, this ingroup

87   bias seemed to be accompanied by a stronger tendency towards outgroup hostility in contexts

88   that involved a competition between groups. Accordingly, in such a group competition context,

89   army platoon members punished members of other platoons more harshly than in a neutral

90   decision context, and even if the outgroup members were cooperative (Goette et al. 2012). It thus

91   appears as if humans have a tendency for both ingroup favoritism and outgroup hostility that

92   may be explained with the prevalent intergroup conflicts in human ancestry. Since cooperation

93   within the own group and successfully competing against outgroups was crucial in terms of

94   survival, these conflicts have been proposed to have led to the evolution of both altruism and

95   parochialism (Bowles 2009; Choi and Bowles 2007).

96   Accumulating evidence has previously linked testosterone to economic decision making in social

97   interactions, yet studies mostly revealed inconsistent results. For instance, some studies found

98   that testosterone was associated with increased fairness preference and thus higher rejection rates

99   in response to unfair proposals made in the context of an ultimatum game (UG) (Burnham 2007;

100   Dreher et al. 2016; Eisenegger et al. 2010; Mehta and Beer 2010; Diekhof, Wittmer, and Reimers

101   2014), which has been interpreted as an act of altruistic punishment as it involves the loss of the

102   offered share. Others found the opposite, namely that testosterone administration may be related

103   to increased greediness and selfishness as well as a reduced fairness preference in the UG, which

104   was reflected by either reduced punishment of violations of the fairness norm or reduced

105   generosity when being in the role of the UG proposer (Kopsida et al. 2016; Zak et al. 2009).

106   Finally, some studies found no effect at all (Cueva et al. 2017; Zethraeus et al. 2009). However,

107   the above-mentioned studies differed in their methodological approach: some investigated

108   endogenous testosterone effects (Burnham 2007; Mehta and Beer 2010; Diekhof, Wittmer, and

109   Reimers 2014), while others tested the effect of testosterone administration (Cueva et al. 2017;

110   Eisenegger et al. 2010; Kopsida et al. 2016; Zak et al. 2009; Zethraeus et al. 2009). Moreover,

111   samples consisted either of men (Burnham 2007; Cueva et al. 2017; Dreher et al. 2016; Zak et al.

112   2009; Diekhof, Wittmer, and Reimers 2014), or women (Eisenegger et al. 2010; Zethraeus et al.

113   2009) or were mixed (Kopsida et al. 2016; Mehta and Beer 2010). This made it difficult to

114   discern the actual effect of testosterone on economic decisions in the UG, and well-designed

115   replication studies are currently lacking.

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117   As to the mechanism underlying parochial altruism, testosterone has recently been proposed to

118   be an important mediator of decision-making in the UG and related economic decision tasks that

119   involved an intergroup factor (Diekhof, Wittmer, and Reimers 2014; Reimers, Büchel, and

120   Diekhof 2017; Reimers and Diekhof 2015). One recent study investigated the behavioral effects

121   of endogenous testosterone by accounting for group membership and intergroup competition.

122   Male soccer fans played the UG against other soccer fans of either their own favorite team

123   (ingroup) or of other teams of varying enmity and social distance (outgroups) (Diekhof, Wittmer,

124   and Reimers 2014). In the UG two players bargain about how to split an initial endowment

125   (Güth, Schmittberger, and Schwarze 1982). Soccer fans with high testosterone levels offered

126   more points to the ingroup and also rejected rather fair offers (40% of initial endowment), when

127   these were made by an outgroup in a competitive relative to a neutral decision context, in which

128   an additional group reward could be acquired (Diekhof, Wittmer, and Reimers 2014). A similar

129   pattern of increased ingroup cooperation in the face of intensified intergroup competition was

130   found in a prisoner's dilemma, another economic decision task measuring cooperation rates

131   (Reimers and Diekhof 2015). Moreover, a recent neuroimaging study has provided first evidence

132   for testosterone's action in the brain in a sample of male soccer fans playing the UG (Reimers,

133   Büchel, and Diekhof 2017). The results indicate dissociable testosterone-brain correlations

134   depending on individual tendency for costly punishment. In individuals with a more selfish (i.e.,

135   economically rational) strategy and lower rejection rates in response to unfair offers of ingroup

136   members, testosterone was positively correlated with activity in the anterior insula. In the context

137   of the UG, the anterior insula has been implicated in processing of negative emotions and norm

138   violations (Civai et al. 2012; Sanfey et al. 2003), as well as with positive emotional affect in

139   other contexts (e.g., Hennenlotter et al. 2005). Therefore, the positive association between

140   testosterone and insular activation despite lower rejection rates could be interpreted as the

141   voluntary decision against sanctioning an unfair ingroup member, thus supposedly reflecting

142   increased ingroup favoritism in a social dilemma situation (Reimers, Büchel, and Diekhof 2017).

143   In inequity averse individuals (i.e., subjects with strong fairness preference and generally

144   enhanced rejection rates) high testosterone was predictive of increased activity in ventromedial

145   prefrontal regions, which have previously been associated with monitoring of subjective reward

146   value (Amodio and Frith 2006; Plassmann et al. 2008). Despite similar rejection rates for ingroup

147   and outgroup offers, this was observed in response to unfair outgroup proposers only, thus

148   supposedly reflecting the increased reward value of sanctioning a norm-violating outgroup

149   member. Interestingly, the selfish players also showed a stronger tendency towards parochial

150   altruism (higher rejection rates in response to unfair outgroup than ingroup offers) even in

151   absence of an intergroup competition. Based on these observations we assume that the

152   inconsistent findings of the previous studies of other researcher, as described above, may be

153   explained by the fact, that testosterone is not associated with unfairness perception per se, but

154   promotes the fine-tuning of economic decisions in an intergroup situation. In that way

155   testosterone may be rather linked to ingroup favoritism and/or outgroup hostility, the two

156   characteristics of parochialism altruism, as indicated by the converging evidence from our own

157   studies. The above-mentioned studies tested male soccer fans, who maintain long-term rivalries

158   to other teams and show a strong, genuine feeling of group affiliation that might even compare to

159   a 'tribal identity' (Vugt and Park 2010). As such, soccer fans represent a natural social group

160   with a strong emotional involvement that is suitable to study parochial altruism (Weisel and

161   Böhm 2015). Here, we investigated whether testosterone similarly affects parochial altruism in

162   artificially created groups (study 1) and in a more natural context of political party supporters

163   during the election year 2017 (study 2). This was based on two reasons: first, we wanted to

164   examine whether the link between testosterone and parochialism is stable enough to be observed

165   in two independent groups and in different social settings, i.e., whether the association found

166   between testosterone in the minimal group study 1 could also be observed in the more realistic

167   social setting of study 2. And second, the group commitment of soccer fans as well as the enmity

168   to other soccer teams can vary with the current position of the admired team in the league and the

169   ongoing team competition can create a stressor, which is often observed in unstable social

170   hierarchies, and could have potentially altered or obscured subtle parochial tendencies in our

171   previous studies. By assessing the present participants in two rather stable group settings, i.e.,

172   either in the minimal group setting with a fixed group association (study 1) or during the German

173   election year (study 2), we tried to control for these interfering variables.

174   In the first study, we conducted the UG experiment with men that were divided into two arbitrary

175   groups according to their behavioral performance in a reaction time task that was completed

176   directly before the UG. In the second study, we questioned male participants about their political

177   orientation using a ranking procedure through which we individually identified the favorite

178   political party as well as the one most distant to the participant. Moreover, since memory for

179   uncooperative group members was found to be enhanced in previous studies (Bell et al. 2012;

180   Bell and Buchner 2009, 2012; Hechler, Neyer, and Kessler 2016; Howard and Rothbart 1980),

181   we assessed cued recall performance in a surprise face memory task (old-new decision) that used

182   same number of new faces that were used to represent players in the UG. With this we wanted to

183   assess whether there was indeed a memory advantage for ingroup members who showed

184   schema-incongruent behavior in the UG, i.e., a norm violation through an unfair proposal, as

185   suggested previously (e.g., Hechler, Neyer, and Kessler 2016). Moreover, we wanted to explore

186   whether enhanced memory for ingroup norm violators might by associated with testosterone,

187   since our previous neuroimaging study showed that there may be a link between testosterone and

188   insular brain activation in this context (Reimers, Büchel & Diekhof, 2017). Based on the results

189   of our previous studies with soccer fans, we hypothesized that subjects with a high endogenous

190   testosterone level would display enhanced parochial altruism in both studies.

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195   **2. Material and Methods**

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197   **2.1 Study 1**

198   **2.1.1 Participants of study 1**

199   61 healthy male students (mean age ± SD: 24.95 ± 4.28 years) participated in this study. The

200   participants were recruited via online advertisement on a campus website and by word of mouth.

201   Only subjects that reported no drug or alcohol abuse, no chronic or psychiatric illness and did not

202   take any form of medication, especially hormones, were included in this study. They were paid a

203   show-up fee of 10 € for participation and were told that they could win even more money (up to

204   5 €) depending on their performance. This study was approved by the local ethics committee

205   (*Aerztekammer Hamburg; Ethical Application Ref: PV3948*). All subjects gave written informed

206   consent prior to participation.

207

208   **2.1.2 Procedure – Minimal group study (study 1)**

209   Data collection took place from 2014 to 2015. Before the test day subjects were given

210   instructions and were handed out five 2 ml polypropylene Eppendorf tubes for the saliva

211   samples, which they had to collect themselves at home the morning of the test day. They had to

212   start with the first sample directly after waking up and then had to collect another four samples

213   with 30 minutes in between. During the sampling period of 2 hours subjects were told to refrain

214   from eating, smoking and drinking anything but water. Directly after the first sample tooth

215   brushing was allowed, however it had to be finished at least 15 minutes before the second

216   sample, to prevent contamination by micro-bleeding.

217   Upon arrival at the test facility, the test procedure started with the group assignment, which was

218   a pencil and paper maze task. This task was intended to create an artificial group formation that

219   was unrelated to the experiment itself. Such a minimal group paradigm (MGP) has previously

220   been shown to evoke ingroup favoritism and intergroup bias (Tajfel et al. 1971). Subjects went

221   through the maze. After seven seconds time was stopped. Participants were instructed that,

222   according to the distance they covered in the maze, they were assigned to one of the two groups.

223   The two groups were named after two famous cartoon characters, which were used as the group

224   icons in the following experiments. To make this group assignment even more authentic to the

225 subjects, maze templates that showed the cut-off distance dividing the two groups were shown to

226 the subjects. In reality, the group assignment was pre-determined by the experimenters to ensure

227 an equal distribution among the two groups. For subjects who were supposed to be in the 'fast

228 group' another template was used than for subjects who were assigned to the 'slow group'. After

229 the group assignment, subjects were given written instructions that explained the rules of the UG

230 (see Diekhof, Wittmer, and Reimers 2014; Reimers, Büchel, and Diekhof 2017 for comparison).

231 The UG was designed as a computer-based experiment that was run using the Presentation

232 software by NBS (Neurobehavioral Systems). A short training version was completed and all

233 further questions were answered. Subsequently, the UG was played in the role of the responder

234 (see below), followed by two questions asking about hypothetical offers in the role of the

235 proposer. After that subjects completed the Barratt-Impulsiveness-Scale (BIS; Patton et al.,

236 1995) and answered several questions from the German socio-economic panel that measure trust,

237 positive and negative reciprocity (Dohmen et al. 2008). Saliva samples were frozen at -20°C

238 until further analysis.

239

240 **2.1.3 Ultimatum Game in a minimal group context (study 1)**

241 One famous and often applied economic decision task is the UG (Güth, Schmittberger, and

242 Schwarze 1982). In the UG two players, the proposer and the responder, interact in an economic

243 exchange. The proposer has to make an offer about how to split a fixed sum of money (or

244 experimental points) to the responder. If the responder accepts the offer, both players get paid

245 according to the proposed share. But in case he rejects the offer, both players get nothing.

246 Despite the costs, humans tend to offer almost equal shares and tend to reject unfair offers lower

247 than 20% (Güth, Schmittberger, and Schwarze 1982; Henrich et al. 2005).

248   Here we applied a computer-based intergroup version of the UG (intergroup-UG) that was

249   similar to previously applied intergroup-UGs (Diekhof, Wittmer, and Reimers 2014; Reimers,

250   Büchel, and Diekhof 2017). The participants of the present study thereby acted in the role of the

251   responder and could accept or reject any offers made to them. Yet in contrast to these previous

252   studies, we will focus the analysis on the first session of the intergroup-UG here. In the first

253   session of the intergroup-UG, subjects play for their personal reward and do not receive any

254   further instructions regarding a competition between groups for an extra group bonus, which

255   would be the case in the second session of the intergroup-UG. In our previous studies (see for

256   example in Diekhof, Wittmer, and Reimers 2014), the first session was termed the "neutral

257   context", since there the group affiliation is not explicitly addressed as being important for the

258   accomplishment of the task goal, i.e., one's individual reward. In contrast, the second session

259   was referred to as the "competitive context", since there we also introduced the second task goal,

260   which was to achieve an additional bonus in form of a group reward for behavior that maximizes

261   the outcome of the group. In that way, the "neutral context" of the first session of the intergroup-

262   UG should reveal the latent parochial tendency of the person which is not enforced by an explicit

263   instruction that refers to the group identity of the proposers (see also Reimers, Büchel, and

264   Diekhof 2017). Moreover, the interpretation of the results from the competitive, second session

265   of the intergroup-UG is problematic. This is because the "neutral context" of session 1 always

266   precedes the "competitive context" of session 2. Consequently, transfer effects cannot be ruled

267   out from the naïve context of session 1 to the competition in session 2. For example, some

268   subjects might, after short reflection, regret that they rejected any offer during session 1 and

269   could switch to a more selfish-strategy, especially if they consider the group reward rather

270   unlikely to achieve. This could be particularly the case in a study in which ingroup cohesion

271   might be expected to be rather lax (as in study 1) or in which more than two groups are

272   competing for the same group reward (like in study 2 below). In particular, when comparing the

273   results from different studies for consistency this could increase the risk of a study-specific bias

274   in the "competitive context" of session 2 that might obscure or contaminate the already subtle

275   effect of testosterone on behavior.

276   In study 1, the first session consisted of 40 single-shot interactions, during which subjects faced

277   either an ingroup or an outgroup proposer (i.e., 20 trials each). The proposers were always

278   endowed with 10 points and half of their offers were either fair (i.e., 4 or 5 out of 10 points) or

279   unfair (i.e., 1, 2, or 3 out of 10 points). Offer types and group membership of the proposers were

280   pseudorandomized and counterbalanced for condition transitions. Fair offers contained either 4

281   points (2 trials/group) or 5 points (8 trials/group) out of 10 points, while unfair offers were

282   determined as 1 point (4 trials/group), 2 points (4 trials/group) or 3 points (2 trials/group). This

283   means that 80% of unfair proposals offered 20% or less of the initial endowment in the present

284   study. Since 20% is assumed to be the threshold at which subjects start to reject more and more

285   unfair offers (Güth, Schmittberger, and Schwarze 1982; Henrich et al. 2005), a rejection rate

286   equal to or exceeding 80% of all unfair offers, i.e., comprising those from both the in- and

287   outgroup in our version of the intergroup-UG, was assumed to reflect a high degree of inequity

288   aversion.

289   In the intergroup-UG the proposers were introduced with a photo and their first name including

290   initials of the surname to increase authenticity. The photographs showed a frontal view of the

291   face with a neutral expression. The pictures were taken from other male students of Hamburg

292   University about five years before the present study. To control for familiarity, we asked all

293   participants after the experiment whether they knew anyone, but this was not the case. The group

294   membership was indicated by small group icons (i.e., the cartoon characters). To further

295   emphasize the social nature of the task, subjects were told that the proposers were former

296   participants and that participants of the present study would now decide about their payoff.

297   However, all proposers and their offers were pre-determined by the experimenter.

298   Before starting the intergroup-UG, participants were instructed to decide about each offer

299   according to their individual preference. As they were told in the instructions, each decision

300   determined their additional payment and the accumulated points would be translated into Euros.

301   A total of 2.50 Euros was the maximum reward that could be accumulated in the first session.

302   Subjects also performed the intergroup-UG in a "competitive context" (session 2) for the same

303   reward and the additional chance to win a group bonus (see Diekhof et al., 2014 for comparison).

304   The data from the second session were however not analyzed here, for reasons outlined above.

305   After having completed the intergroup-UG (total duration of 30 minutes), subjects were asked to

306   switch to the role of the proposer and to make two offers to an anonymous ingroup and outgroup

307   member.

308

309   **2.1.4 Analysis of hormonal parameters from human saliva (study 1)**

310   After having collected and frozen all samples, the saliva samples were thawed at 26°C and then

311   vortexed and centrifuged at RCF 604 ×g in a common Eppendorf Minispin centrifuge for 5

312   minutes to discard mucus and other residuals. The five morning samples were pooled into one

313   aliquot by extracting an equal volume of each sample and mixing them together. This was done

314   to control for the pulsatile secretion pattern of testosterone and ensured that the morning peak

315   concentration was captured by the pooled aliquot sample. Samples that looked contaminated

316   (e.g., had no transparent color or contained traces of blood) were discarded. Testosterone

317   concentrations in the aliquot samples were analyzed using two enzyme-linked immunosorbent

318   assay (ELISA) kits by Demeditec Diagnostics (sensitivity = 2.2 pg/ml). The denoted intra-assay

319   coefficient of variation is indicated as 6.58% at 90.8 pg/ml and the interassay variation is given

320   as 7.4% at 74.3 pg/ml. All aliquots were assayed twice and two control samples, one with a low

321   and another one with a high concentration, were included.

322

323   **2.1.5 Statistical analyses of study 1**

324   Mean rejection rates in all experimental conditions, i.e., group membership of proposer (ingroup,

325   outgroup), and type of offer (fair, unfair), were calculated for each subject. The testosterone

326   concentration was standardized (z-transformed). The rejection rates were then submitted to a

327   repeated-measures ANOVA, to test whether they were affected by group membership, offer type

328   and standardized testosterone level.

329   In case of a significant Mauchly-test for sphericity in the ANOVA, results were reported using

330   the Greenhouse-Geisser-corrected values. Post-hoc assessment of the interactions with

331   standardized testosterone were further subjected to simple slope analyses based on the estimated

332   marginal means. We thereby compared the interaction effect in men with high testosterone

333   (standardized testosterone at +1SD) and those with low testosterone (standardized testosterone at

334   -1SD) using t-tests. P-values smaller than 0.05, two-tailed, were considered as significant.

335

336   **2.2 Study 2**

337   **2.2.1 Participants of study 2**

338   34 healthy male students (mean age ± SD: 25.06 ± 4.46 years) participated in the second study.

339   The subjects were recruited via online advertisement on a campus website and by word of

340   mouth. Participants reported no drug or alcohol abuse, and were free of any chronic illness

341   including disorders of the hormone system as well as psychiatric or neurological disorders. They

342   were also free of medication. A participation fee and an additional monetary reward related to

343   the points acquired during the intergroup-UG were paid (see Study 1). All subjects gave written

344   informed consent and the study was approved by the local ethics committee (*Aerztekammer*

345   *Hamburg*).

346

347   **2.2.2 Procedure of political supporter study (study 2)**

348   Key to participation in study 2 was an interest in politics, which was assessed by the German

349   Scale for Political Interest (the PIKS questionnaire; (Otto and Bacherle 2011)). The PIKS

350   questionnaire was sent by e-mail to the potential participant. The five questions on political

351   interest and involvement were to be answered on a 5-point-Likert-scale, possible options ranging

352   from 5, "applies fully", to 1, "doesn't apply at all", resulting in a mean PIKS-score ($\pm$ SD) of

353   4.14 ($\pm$ 0.59) for all participants. To determine group affiliation, the participants were

354   additionally asked to rank the 6 political parties, which had a chance to win seats in the German

355   parliament (*Bundestag*) according to their preference in the upcoming vote. The rating was

356   thereby to be based on the shared values a participant held with the parties. The political parties

357   comprised the four mainstream parties, i.e., the *SPD (Social Democrats)*, the *CDU (Christian*

358   *Democrats)*, the *Greens*, and the *FDP (Free Liberals)*, as well as two parties from the extreme

359   left and right wing, i.e., *The Left* and the *AfD (Alternative for Germany)*, which all succeeded to

360   acquire seats in the German Bundestag in 2017. The rating procedure was carried out with

361   attention to privacy of the participant in order to avoid social pressure and to rule out bias from

362   the experimenter's side. Based on the political ranking, the participants were ascribed an

363   affiliated ingroup (ranked as 1), while all other parties were considered as outgroups with

364   varying degree of social distance depending on their rank. The party with a ranking of 6 was

365   considered as the most distant outgroup. For subsequent trend analysis, these individual ranks

366   were used. In order to compare the results of study 2 to those of study 1, we averaged the data

367   (UG rejection rates) from ranks 1 to 3 as well as the data from ranks 4 and 6. By this we created

368   one relatively close 'ingroup' (ranks 1 to 3) that shared similar political values from one end of

369   the political spectrum (e.g., the left, more liberal wing) with the respondent, while the 'outgroup'

370   (ranks 4 to 6) consisted of more distant parties from the other end of the political spectrum (e.g.,

371   the more conservative parties oriented towards the right wing or vice versa). Otherwise the

372   procedure of study 2 closely matched the one employed in study 1, including the same

373   questionnaires and saliva sampling procedure. Data collection took place in 2017. The complete

374   experiment lasted about 1 hour and 15 minutes in total, which included the two sessions of the

375   UG (see above) followed by a short distraction period and a face memory task.

376

377   **2.2.3 Ultimatum game in a political context (study 2)**

378   The structure of the intergroup-UG strongly resembled the one of the minimal group study

379   (approximate total duration of 30 minutes), starting with participants in the role of the responder

380   and finally switching to the role of the proposer. Yet, in contrast to study 1, proposals came from

381   6 different groups that comprised the supporters from the 6 political parties. Again, each

382   proposer was indicated by a unique photograph. The photographs were taken from the

383   anonymous experimental picture stock of the department as well as from other universities. The

384   pictures to be used in the game had previously been tested for approachability, making sure that

385   none of the faces evoked a biased response in the participants. The approachability test was

386   performed in an independent sample of 30 students, male and female, who rated each of the faces

387   on a seven-point Likert-scale answering the question: "Would you ask this stranger for

388   directions?" Based on the rating, three faces remained unused in the experiment due to an

389   extraordinary mean approachability rating, the others were equally distributed into the categories

390   of (un)fairness and political inclination by approachability.

391   The first, unbiased session of the intergroup-UG comprised 48 single-shot computer game

392   interactions with an apparently real, but actually fictional opponent indicated by the unique

393   photograph. In an introductory text, participants were falsely informed about a nation-wide study

394   in which other students had already participated, whose pictures, proposals and party affiliation

395   participants were about to see in the game. From each political party four offers were considered

396   as (rather) fair (with two proposers offering either 4 or 5 points of 10), while the remaining four

397   offers were unfair and included one offer of 1 point and 2 points, each, as well as 2 offers of 3

398   points. This resulted in a different threshold for determination of the individual decision strategy

399   in study 2. Here, only 50% of the unfair proposals offered 20% or less of the initial endowment.

400   This is why a mean rejection rate equal to or exceeding 50% across all unfair offers of the 6

401   ranks was assumed to reflect a high degree of inequity aversion.

402

403   **2.2.4 Cued recall task (memory for faces) of study 2**

404   In the second study we also wanted to test (1.) whether the different strategy groups differed in

405   their overall ability to recollect the identity of faces from previous interactions, in particular

406   unfair ingroup members, (2.) whether they showed a differential recollection for persons who

407   treated them unfair or fair on previous trials, and (3.) whether recollection ability varied in

408   relation to testosterone level. Similar procedures have already been employed in studies using

409 related paradigms like the dictator game and demonstrated a memory advantage during

410 recollection of the identity of unfair interaction partners, particularly for those from the ingroup

411 (Hechler, Neyer, and Kessler 2016). The face memory task followed a short distraction period, in

412 which participants filled out several questionnaires including the Trust and Reciprocity

413 questionnaire (Dohmen et al. 2008) and a demographic questionnaire. In addition, they were

414 asked to see themselves as proposer in an UG and make their own proposals to future opponents.

415 These proposals were to be made to 6 hypothetical future respondents, portrayed as grey

416 anonymous silhouettes, each of whom was stated to be favoring one of the aforementioned 6

417 political parties. Offers were allowed to range between 1 and 5 points. Another assignment

418 consisted of the same proposal task with a variation: instead of the UG, the participants were

419 playing a dictator game, in which none of the anonymous partners would be able to reject their

420 offer.

421 The subsequent cued recall task was presented to the participants by surprise. The 48 faces used

422 in the two sessions of the UG were pseudorandomized and mixed with 48 new faces which had

423 been selected from the same database and tested for approachability as stated above. Appearing

424 one after another like in the UG, none of the faces were juxtaposed with any information.

425 Instead, participants were asked to indicate with a button press whether the face was known or

426 unbeknownst to them (old vs. new decision). Each trial ended with the subject's decision. The

427 aim of this face memory task was to assess individual memory for unfair opponents in

428 relationship with the ingroup-outgroup dynamic (Hechler, Neyer, and Kessler 2016).

429

430 **2.2.5 Hormone analysis (study 2)**

431 The analysis of saliva samples followed the procedure described above (see study 1 above).

432

433   **2.2.6 Statistical analyses (study 2)**

434   Data analysis of the UG data in study 2 paralleled the analysis in study 1. We performed a

435   repeated measures ANOVA to assess the influence of group affiliation, offer type and

436   standardized testosterone on rejection rates. Post-hoc testing also followed the procedure in study

437   1. In order to also assess the 6 ranks in more detail, we further performed a linear trend analysis

438   to determine the influence of social distance (political party ranking from 1 to 6) on rejection

439   rates, as outlined in detail in the results section. In contrast to study 1, study 2 also incorporated

440   a cued recall task, in which we wanted to examine differences in the ability to recollect

441   previously encountered face identities as a function of their unfairness and social distance as well

442   as in relation to testosterone and the two strategy groups. For this purpose we analyzed the hit

443   rates for recalling the unfair proposers from the 'ingroup' (ranks 1 to 3) and the outgroup (ranks

444   4 to 6).

445
446   **3. Results**

447

448   **3.1 Results of Study 1**

449   Replicating previous results (Diekhof, Wittmer, and Reimers 2014; Reimers, Büchel, and

450   Diekhof 2017; Reimers and Diekhof 2015) a clear tendency towards parochialism was found. A

451   2 ("group": ingroup, outgroup) x 2 ("offer": unfair, fair) repeated-measures ANOVA with the

452   covariate "standardized testosterone" revealed a significant two-way interaction between

453   "group" and "offer" ($F_{1, 59} = 5.44$; $p = 0.023$; partial eta$^2 = 0.08$). In addition, we also found a

454   main effect of "group" ($F_{1, 59} = 10.56$; $p = 0.002$; partial eta$^2 = 0.15$) as well as of "offer" ($F_{1, 59} =$

455   194.07; $p < 0.001$; partial eta$^2 = 0.77$) (see also Table 1). Apart from that, there was a significant

456   three-way interaction between "offer", "group" and "standardized testosterone" ($F_{1,59} = 7.82$; p =

457   0.007; partial eta^2 = 0.12). Post-hoc simple slope analysis of the estimated marginal means

458   indicated that unfair offers were more likely to be rejected if they came from an outgroup

459   proposer than from an ingroup member, however only if the respondents were men with

460   relatively high testosterone levels ($t_{(59)} = 3.64$, p = 0.001). For men with low testosterone the

461   same comparison was not significant ($t_{(59)} = 0.93$, p = 0.358) (Bonferroni-corrected threshold: p =

462   0.025). In case of rather fair offers, which also include the 40% offers, both participants with low

463   and high testosterone level tended to be more likely to reject offers from outgroup than from

464   ingroup members, yet these differences were only numerical as they missed the threshold for

465   significance in a two-tailed t-test (high testosterone: $t_{(59)} = 1.81$, p = 0.076; low testosterone: $t_{(59)} =$

466   1.96, p = 0.055) (Bonferroni-corrected threshold: p = 0.025). The results from the simple slope

467   analysis of the estimated marginal means were confirmed by an analysis based on the complete

468   data that compared the subjects with a testosterone concentration above the standardized mean

469   (0) as the high T group (n = 29) with those with a testosterone level below 0, i.e., the low T

470   group (n = 32). Accordingly, only the high T group showed increased rejections of the unfair

471   outgroup offers compared to unfair ingroup offers ($t_{(28)} = 2.97$, p = 0.006), while this was not the

472   case in the low T group ($t_{(31)} = 1.40$, p = 0.173). Again both groups showed enhanced rejection

473   rates when rather fair offers were made by an outgroup member, whereby only in the low T

474   group this difference was significant (high T group: $t_{(28)} = 1.84$, p = 0.077; low T group: $t_{(31)} =$

475   2.13, p = 0.041) (see Fig. 1A). Yet, the latter effect did not survive the Bonferroni correction (p <

476   0.025), which needed to be applied since the same data were also used in the direct comparisons

477   of rejection rates between the testosterone groups that yielded no significant differences. We

478   only found a non-significant increase in the Delta of rejections of unfair offers made by the

479   outgroup minus those from the ingroup (Delta$_{(high\ T)}$: mean = 17.93%; sem = 6.05%; Delta$_{(low\ T)}$:

480   mean = 5.31%; sem = 3.81%; $t_{(59)}$= 1.77, p = 0.084). Collectively, these results indicate a

481   somewhat greater parochialistic tendency in men at the high end of the testosterone distribution,

482   who differentiated more between unfair proposals from the out- and the ingroup.

483   In a second step, we also looked at the proposals made by the participants to anonymous ingroup

484   and outgroup members after having completed the UG. A repeated measures ANOVA with the

485   factor "group" and the covariate standardized testosterone only showed a significant main effect

486   of "group" ($F_{1,\ 59}$ = 19.48; p < 0.001; partial eta^2 = 0.25), while no significant interaction with nor

487   a main effect of standardized testosterone could be observed. A post hoc t-test showed that

488   participants offered significantly more points to an anonymous ingroup member (mean ± sem =

489   4.1 ± 0.1 points) compared to an outgroup member (mean ± sem = 3.4 ± 0.2 points) ($t_{(60)}$ = 4.45,

490   p < 0.001), yet this effect was independent of testosterone.

491   Finally, being in the 'fast' or 'slow group' did not influence the rejection rates, which was tested

492   by re-running the first ANOVA including the subject's artificial group membership. Also when

493   comparing rejection rates of the 'fast' and 'slow group' directly, no significant differences

494   emerged (p > 0.347).

495

496   **3.2 Results of Study 2**

497   Study 2 was intended to examine whether the results related to parochial altruism in study 1

498   could also be found in a more natural group context (supporters of political parties tested during

499   the German election year 2017). First of all, we found that the political preferences of our student

500   sample were clearly oriented towards the left wing parties (SPD, The Greens, The Left), which

501   was also reflected by the mean ranking across participants (lower mean ranks indicate a more

502   favorable rating (mean ± sem): SPD = 2.44 ± 0.23, The Left = 2.94 ± 0.29, The Greens = 2.97 ±

503   0.23, CDU = 3.06 ± 0.22, FDP = 4.03 ± 0.23, AfD = 5.56 ± 0.20). Moreover, in line with study 1

504   and our previous results (Diekhof, Wittmer, and Reimers 2014; Reimers, Büchel, and Diekhof

505   2017; Reimers and Diekhof 2015) we found a significant two-way interaction ($F_{3.69, 121.78}$ = 2.81;

506   p = 0.032; partial eta^2 = 0.079) in the repeated-measures ANOVA with the factors rank of

507   "political preference" (6 ranks) and "offer" (unfair, fair). This was also reflected by a significant

508   linear trend with increasing social distance, as determined by an univariate ANOVA with the

509   independent factor "rank" and the dependent variable "mean rejection rate for unfair offers"

510   ($F_{1,203}$ = 9.94; p = 0.002). When comparing rejection rates between the most extreme cases, i.e.,

511   the first rank (one's favorite political party) and the last rank (the 6th rank, which is associated

512   with the least liked party with the most distant political values in the ranking) we found

513   significantly enhanced rejection rates for offers by rank 6, both in the context of fair and unfair

514   offers (p < 0.001). In the comparison of the rank 1 with the other ranks, we also documented

515   another two significant differences in the treatment of unfair offers by supporters of distant

516   political parties ranked as 4 and 5, whose rejection was also more frequent (p < 0.001) (see Fig.

517   2, which displays the rejection rates related to unfair offers). All these differences survived a

518   Bonferroni corrected threshold for multiple comparisons of 0.01. This means, that the design of

519   study 2 was also suitable to show parochialistic tendencies amongst the supporters of political

520   parties. Also the subsequent subdivision of ranks into the "ingroup" (ranks 1 to 3) and the

521   "outgroup" (ranks 4 to 6) below is in line with these observations of a differential treatment of

522   ranks 4 to 6, but not ranks 2 and 3 compared to rank 1.

523   More importantly, the main question was whether these parochialistic tendencies were also

524   related to endogenous testosterone as already documented in study 1. For this purpose and to

525   make the data of study 2 (6 groups) most comparable to those of study 1 (2 groups) the rejection

526   rates from ranks 1 to 3 were combined as the "ingroup", while the remaining ranks represented

527   the "outgroup". These data were then subjected to a repeated-measures ANOVA with the factors

528   "offer" and "group" and the covariate standardized testosterone. In contrast to study 1 this

529   ANOVA only revealed two main effects of "group" and "offer", while the three-way interaction

530   of the factors merely approached statistical trend level (see Table 2 for details). Nevertheless,

531   following the procedure of study 1 we subjected the estimated marginal means to an exploratory

532   simple slope analysis. This exploratory analysis showed that, similar to study one, only men with

533   very high testosterone showed a significantly increased rejection rate for unfair offers made by

534   outgroup compared to ingroup members ($t_{(32)} = 4.46$, p <0.001), while this was not the case in

535   men with low testosterone ($t_{(32)} = 1.78$, p = 0.085) (Bonferroni-corrected threshold: p < 0.025).

536   Further, fair offers of the outgroup were more often rejected than fair ingroup offers by both

537   testosterone groups (high testosterone: $t_{(32)} = 2.68$, p = 0.012; low testosterone: $t_{(32)} = 2.50$, p =

538   0.018) (Bonferroni-corrected threshold: p < 0.025). If subdividing the sample by the standardized

539   mean of testosterone (0) in a group with above (n= 16) and one below average testosterone

540   (n=18) direct comparisons showed no differential rejection pattern as originally demonstrated in

541   study 1. Further paired t-tests comparing rejection rates for fair ingroup vs. outgroup offers and

542   unfair ingroup vs. outgroup offers in the two testosterone groups all yielded significant

543   differences, that were in line with the interaction effect between "group" and "offer" (all p <

544   0.020; Bonferroni-corrected threshold: p < 0.025; see Fig. 1B). This suggests that there was no

545   clear association between testosterone and parochialism in this smaller sample of political

546   supporters.

547 Similar to study 1, the ANOVA of the proposals the participants made to anonymous members

548 of the first and the last rank after completion of the UG yielded no interaction with standardized

549 testosterone, yet only revealed a main effect of "group" ($F_{1, 32} = 26.40$; $p < 0.001$; partial eta^2 =

550 0.45). A post hoc t-test showed that participants offered significantly more points to a member of

551 the closest rank 1 (mean ± sem = 4.6 ± 0.1 points) compared to a member of most distant rank 6

552 (mean ± sem = 3.0 ± 0.3 points) ($t_{(33)} = 5.17$, $p < 0.001$).

553 Finally, in study 2 subjects performed a surprise cued recall task that was similar to the one used

554 by Hechler, Neyer, and Kessler (2016). However, in our task version the group identity of the

555 faces shown was not indicated during the memory test, but all faces were shown without any

556 notion of group identity. It has been suggested that there may be a memory advantage for

557 individuals of one's own group, especially if they exhibited schema-incongruent behavior (e.g.,

558 behaved unfairly) (Hechler, Neyer, and Kessler 2016). We performed a repeated-measures

559 ANOVA with the factors "offer" and "group" and the covariate standardized testosterone to

560 assess their effects on memory performance. This yielded a significant two-way interaction

561 between "offer" and testosterone ($F_{1, 32} = 5.57$; $p = 0.025$; partial eta$^2 = 0.15$), but no other

562 significant effect emerged (Table 3). The simple slope analysis of the estimated marginal means

563 revealed one significant difference that was restricted to subjects with low testosterone. These

564 participants showed a better recall rate for fair than unfair proposers ($t_{(32)} = 2.53$, $p = 0.017$), yet

565 independent of group (Bonferroni-corrected threshold: $p < 0.025$). In the analysis of all subjects

566 with a testosterone level below the standardized mean (n = 18) an increased hit rate for the

567 identity of fair proposers per se (mean ± sem = 51.3% ± 3.8% correct) compared to unfair

568 proposers could also be observed (mean ± sem = 44.0% ± 4.6% points) , yet this numerical

569 difference was not significant ($t_{(17)} = 1.47$, $p = 0.11$). Similarly, the numerically difference in

570   recall of unfair proposers between men with high testosterone (n=16; mean ± sem = 52.6% ±

571   3.6% correct) and those with low testosterone (n=18; mean ± sem = 44.0% ± 4.6% points) did

572   not reach significance ($t_{(32)}$ = 1.450, p = 0.157). It thus remains to be determined in a bigger

573   sample whether testosterone may promote memory for unfairness and whether better memory

574   performance indeed depends on group affiliation as previously suggested.

575

576   **3.3 Analysis of the combined data from study 1 and 2**

577   The previous results suggested similar effects of testosterone on parochialistic behavior in the

578   two studies. However, the observations made in study 2 were not significant, which was most

579   likely a result of the smaller sample size. We therefore combined the ingroup and outgroup data

580   from the UG in a meta-analysis of all cases (n = 95) and re-ran the repeated-measures ANOVA

581   of the rejection rates described previously, this time with the additional between-subjects factor

582   "study". This analysis confirmed the significant three-way interaction of "offer", "group" and

583   standardized testosterone ($F_{1, 92}$ = 10.65; p = 0.002; partial eta^2 = 0.10) as well as the two main

584   effects of the factors "offer" ($F_{1, 92}$ = 222.29; p < 0.001; partial eta^2 = 0.71) and "group" ($F_{1, 92}$ =

585   29.46; p < 0.001; partial eta^2 = 0.24) (see also Table 4). Further, the simple slope analysis of the

586   estimated marginal means showed that unfair offers were more often rejected if they came from

587   an outgroup proposer than from an ingroup member, however only if the respondents were men

588   with high testosterone ($t_{(93)}$= 5.28, p < 0.001). For men with low testosterone the same

589   comparison yielded no significant difference ($t_{(93)}$ = 1.71, p = 0.091). In case of the rather fair

590   offers, all participants rejected offers from outgroup members more often than those from

591   ingroup members (high testosterone: $t_{(93)}$= 3.61, p = 0.001; low testosterone: $t_{(93)}$= 3.58, p =

592   0.001). Apart from these replications, we also found a two-way interaction between "offer" and

593   "study" ($F_{1,\,92}$ = 8.00, p = 0.006; partial eta^2 = 0.08). Post-hoc comparisons showed that the

594   participants of study 1 rejected unfair offers more often (mean ± sem = 68.6% ± 4.2%) than the

595   participants of study 2 (mean ± sem = 53.4% ± 5.5%) ($t_{(93)}$= 2.2, p = 0.03) indicating a higher

596   degree of inequity aversion in the first sample. We therefore also looked into the questionnaire

597   data from the two studies as these might help to explain these differences in inequity aversion

598   (please note that missing questionnaire data of some subjects explain the reduced degrees of

599   freedom below). We found that the participants of study 1 were significantly more impulsive as

600   indicated by a higher BIS score ($BIS_{study\ 1}$: mean ± sem = 65.7 ± 1.3) compared to the subjects of

601   study 2 ($BIS_{study\ 2}$: mean ± sem = 60.4 ± 1.4) ($t_{(88)}$= 2.60, p = 0.011). The participants of study 1

602   also showed a significantly enhanced negative reciprocity score in the trust and reciprocity

603   questionnaire (negative reciprocity$_{study\ 1}$: mean ± sem = 8.65 ± 0.25; negative reciprocity$_{study\ 2}$:

604   mean ± sem = 5.52 ± 0.29; $t_{(91)}$= 7.94, p <0.001). At the same time both the trust and the positive

605   reciprocity score were significantly reduced in study 1 (trust $_{study\ 1}$: mean ± sem = 7.20 ± 0.21;

606   positive reciprocity $_{study\ 1}$: mean ± sem = 4.18 ± 0.13) compared to study 2 (trust $_{study\ 2}$: mean ±

607   sem = 8.48 ± 0.27; positive reciprocity $_{study\ 2}$: mean ± sem = 10.58 ± 0.24) (trust $_{comparison}$: $t_{(91)}$=

608   3.65, p <0.001; positive reciprocity $_{comparison}$: $t_{(91)}$= 23.57, p <0.001). These results suggest that the

609   participants from the two studies might have shown a general difference in the way to treat other

610   humans in economic interactions, which might explain the increased rejection rate in relation to

611   unfair offers made in study 1. Interestingly, when correlating of the scores from the trust and

612   reciprocity questionnaire with the degree of political interest in subjects of study 2 (PIKS score),

613   we found a negative relationship between negative reciprocity and PIKS score (r = -0.396; p =

614   0.021). Unfortunately, the p-value did not survive the Bonferroni-correcte threshold of p =

615   0.0167 (the PIKS score was used in three correlations with the trust, negative and positive

616 reciprocity scores). So we can only speculate that people with a higher political interest, who

617 also show a stronger need to get political information to make an informed voting decision,

618 might be more conscientious, which is why they would show less retaliation, yet more positive

619 reciprocity and trust .

620 In addition to that, we wanted to further ascertain to what extent the actual degree to which an

621 individual shows a 'parochialism bias', i.e., the differential treatment of unfair offers made by

622 the ingroup and the outgroup, may be related to testosterone. For this, we performed a correlation

623 analysis with the data of all cases (n = 95). This analysis revealed a small, yet significant positive

624 correlation between standardized testosterone and the delta of the rejection rate of unfair

625 outgroup minus unfair ingroup offers (Delta$_{out-in}$: r = 0.245, p = 0.017; see Fig. 3).

626 Finally, in order to further explore this positive correlation we followed the procedure of our

627 previous study (Reimers, Büchel and Diekhof, 2017), in which we subdivided the sample by the

628 individual tendency to treat highly unfair proposals. It has previously been assumed that offers of

629 20% of the original share are assumed to be the threshold at which rejection rates start to

630 increase tremendously, yet at the same time inter-individual variation of rejection rates increases

631 (Güth, Schmittberger, and Schwarze 1982; Henrich et al. 2005). In the first study 80% of unfair

632 proposals offered 20% or less of the initial endowment, while in study 2 50% of the unfair

633 proposals fell within this range. Thus a rejection rate for unfair offers (regardless of group) that

634 was exceeding these study-specific thresholds of 80% (study 1) and 50% (study 2) was assumed

635 to reflect a high degree of inequity aversion that was marked as the first individual decision

636 strategy (inequity averse subjects). In contrast, rejection rates well below the respective study-

637 specific threshold were considered as reflecting both a high tolerance for unfairness and the

638 motivation to collect as many points as possible for oneself (selfish strategy). Based on this

639   classification, that was exclusively based on the experimental structure of the UG task (i.e.,

640   referred to the percentage of highly unfair trials as cut-off value), participants were divided into

641   the two strategy groups (see also Reimers, Büchel and Diekhof, 2017 for a similar procedure).

642   This sub-division showed that the positive correlation between standardized testosterone and the

643   parochialism bias, i.e., delta of the rejection rate of unfair outgroup minus unfair ingroup offers,

644   stemmed from the selfish subjects (n = 44; r = 0.394, p = 0.008) with their relatively few

645   rejections overall (selfish group: mean rejection rate$_{unfair}$ ± sem = 34.3% ± 3.6%), while it was

646   not present in the more inequity averse subjects (n = 51; r = -0.016, p = 0.909). One might argue

647   that the absence of a correlation could be explained by the generally high rejection rates in the

648   latter group (mean rejection rate$_{unfair}$ ± sem = 88.1% ± 1.9%) and the resulting ceiling effect.

649   However, it may also be that, similar to Reimers, Büchel and Diekhof (2017), selfish and

650   inequity averse subjects were differently affected by testosterone when deciding how to treat

651   unfair offers made by different groups.

652

653
654   **4. Discussion**

655   The aim of this research was to test whether an artificial group formation (study 1) and a natural

656   group affiliation (study 2) would both install a sufficient group commitment to measure

657   individual differences in parochial altruism in the intergroup-UG and to investigate how these

658   differences may be related to circulating testosterone. In study 1, the subjects were divided into

659   two artificial groups according to the distance they had covered in a maze task after seven

660   seconds. For study 2, we tested supporters of political parties in the German election year of

661   2017, who showed a strong interest in politics and had a clear favorite party as well as

662   reservations of varying degree towards the other parties competing in the election. The subjects

663   of both studies acted as responders in a computer-based intergroup-UG with single-shot

664   interactions and offers of varying degrees of unfairness. In the end, participants switched to the

665   role of the proposer and had to decide about hypothetical offers they made to members of their

666   own group or the other group(s). Moreover, study 2 also included a cued recall task to assess

667   memory for previously unfair proposers of the different groups. Altogether, both studies showed

668   a relationship between testosterone and the intergroup bias, thus supporting the assumption that

669   endogenous testosterone may be related to male parochial altruism. However, the correlative

670   nature of the two studies and the relatively small sample sizes limit any strong inferences and

671   render the present results rather preliminary.

672

673   **4.1 Parochial altruism in the intergroup UG emerged across different studies**

674   As hypothesized and in line with previous studies (Diekhof, Wittmer, and Reimers 2014;

675   Reimers, Büchel, and Diekhof 2017) a marked pattern of parochial altruism with higher rejection

676   rates in outgroup than ingroup interactions was evident in both studies, which was also reflected

677   by a linear trend for increased social discounting with increasing social distance in study 2

678   corresponding to the results of earlier studies (e.g., Strombach et al. 2015). Such rejections could

679   indicate the willingness to forgo points in order to punish outgroup members, which would

680   reflect a behavior consistent with the theory of parochial altruism (Choi & Bowles, 2007). An

681   alternative view would interpret this behavior as spiteful rather than altruistic, with the major aim

682   to minimize the other's payoff in order to equalize relative gain between the interaction partners

683   (Jensen 2010). It has been assumed that spiteful individuals see others as competitors, whose

684   gains negatively affect their own utility (Espín et al. 2015). Yet, it is not clear why spitefulness

685   should necessarily follow a parochial pattern or should lead to increased punishment of one

686   social group above the other. We observed that 41 of the 95 participants ($n_{study1} = 20$, $n_{study\ 2} = 21$)

687   showed a preference to minimize the payoff of unfair outgroup members more than that of unfair

688   ingroup members (Mean Delta$_{out-in}$ for unfair offers $\pm$ sem = 32.19% $\pm$ 4.19%). This behavior

689   would fit with the theory of parochial altruism (Choi and Bowles, 2007). First, these rejections

690   indirectly benefited the relative gain of the ingroup, as did the somewhat lowered fairness norm

691   in ingroup interactions. Second, it also clearly harmed the payoff of the outgroup, yet this

692   happened at the responder's expense, since in the latter case the responder declined a share he

693   could have otherwise acquired for himself. In contrast, another 14 subjects ($n_{study1} = 11$, $n_{study\ 2} =$

694   3) preferentially rejected unfair ingroup offers compared to unfair outgroup offers (Mean

695   Delta$_{out-in}$ for unfair offers $\pm$ sem = -10.87% $\pm$ 1.09%). This decision behavior would rather fit

696   with the theory of indirect reciprocity (Gintis et al., 2003; Yamagushi & Mifune, 2008),

697   according to which rejections of unfair offers by ingroup members even in single-shot

698   interactions promote the adherence to fairness norms and cooperation within one's group.

699   Altruistic punishment of ingroup unfairness is thereby assumed to be the glue of large

700   anonymous societies that follow the principle of generalized exchange. In addition, harsher

701   punishment of norm violations in the ingroup may not only increase the individual probability to

702   get fairer shares in the future, but could benefit one's social reputation and thus enhance

703   individual social status (Fehr and Gächter 2002; Yamagishi et al., 2012). Finally, the remaining

704   40 subjects ($n_{study1} = 30$, $n_{study\ 2} = 10$) showed no difference in responding to unfair offers from the

705   out- and the ingroup. This latter group also showed significantly higher rejection rates in

706   response to unfair offers per se (mean $\pm$ sem = 73.01% $\pm$ 5.88%) than the subjects with a

707   negative Delta$_{out-in}$ (mean $\pm$ sem = 53.37% $\pm$ 4.00%) ($t_{(79)}$= 2.78, p = 0.007), which might have

708   indeed reflected a motive driven by increased spitelfulness (Jensen 2010). Altogether, the present

709   data do not conform to the assumption that the spitefulness motive was the only driving force of

710   rejections in case of unfair offers, yet it could have motivated a subgroup of subjects, which

711   needs to be determined by future studies.

712   When looking at the findings of study 1 we found that the minimal group formation task elicited

713   parochial altruism in the same manner as did previous studies with natural groups (e.g., ethnic

714   groups as in Fershtman and Gneezy 2001, or the sample of political supporters tested in study 2).

715   The minimal group formation task resembled previously applied methods of assigning subjects

716   to different groups according to their performance on a meaningless task (like in a task that

717   required the estimation of the number of presented dots). Given previous evidence indicating that

718   even such minimal conditions for group assignment promote an intergroup bias (Brewer 1979;

719   Tajfel et al. 1971; Volz, Kessler, and Cramon 2009), we expected to find a similar pattern. But

720   note that alternative methods to create group identity have also revealed conflicting findings

721   indicating that norm violations committed by ingroup members are punished more often (e.g.,

722   McLeish and Oxoby 2007; Mendoza et al., 2014). Although costly punishment has been

723   proposed to sustain group cooperation (e.g., Fehr and Gächter 2002) and may thus be expected to

724   occur more often in response to unfair ingroup members, we found previously that our version of

725   the intergroup-UG particularly provoked increased punishment of unfair outgroup members by

726   young healthy men, even when our participants played for themselves without a direct intergroup

727   competition (Diekhof, Wittmer, and Reimers 2014; Reimers, Büchel, and Diekhof 2017).

728   Apart from similarities study 1 and study 2 nevertheless also exhibited a difference, namely in

729   the percentage of rejections of unfair proposals per se (study 1 > study 2). This might have been

730   related to differences in aspects of the personality of subjects, that were determined by two self-

731   report questionnaires. For one thing, the participants of study 1 showed a higher degree of

732   negative reciprocity, which comprised the increased tendency for retaliation or to harm someone

733   who has previously harmed oneself, while the tendency to return a favor (positive reciprocity)

734   and the trust in strangers was reduced in comparison of subjects from study 2. For another, the

735   participants of study 1 were also more impulsive. Impatience as an aspect of impulsiveness has

736   previously been shown to influence decisions in the UG. In particular, spitefulness in the UG

737   may be driven by an increased impatience, which would result in increased rejections of unfair

738   offers as well as reduced proposals in general (Espín et al. 2015). Interestingly, of the 40

739   subjects, who showed no difference in responding to unfair offers from the out- and the ingroup

740   30 were from study 1, which is approximately 50 percent of the sample (see above). This would

741   fit with the observed average personality profile of increased negative reciprocity in combination

742   with heightened impulsivity of the men from study 1, and points in the direction of increased

743   spitefulness as one motive for the exceedingly high rejection rates.

744

745   **4.2 Testosterone may modulate parochial altruism in different social contexts**

746   The major aim of this research project was to assess the relation between endogenous

747   testosterone and parochial altruism in two related, yet distinct social settings. Taken together, we

748   found only weak, yet consistent evidence for a positive connection between testosterone and the

749   preferential punishment of unfairness in outgroup members in the two studies (see Fig. 3). Not

750   surprisingly this correlation was most visible in subjects who exhibited a more selfish decision

751   strategy (i.e., who did not show a general distaste for unfairness and thus overall high rejection

752   rate, but in contrast exhibited a rather flexible rejection style that also differentiated more

753   between the in- and the outgroup). This might indicate a modulatory role of testosterone on the

754   behavioral expression of male parochial altruism as suggested previously (see also Reimers,

755 Büchel, and Diekhof, 2017). The effects of testosterone on altruistic punishment in the UG have

756 often been subtle or were even contradictory at times (see introduction). This currently precludes

757 an unequivocal interpretation of the role of testosterone in altruistic punishment in the UG and its

758 interaction with parochialism. For this reason, the present data need to be replicated in other

759 intergroup contexts (e.g., in the comparison of different ethnic groups or in members of different

760 universities). Further, the causal relationship between testosterone and parochial altruism has to

761 be determined by pharmacological intervention studies that ideally test both men and women.

762

763 As it stands, the two employed intergroup paradigms are most comparable to the ones used by

764 Diekhof, Wittmer and Reimers (2014) and by Reimers, Büchel and Diekhof (2017), who also

765 assessed healthy young men. However, the present results do not correspond to our previous

766 findings. In the behavioral study of Diekhof, Wittmer and Reimers (2014) the positive

767 relationship between testosterone and parochial altruism was not observed in the unbiased

768 context, but only occurred when soccer fans transitioned from the neutral session to the

769 competitive part of the intergroup-UG, during which groups explicitly competed for an

770 additional group bonus. This was reflected by the relative enhancement of rejections of rather

771 fair outgroup offers (4:6), which was stronger in soccer fans with a high testosterone level.

772 Moreover, the same subjects showed an increased parochialism bias, but only during the

773 competition, whereas there was no such relationship in the unbiased session of the intergroup-

774 UG. Finally, when being in the role of a proposer, soccer fans with high testosterone made more

775 generous proposals to members of their ingroup, which could not be observed in the present

776 studies. However, our previous and present behavioral studies differ in some important aspects.

777 While in the previous study (Diekhof, Wittmer, and Reimers 2014) participants faced proposers

778   of four different sports teams (i.e., the soccer ingroup, a neutral soccer outgroup, an unknown

779   cricket outgroup and a disliked soccer outgroup), three of whom were directly competing in the

780   German soccer league (*Bundesliga*), the present research either used artificially created group

781   identities or employed a natural group of German voters with high political interest. We can only

782   assume that the differences in the groups under research might have led to different degrees of

783   group commitment, as demonstrated previously by Weisel and Böhm (2015). Despite the use of

784   natural groups in both study 2 and the study by Diekhof, Wittmer, and Reimers (2014), who

785   were competing for desired resources, i.e., either for seats in the German *Bundestag* or a high

786   *Bundesliga* ranking, we speculate that soccer fandom evokes a much stronger emotional group

787   affiliation than being a supporter of a certain political party prior to an important election in

788   Germany, even though this was not explicitly tested here. Compared to these natural social

789   settings, even less emotional commitment should be assumed in a member of a minimal group

790   that was based on the performance in a simple reaction time task like in study 1, although this

791   assumption is again speculative since it was not tested here. As already discussed in detail by

792   Weisel and Böhm (2015), the election campaigns of the different mainstream parties in Germany

793   (*SPD, Greens, CDU* and *Free Liberals*) are less emotional than for example in the United States

794   (US). As Weisel and Böhm (2015) put it, the political discourse in Germany is mild and the

795   mainstream parties are not as polarized as for example the Democrats and Republicans in the US.

796   Also, many voters may consider them to have more in common than in separation. Only parties

797   on the extreme right or left wing may be considered as distinct, which was also demonstrated

798   here by the ranking of the extreme right wing party, the *AfD*. Of the 34 participants of study 2, 28

799   categorized the extreme right as rank 6, and another 3 did so as rank 5. In contrast to interactions

800   between political voters in real life, the context of soccer fandom is characterized by a high

801   degree of enmity between teams and normally the affiliation with one's own team is very strong

802   and emotional, that it may often resemble a tribal identity (van Vugt and Park 2010). Our

803   previous study only tested subjects who strongly agreed with statements like "*soccer is my life*"

804   and who owned not only season tickets for matches of their favorite team, but also went to away

805   matches and owned fan merchandise like bedclothes with a team logo (Diekhof, Wittmer, and

806   Reimers 2014). Further, a soccer season comprises 34 weeks of a year with games every

807   weekend, while an election for the German *Bundestag* happens only every 4 years and the hot

808   phase of the election campaign comprises only a handful of weeks directly before the election.

809   Soccer fandom thus requires a constant engagement with the success of one's favorite team as

810   well as real life interactions with other supporters of one's team as well as those from rival teams

811   (criteria that were all fulfilled by the participants of the study performed by Diekhof, Wittmer,

812   and Reimers 2014). Weisel and Böhm (2015) found less outgroup hate in supporters of political

813   parties than in soccer fans in an economic exchange task, which was also sensitive for the

814   different aspects of parochialism. When comparing the parochialism bias in relation to unfair

815   offers (i.e., the Delta of rejections of unfair offers made by the outgroup minus those from the

816   ingroup) of the present two and our previous behavioral soccer study (Diekhof, Wittmer, and

817   Reimers 2014), we see that the minimal group study 1 had the lowest value (mean ± standard

818   deviation = 11.3% ± 27.8%), which was lower than the bias found in study 2 (mean ± standard

819   deviation = 14.1% ± 19.1%). In contrast, the parochialism bias documented by Diekhof,

820   Wittmer, and Reimers (2014) when comparing the ingroup and the antagonistic outgroup was

821   much higher (mean ± standard deviation = 24.8% ± 36.5%) as was the bias observed in the

822   neuroimaging study by Reimers, Büchel and Diekhof (2017) (mean ± standard deviation =

823   21.7% ± 29.7%). Further, even the Delta based on the average of the three outgroups of the

824   behavioral soccer study (i.e., the antagonistic soccer team, the neutral soccer team, and the

825   unknown cricket team) minus the ingroup rejection rates remained the highest compared to the

826   present two studies (mean ± standard deviation = 17.6% ± 28.3%). Based on this and the

827   observations made by Weisel & Böhm (2015), we speculate that the emotional engagement

828   might have been highest in the hardcore soccer fans, which could be the reason why we had been

829   unable to observe the rather subtle effect of testosterone on behavior during the unbiased context

830   of the UG there, during which soccer fans already exhibited a very high degree of parochialism

831   per se. Nevertheless, the present result emerged across the two different social settings of study 1

832   and 2, which may point to a valid, but small effect of testosterone on latent behavioral

833   parochialism during socio-economic interactions outside of the context of soccer fandom.

834

835   Finally, we also performed a cued memory recall task in study 2. We did not find a memory

836   advantage for schema-incongruent information in the given social setting (e.g., for unfair

837   proposals made by ingroup members) as suggested previously (Bell and Buchner 2012; Hechler,

838   Neyer, and Kessler 2016). However, in contrast to these studies group association was not

839   reinstated in the cued recall task, but facial identities were shown without any reference to the

840   group they belonged to. This may explain why the general recall performance ranged around

841   50% chance level for fair and unfair proposers across ranks (mean ± sem: hit rate for all fair

842   proposers = 51.3% ± 2.7%; hit rate for all unfair proposers = 48.0% ± 3.0%), while the hit rate

843   for new pictures was the highest (mean ± sem: hit rate for new pictures = 57.5% ± 2.0%). We

844   also found a small effect of reduced testosterone on hit rates for fair as compared to unfair

845   proposers (better recall of fair proposers) in the analysis of the estimated marginal means. A

846   recent neuropsychological study with a focus on cue-induced forgetting and recall in relation to

847 salivary testosterone found something similar, namely that low testosterone levels were

848 associated with improved binding of the newly encoded memories to their context cue (Sterzer et

849 al., 2015). However, since the present effect could not be ascertained in study 1, in which no

850 cued recall test was performed, and did not occur when the complete sample was subdivided by

851 the mean of standardized testosterone (below or above average testosterone), we cannot infer that

852 this was not just a sporadic finding. Future studies have to more carefully assess the interaction

853 of social distance by fairness in larger samples using different cued recall tasks, with or without

854 indicators of group identity.

855

856 **4.2 Limitations and future perspective**

857 The present studies have several limitations that need to be addressed by future studies. First,

858 sample size, especially that of study 2, was limited and therefore the power to identify the

859 potentially subtle associations between testosterone and behavior was restricted. Nevertheless,

860 we found similar effects in both studies that also held when combining both data sets.

861 Second, the present studies identified a single hormone as a correlate of parochial altruism in the

862 intergroup-UG. However, testosterone may not be the only hormone involved in ingroup

863 favoritism and outgroup hostility. There is recent evidence for other hormonal systems to play a

864 role in shaping parochial altruism. For instance, the neuropeptide oxytocin has been shown to

865 drive parochial altruism in men during economic interactions (De Dreu et al. 2010). The steroid

866 hormones testosterone and also estrogen have been shown to modulate the expression of the

867 neuropeptides oxytocin and vasopressin (Liening and Josephs 2010; Soares et al. 2010), which

868 are both involved in a variety of social behaviors and economic decision making (Bos et al.

869 2012). Further, another steroid hormone that might potentially influence testosterone's effects on

870   social behavior is cortisol. A growing number of studies provide evidence for the *dual-hormone*

871   *hypothesis*, which states that the effects of testosterone on status-related behavior, such as

872   dominance, depend on the levels of cortisol (Mehta and Josephs 2010). In fact, a recent study has

873   provided initial evidence for the dual-hormone hypothesis in the context of an UG showing that a

874   rise in testosterone was associated with increased acceptance rates of unfair offers in individuals

875   with decreased cortisol levels (Mehta et al. 2015). Yet, the dual-hormone hypothesis has not

876   remained undebated and two recent meta-analyses demonstrate only weak effects (Dekkers et al.,

877   2019; Grebe et al., 2019). These results call for much larger samples for hypothesis testing as

878   well as pre-registered study protocols in the future.

879   Third, another aspect that currently remains unknown, as it was not in the focus of the present

880   study, is the impact of genetic predispositions on individual differences in parochial altruism. For

881   instance, a genetic polymorphism in the androgen receptor gene, the CAG tandem repeat length,

882   is associated with the sensitivity for circulating androgens such as testosterone (Chamberlain,

883   Driver, and Miesfeld 1994). Subjects with a more selfish decision strategy were reported to show

884   a tendency towards shorter repeat lengths and thus supposedly increased androgen sensitivity

885   (Reimers, Büchel, and Diekhof 2017), which would help to explain the present findings of a

886   positive correlation between the parochialism bias and testosterone that was particularly evident

887   in men who showed reduced inequity aversion across groups. Other studies also demonstrated

888   nuanced relationships between personality, repeat length, testosterone and aggression (Geniole et

889   al., 2019), suggesting that genetic predisposition may be an important moderator of the relation

890   between fluctuating hormones and behavior as well as brain physiology.

891   Fourth, the present studies as well as our previous ones (e.g., Diekhof, Wittmer and Reimers,

892   2014) were restricted to men. It thus remains to be determined how women would react to

893   intergroup manipulations in the UG and whether endogenous testosterone may be related to

894   female parochial altruism. Evolutionary theories of parochial altruism like the one formulated by

895   Choi & Bowles (2007) or the 'male warrior hypothesis' (van Vugt & Park, 210) do not make

896   explicit claims about female behavior during group competition or conflict. However, the

897   'steroid/peptide theory of social bonds' (van Anders, Goldey and Kuo, 2011) makes some

898   suggestions regarding the role of testosterone in the achievement of social goals that may also

899   apply for females. Accordingly, in females testosterone may trigger defensive aggression in a

900   special case of social threat, namely when there is a need to protect her offspring against outside

901   threat. One may therefore speculate that women may also show parochialistic behaviors that are

902   related to testosterone, however these might become particularly evident in situations that

903   involve the core ingroup (e.g., family, mother-infant interaction) rather than an abstract group

904   (like in study 1) or a political view (like in study 2). So it remains to be determined by future

905   studies to what extent female testosterone mediates parochialism in general and parochial

906   altruism in particular.

907   Finally, the expression of parochial altruism may not only be driven by physiological factors, but

908   may further be shaped and could even be intensified by cultural ramifications like gender or

909   racial stereotypes, socially preferred or sanctioned behaviors and long-standing rivalries between

910   groups. Yet, by thoroughly assessing the physiological basis of parochial altruism we might be

911   better able to formulate hypotheses that address the potential interaction between physiological

912   and cultural factors that may collectively lead to prevailing intergroup biases and may fuel

913   racism across the globe.

914

915   **5. Conclusion**

916   In conclusion, the present findings show that high levels of testosterone are linked to behavioral

917   patterns of parochial altruism depending on individual decision strategy. Extending previous data

918   that demonstrated an association between testosterone and parochial altruism in soccer fans

919   (Diekhof, Wittmer, and Reimers 2014; Reimers, Büchel, and Diekhof 2017; Reimers and

920   Diekhof 2015), the present study revealed a comparable relationship in artificially created groups

921   and supporters of political parties. Based on the concordant findings of study 1 and 2, it may be

922   assumed that the effect of testosterone on parochial altruism represents an evolutionary

923   conserved neurobiological mechanism that is also detectable in minimal group contexts as well

924   as natural social settings outside the context of soccer fandom. In sum, our results add further

925   evidence to the modulatory role of testosterone in shaping parochial altruism and point to

926   potential future avenues for research aiming to understand the neuroendocrinology underlying

927   this prevalent human behavior.

928

929   **6. Author contributions**

930   LR and ED designed the experiments. Data collection was performed by LS, EK and MY. All

931   authors analyzed the data. ED and LR wrote the first draft of the paper and all authors

932   contributed in revising and finalizing the manuscript.

933

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938

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9. Figure legends

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1102 **Figure 1: Rejection rates of ingroup and outgroup offers in association with testosterone.**

1103 Data are subdivided by testosterone group and study. The low testosterone group comprised

1104 individuals with a standardized testosterone level below the standardized mean (0), whereas the

1105 high testosterone group included the subjects with above-average testosterone. The results of

1106 study 1 indicate that men with low testosterone **(A)** were less inclined to reject unfair outgroup

1107 offers than men with higher testosterone **(B)**, while the former group showed a parochialism bias

1108 only in response to rather fair offers. Study 2 indicates no clear effect of testosterone on the

1109 parochialism bias, when subdividing the complete sample in two groups with low **(C)** versus

1110 high **(D)** testosterone. However the analysis of the estimated marginal means that reflect the

1111 most extreme cases at the high versus low spectrum of testosterone, showed a similar

1112 parochialism bias in high testosterone men as observed in study 1 (see text). Significant

1113 differences (Bonferroni-corrected threshold of p<0.025) in rejection rates are marked with an

1114 asterisk.

1115

1116 **Figure 2: Rejection rates for unfair offers increase with increasing social distance of**

1117 **political party supporters in study 2.** Significant differences are observed between the first

1118 rank, i.e. supporters of one's favorite political party, and the last three ranks ($p \leq 0.002$)

1119 (Bonferroni-corrected threshold of p<0.01).

1120

1121 **Figure 3: Testosterone was positively correlated with the parochialism bias across studies.**

1122 Higher endogenous testosterone was significantly associated with higher rejection rates related to

1123 unfair outgroup offers relative to unfair ingroup offers (n = 95; r = 0.245, p = 0.017).

1124

Figure 1

Figure 1: Rejection rates of ingroup and outgroup offers in association with testosterone.

Data are subdivided by testosterone group and study. The low testosterone group comprised individuals with a standardized testosterone level below the standardized mean (0), whereas the high testosterone group included the subjects with above-average testosterone. The results of study 1 indicate that men with low testosterone **(A)** were less inclined to reject unfair outgroup offers than men with higher testosterone **(B)**, while the former group showed a parochialism bias only in response to rather fair offers. Study 2 indicates no clear effect of testosterone on the parochialism bias, when subdividing the complete sample in two groups with low **(C)** versus high **(D)** testosterone. However the analysis of the estimated marginal means that reflect the most extreme cases at the high versus low spectrum of testosterone, showed a similar parochialism bias in high testosterone men as observed in study 1 (see text). Significant differences (Bonferroni-corrected threshold of $p<0.025$) in rejection rates are marked with an asterisk.

A Study 1 – Low testosterone (n = 32)

B Study 1 – High testosterone (n = 29)

C Study 2 – Low testosterone (n = 18)

D Study 2 – High testosterone (n = 16)

☐ Ingroup ◼ Outgroup

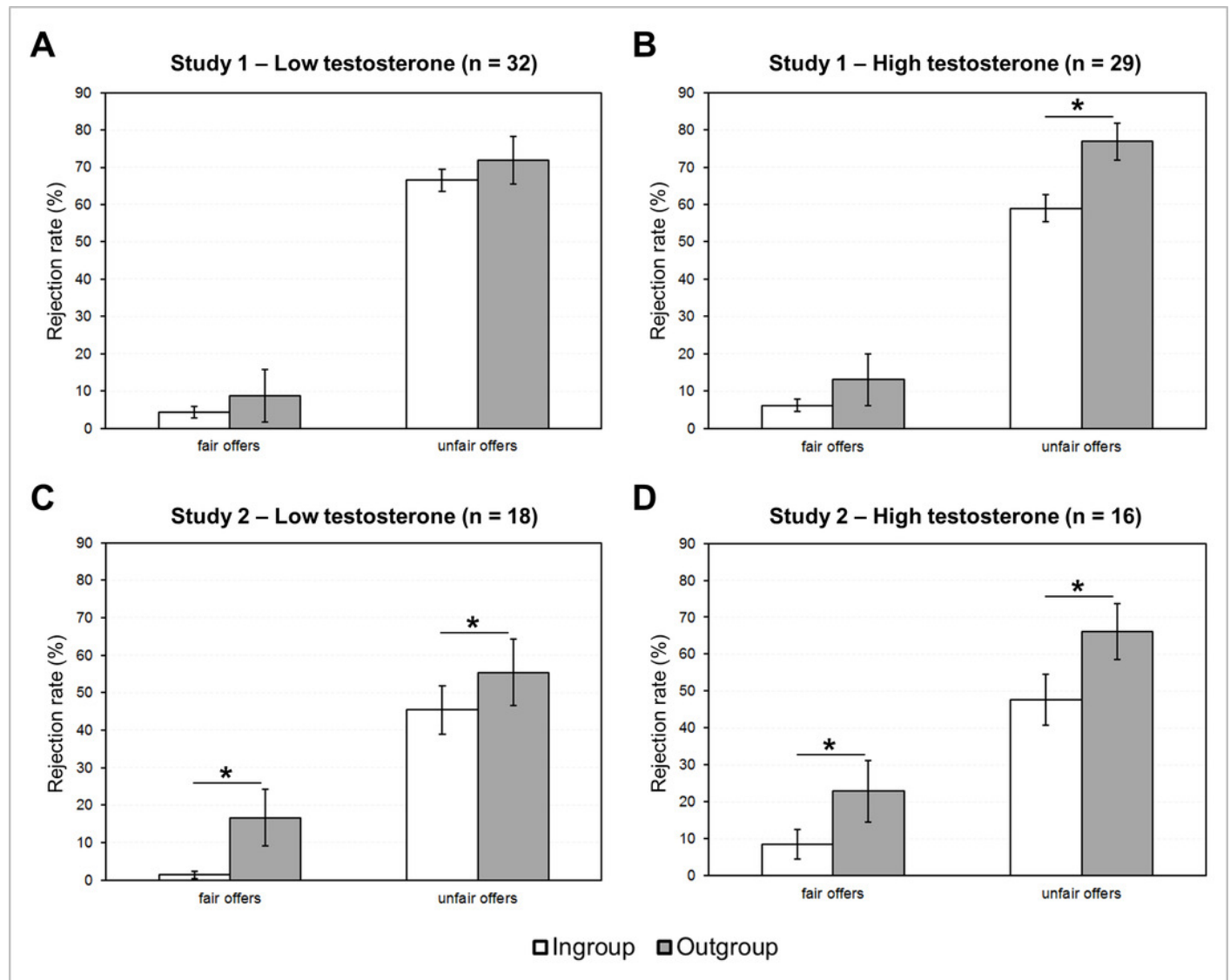



Figure 2

Rejection rates for unfair offers increase with increasing social distance of political party supporters in study 2.

Significant differences are observed between the first rank, i.e. supporters of one's favorite political party, and the last three ranks ($p \leq 0.002$) (Bonferroni-corrected threshold of $p<0.01$).

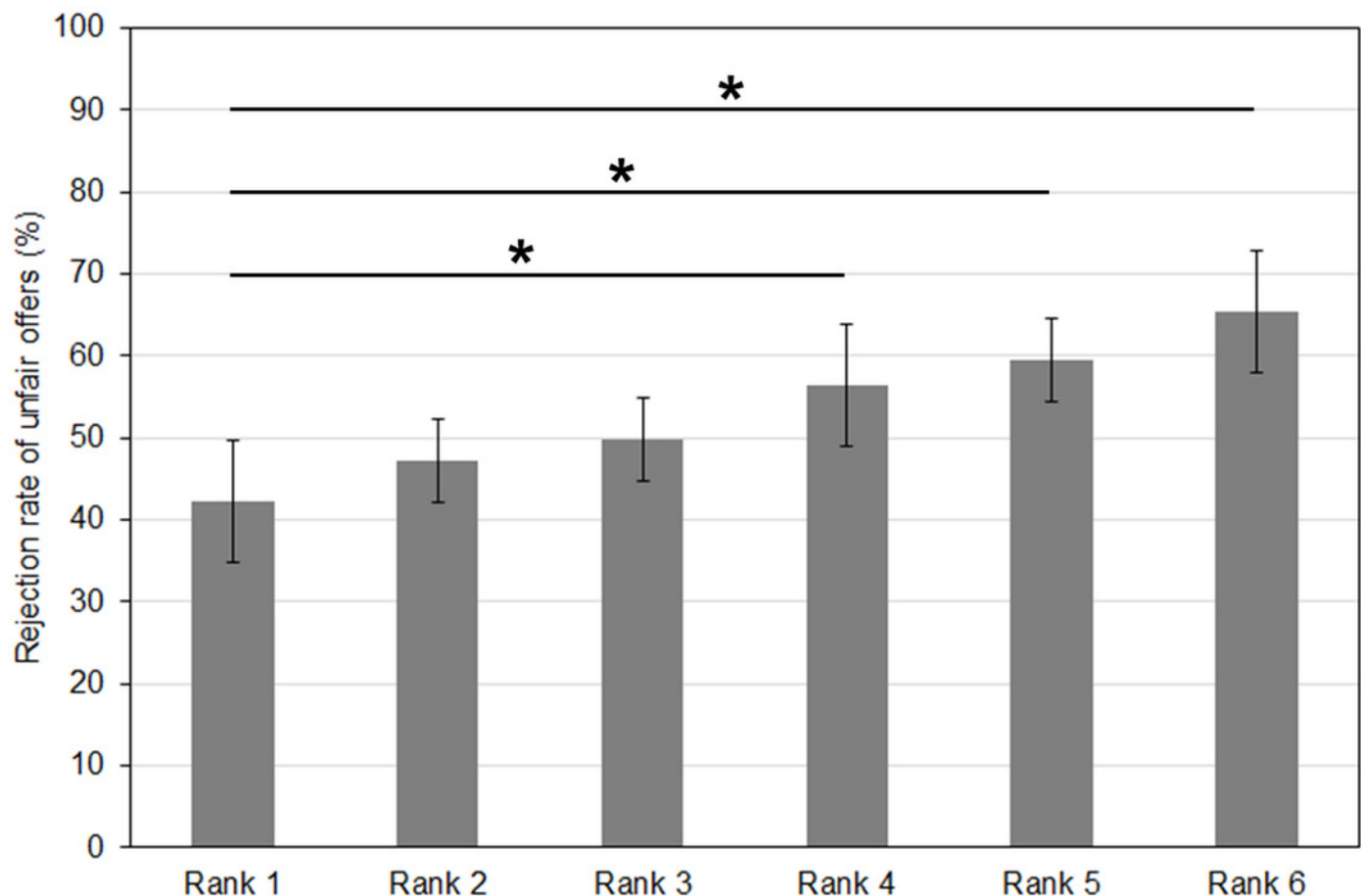
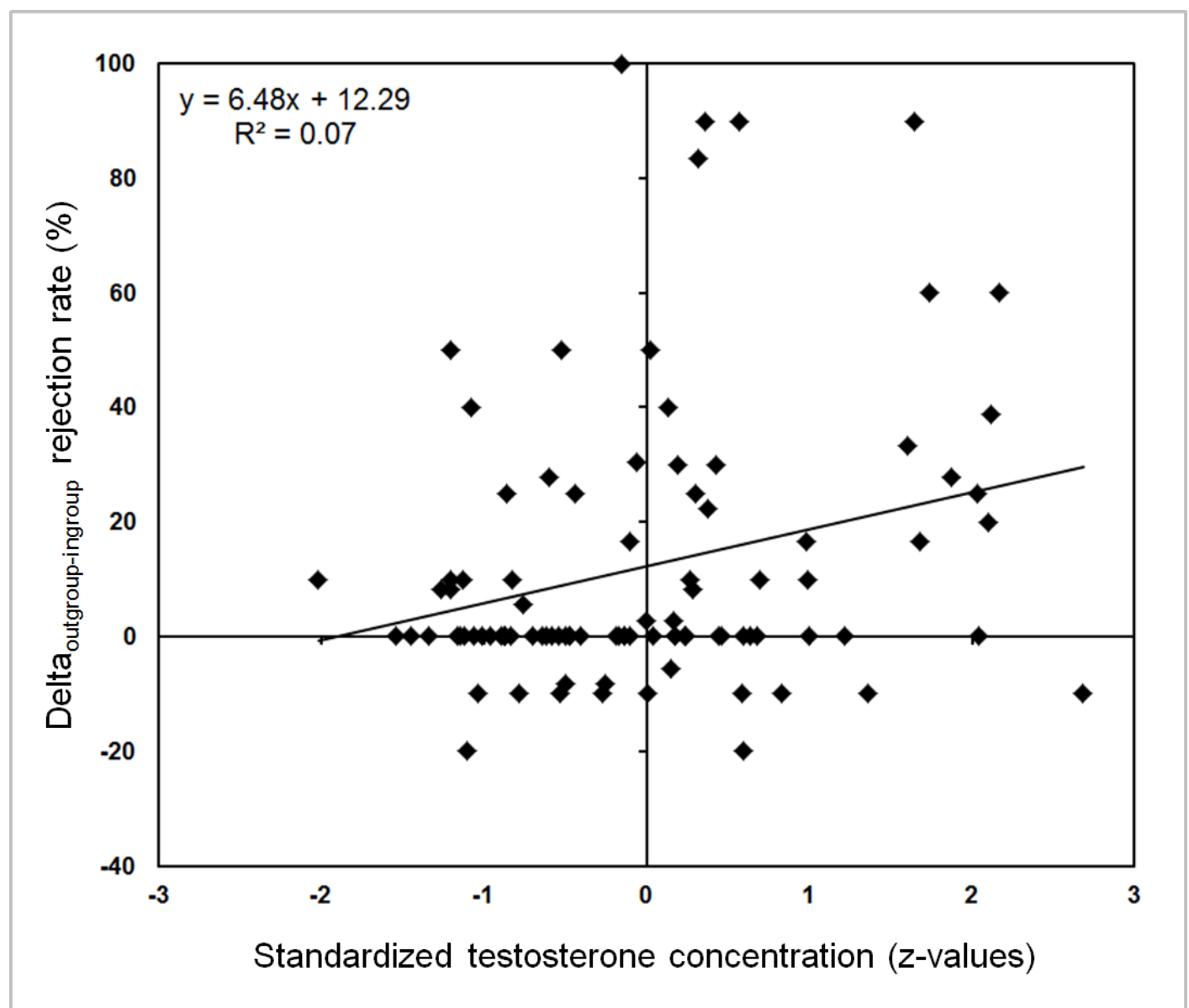



Figure 3

Testosterone was positively correlated with the parochialism bias across studies.

Higher endogenous testosterone was significantly associated with higher rejection rates related to unfair outgroup offers relative to unfair ingroup offers (n = 95; r = 0.245, p = 0.017).

Study 1 – Minimal group design (n = 61). Results of the repeated measures ANOVA of rejection rates (%)

*Significant effects (p<0.05) are marked with an asterisk

1   **Table 1:**

2   **Study 1 – Minimal group design (n = 61). Results of the repeated measures ANOVA of rejection rates**

3   **(%)**

Main effect or interaction	F-value	df	p-value	partial eta^2
Offer*	194.07	1, 59	<0.001	0.77
Group*	10.56	1, 59	0.002	0.15
z-testosterone	0.45	1, 59	0.505	0.01
Offer x group*	5.44	1, 59	0.023	0.08
Offer x z-testosterone	0.10	1, 59	0.758	<0.01
Group x z-testosterone	1.54	1, 59	0.220	0.03
Offer x group x z-testosterone*	7.82	1, 59	0.007	0.12

4   *Significant effects (p<0.05) are marked with an asterisk

Study 2 – Political party supporters (n = 34). Results of the repeated measures ANOVA of rejection rates (%)

*Significant effects (p<0.05) are marked with an asterisk

1 **Table 2:**

2 **Study 2 – Political party supporters (n = 34). Results of the repeated measures ANOVA of rejection**
3 **rates (%)**

Main effect or interaction	F-value	df	p-value	partial eta^2
Offer*	72.26	1, 32	<0.001	0.69
Group*	19.83	1, 32	<0.001	0.38
z-testosterone	0.60	1, 32	0.443	0.02
Offer x group	0.06	1, 32	0.802	<0.01
Offer x z-testosterone	0.22	1, 32	0.642	<0.01
Group x z-testosterone	0.99	1, 32	0.327	0.03
Offer x group x z-testosterone	2.81	1, 32	0.104	0.08

4 *Significant effects (p<0.05) are marked with an asterisk

Study 2 – Political party supporters (n = 34). Results of the repeated measures ANOVA of cued recall hit rate (%)

*Significant effects (p<0.05) are marked with an asterisk

1 **Table 3:**

2 **Study 2 – Political party supporters (n = 34). Results of the repeated measures ANOVA of cued recall**
3 **hit rate (%)**

Main effect or interaction	F-value	df	p-value	partial eta^2
Offer	1.44	1, 32	0.238	0.04
Group	0.42	1, 32	0.521	0.01
z-testosterone	0.55	1, 32	0.464	0.02
Offer x group	0.04	1, 32	0.846	<0.01
Offer x z-testosterone*	5.57	1, 32	0.025	0.15
Group x z-testosterone	2.21	1, 32	0.147	0.06
Offer x group x z-testosterone	0.19	1, 32	0.670	0.01

4 *Significant effects (p<0.05) are marked with an asterisk

Meta-analysis of combined data from study 1 and 2 (n = 95) - Results of the repeated measures ANOVA of rejection rates (%) with between subjects factor "study"

*Significant effects (p<0.05) are marked with an asterisk

1 **Table 4:**

2 **Meta-analysis of combined data from study 1 and 2 (n = 95) - Results of the repeated measures**

3 **ANOVA of rejection rates (%) with between subjects factor "study"**

Main effect or interaction	F-value	df	p-value	partial eta^2
Offer*	222.29	1,92	<0.001	0.71
Group*	29.46	1,92	<0.001	0.24
z-testosterone	1.05	1,92	0.309	0.01
study	1.82	1,92	0.181	0.02
Offer x group	1.46	1,92	0.23	0.02
Offer x z-testosterone	0.26	1,92	0.609	<0.01
Offer x study*	8.00	1,92	0.006	0.08
Group x z-testosterone	2.54	1,92	0.114	0.03
Offer x group x z-testosterone*	10.65	1,92	0.002	0.10
Offer x group x study	2.59	1,92	0.111	0.03

4 *Significant effects (p<0.05) are marked with an asterisk