The presence of aggression cues inverts the relation between digit ratio (2D:4D) and prosocial behaviour in a dictator game

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Digit ratio (2D:4D) is a sexually dimorphic trait. Men have relatively shorter index (2D) compared to ring (4D) fingers than women. More masculine ratios are thought to be influenced by higher prenatal testosterone levels. In the present paper, we aim to show the context-dependency of the relation between 2D:4D and social behaviour. In two studies, we expose participants either to control or to aggression cues. Afterwards, they make a decision in a dictator game. Participants with low 2D:4D showed higher allocation levels (i.e. they were more prosocial) than participants with high 2D:4D in a neutral situation. However, this relationship inverts after exposure to an aggression cue. It turns out that in high 2D:4D people, aggression cues even increase prosocial behaviour. We call for future research which focuses on other plausible interactions between 2D:4D and context cues rather than on linear relations.

A lot of recent evidence suggests that the ratio between the length of the index (or second digit, 2D) and ring (or fourth digit, 4D) finger or ‘2D:4D’ reflects the influence of prenatal testosterone during development. A higher 2D:4D is thought to indicate a lower level of prenatal testosterone exposure: (a) It has been shown that the maternal waist to hip ratio is related to 2D:4D: women with high waist to hip ratio (a proxy for higher testosterone and lower estrogen concentrations; Evans, Hoffmann, Kalkhoff, & Kissebah, 1983) tended to have children with low 2D:4D (Manning, Trivers, Singh, & Thornhill, 1999). (b) Childhood behaviours which are thought to be related to prenatal testosterone (hyperactivity and poor social cognition) are associated with low 2D:4D (Williams, Greenhalgh, & Manning, 2003). (c) It has been found that humans with congenital adrenal hyperplasia, a trait associated with elevated fetal testosterone levels, have lower digit ratios compared to controls (Brown, Hines, Fane, & Breedlove, 1992).
It has already been known for a while that testosterone levels are much higher in male than female fetuses (e.g., Smail, Reyes, Winter, & Faiman, 1981; van de Beek, Thijsen, Cohen-Kettenis, van Goozen, & Buitelaar, 2004) and it has also been found in an amniocentesis that low 2D:4D is related to a high ratio of testosterone to estradiol (Lutchmaya, Baron-Cohen, Raggatt, Knickmeyer, & Manning, 2004). Consistently, 2D:4D is sexually dimorphic, with male 2D:4D lower on average than female (e.g., Bailey & Hurd, 2005; Lippa, 2006; Luxen & Buunk, 2005). In addition, females from opposite-sex twins have lower ratios compared to controls, which is consistent with the idea that they are affected by testosterone from their male twin (Van Anders, Vernon, & Wilbur, 2006). Also several behavioural traits that are more typically male such as high visuospatial ability (Kempel et al., 2005; Manning & Taylor, 2001), left hand preference (Manning, Trivers, Thornhill, & Singh, 2000), autism, and Asperger’s syndrome (Manning, Baron-Cohen, Wheelwright, & Sanders, 2001) have been shown to be associated with low values of 2D:4D.

Fink, Thanzami, Seydel, and Manning (2006) reported that men with higher grip strength had lower 2D:4D, and concluded that higher prenatal T exerts an organizational influence on strength. Consistently, the effect of prenatal testosterone on any behaviour might also be organizational in nature. However, there is also another possibility. Some research has suggested that 2D:4D is related to circulating testosterone levels (see e.g., Falter, Aroyo, & Davis, 2006; Manning, Scutt, Wilson, & Lewis-Jones, 1998) and that low 2D:4D people are more sensitive to circulating testosterone (Manning, Bundred, Newton, & Flanagan, 2003). Therefore, similar effects might be obtained in both research on circulating testosterone and 2D:4D. Both streams of research are not unrelated, and, as a result, both streams of research can at least provide hints at new hypotheses. Elevated circulating testosterone levels have been found to increase aggressive behaviour in a wide range of vertebrate species (Archer, 1988). Similarly, there also seems to be a relationship between testosterone and aggression in humans (e.g., see Archer, Graham-Kevan, & Davies, 2005; Book & Quinsey, 2005): Kouri et al. (1995) administered testosterone to participants and afterwards these participants could press a button to accumulate points exchangeable for money (non-aggressive response) or press another button to subtract points from a fictitious opponent (aggressive response). It turned out that testosterone administration resulted in a significantly higher level of aggressive responding compared to placebo. Consistently, Klinesmith, Kasser & McAndrew (2006) showed that an aggression cue (i.e., interaction with a gun) increased testosterone levels and that this increase in testosterone levels had an impact on the subjects’ aggressive behaviour.

Accordingly, a relationship has recently been shown between 2D:4D and aggression: In children, a low 2D:4D has been related to physical aggression in schoolboys (Manning & Wood, in Manning, 2002). Bailey and Hurd (2005) showed a negative relationship between male 2D:4D and trait physical aggression. Consistently, Kuepper & Hennig (2007) found a negative relationship between behavioural aggression and 2D:4D in men. In addition, McIntyre et al. (2007a) also showed that low 2D:4D was related to higher levels of aggression in a simulated war game. Benderlioglu and Nelson (2004) provided evidence that low female 2D:4D was associated with reactive aggression when sufficient provocation was present.

Although several studies point in the same direction, the relation tends to be weak at best. Most manuscripts on 2D:4D are focusing on linear relationships with personality traits and corresponding behaviours and thereby assume stable individual differences across situations. However, the debate about whether people are consistent across
situations has a long history in personality psychology (Larsen & Buss, 2005). Abundant evidence has documented that individual differences in social behaviours tend to be surprisingly variable across different situations (Bem & Allen, 1974; Mischel & Shoda, 1995). However, when closely observed, individuals are characterized by stable, distinctive, and highly meaningful patterns of variability in their actions, thoughts, and feelings across different types of situations (Mischel, 2004). These person–situation interactions are conceptualized in terms of what Mischel and Shoda (1995) call ‘if . . . then’ patterns of behavioural variability. This ‘if . . . then’ pattern might be illustrated by the following abstract example (Funder, 2006): while Person 1 and Person 2 have the same average level of behaviour X in situation A, the pattern of the expression of this behaviour across different situations might be different for the two individuals. For example, behaviour X might be equally likely for both persons in situation A, more likely for Person 1 than for Person 2 in situation B, but more likely for Person 2 than for Person 1 in situation C. Following this reasoning, perhaps the strength and even the sign of the relation between 2D:4D and certain behaviours may vary from situation to situation. Illustrative evidence in the literature on circulating testosterone indicates that correlates of circulating testosterone might be influenced by the social context (e.g. Booth & Osgood, 1993; Booth, Johnson, Granger, Crouter, & McHale, 2003; Rowe, Maughan, Worthman, Costello, & Angold, 2004) and a recent stream of research in the 2D:4D domain also hints at the importance of social context. Millet and Dewitte (2007) found that exposure to a violent music video reinforced the negative relation between 2D:4D and aggression. In a neutral situation, the relation was absent. After having seen the violent music video, 2D:4D was a moderate predictor of aggression ($r = -0.46$). A recent stream of research suggests that the strength of these relationships may indeed be context dependent to a substantial degree, and may even invert under the right circumstances. Van den Bergh and Dewitte (2006) showed in three studies that a subtle cue related to sex moderates the relationship between 2D:4D and economic decision-making in the ultimatum game. Men with lower digit ratios are tougher negotiators (i.e. they set higher respondent levels in the ultimatum game) in a neutral situation. However, when men with lower digit ratios were exposed to a sex cue (i.e. a non-nude female model wearing a bra/swimsuit/bikini) before their decision, they became milder negotiators (i.e. they set lower acceptance levels in the ultimatum game). Further evidence comes from Millet and Dewitte (2008), who found in two studies a significant negative relationship between male 2D:4D and impulsiveness (as measured by temporal discounting) in a ‘subordinate’ status position as induced by loss in a contest, but no significant relationship emerged after winning a contest. Summarized, the reviewed findings suggest that 2D:4D research should focus on interactions between 2D:4D and situational cues on relevant behaviour, which will also increase our understanding of the nature of 2D:4D.

In this paper, we want to explore the moderating role of 2D:4D in the reactivity to aggression cues on prosocial decision-making in a dictator game. There are reasons to believe that the manipulation of aggression cues may not only suppress but even reverse the relation between 2D:4D and cooperation in situations that offer a clear norm of fair conduct. Acting cooperatively in the public good game and setting higher responder levels in an ultimatum game reflect a strong preference for the fair share and are both related to a low 2D:4D in a neutral context (resp. Millet & Dewitte, 2006; Van den Bergh & Dewitte, 2006). If the negative relation between 2D:4D and cooperation is indeed a matter of a preference for social norms, we should replicate this finding in a dictator game, which is the first goal of the present paper. The procedure of a dictator game is similar to the ultimatum game but it is rid of reciprocal concerns. One player, the
'dictator', determines an allocation (split) of a fixed amount of money to himself and one other, the 'recipient'. The recipient in this case simply receives, so the recipient’s role is entirely passive (he has no strategic input into the outcome of the game as in the ultimatum game). Dictator and recipient do not know each other’s identity. As recipient’s behaviour is passive, we focus on the dictator decision. Allocations to the recipient typically range between 0 and 50% of the dictator’s endowment. This implies that splits approaching equal allocation (i.e. prosocial behaviour) reflect a strong preference for the fair share. Given the above-mentioned relationship between a low 2D:4D and fair decision-making in the ultimatum (Van den Bergh & Dewitte, 2006) and public good game (Millet & Dewitte, 2006) in a neutral context, we predict a negative relationship between 2D:4D and allocation levels in the dictator game, at least in the control condition without aggression cues (Hypothesis 1): the lower people’s 2D:4D, the more prosocially they will behave (in a neutral situation).

Low levels of allocation levels in dictator games can be considered as an act of aggression. Indeed Anderson and Bushman (2001) found, in a meta-analysis, that exposure to violent video games is negatively correlated with prosocial behaviour and positively with aggressive behaviour. Lower allocation levels in a dictator game reflect a higher level of antisocial behaviour. As recent evidence shows that 2D:4D and aggression are negatively related after exposure to an aggressive music video (Millet & Dewitte, 2007), we expect lower allocation levels in participants with a low 2D:4D as compared to participants with a high 2D:4D after exposure to an aggression cue. Consequentially, we predict a positive relationship between 2D:4D and allocation levels in the aggression condition (Hypothesis 2). Both hypotheses combine to the prediction that aggression cues will moderate the effect of 2D:4D on allocation levels in the dictator game. We conducted two similar experiments to test these predictions. For efficiency of reporting, we report the method of both studies together and highlight differences.

**Material and methods**

Hundred twenty-one undergraduate students (51 men) between 18 and 29 years of age participated in Study 1. Ninety-one undergraduate students (50 men) between 18 and 25 years of age participated in Study 2.

**Aggression manipulation**

**Study 1**

Participants were exposed to an aggressive or non-aggressive 4-minutes music video of the same band (resp. ‘Rosenrot’, Rammstein, 2005, track 3 and ‘Keine Lust’, Rammstein, 2004, track 4; cf. Millet & Dewitte, 2007). Next, to check our manipulation, we asked on a visual analog scale: (a) ‘To what extent has physical aggression been shown in the video?’ (0: not at all; 100: very much) and (b) ‘How aggressive does this video look in general?’ (0: not aggressive at all; 100: very aggressive). We used the average of both variables \(r = 0.78\) to obtain a manipulation check. The manipulation check indicated that the aggressive video \(M = 82.96, SD = 11.17\) was perceived as more aggressive than the non-aggressive video \(M = 35.88, SD = 23.77; t(119) = 14.05, p < .001\).

**Study 2**

We examined the effect of a different aggression cue by applying a priming technique, resulting in two conditions: a control condition without aggression references (neutral
prime) and an experimental condition with aggression references (aggression prime).
The aim of priming is to activate a concept in memory by exposing participants to words
related to that concept (Bargh & Chartrand, 1999). With this priming technique, we
simulated the presence versus absence of aggression references in the environment.
The participants first received a ‘language test’ that primed them with aggression-related
or with neutral words. The language test was a scrambled sentences task (Bargh &
Chartrand, 2000). Each sentence consisted of five words and participants were
instructed to construct a grammatically correct four-word sentence. In the aggression
prime condition, 12 of the 25 sentences in the test contained a word that was related to
aggression. The words were chosen in a way that ensured that the aggression-related
words would be used in the sentence composition. In the neutral prime condition the
aggression-related words were replaced by neutral words.

**Dependent measure: Dictator game**
After the manipulation, we introduced a dictator game. We used a hypothetical dictator
game, because the gain in convenience is not offset by a decrease in validity (Ben-Ner &
Levy, 2005). All participants were allocated to the ‘dictator’ position and had to answer
the following question on a visual analog scale ‘Suppose you are entitled to allocate 10€
between you and an arbitrary other in the laboratory that you do not know (e.g. If you
give 5€ to the other, you keep 5€ for yourself and If you give 3€ to the other, you keep 7€
for yourself.). How much would you give to this other?’ Respondents answered by
clicking on a line on the screen, indicating the amount of money they would give, from 0
(left-end) to 10€ (right-end). We coded the positions on the line from 0 (left-end) to 100
(right-end) in the computer program (this was not visible for the participants).

**Assessment of 2D:4D**
Afterwards, participants’ right-hand was scanned to measure finger lengths. Participants
placed their hand palm on the glass plate of a scanner and we ensured that details of
major creases could be seen on the scans. Finger lengths were measured from the
ventral proximal crease to the fingertip by means of the Adobe® Photoshop 7 measure
tool. When there was a band of creases at the base of the digit we measured from the
most proximal crease (cf. Millet and Dewitte’s (2006) procedure). To check for
reliability, a second independent rater also measured finger lengths. Both ratios were in
each study highly correlated (Study 1: \( r_{2D:4D} = .930 \) and Study 2: \( r_{2D:4D} = .966 \)).

**Statistical analysis**
Before starting further analyses, a Mahalanobis distance (within gender and condition)
was calculated for each participant (based on 2D:4D and dictator game decision) to
determine outlying participants in each study (see Barnett & Toby, 1984; Hawkins,
1980). Participants with a distance higher than the .995 fractile were considered
outliers. Accordingly, we identified two outliers in Study 1 and one outlier in Study 2
which we excluded from analyses. First, we start by testing gender differences in 2D:4D
by using a two-tailed \( t \) test. In both samples, a general linear model (GLM) analysis was

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used for the analysis. The GLM combines features of ANOVA and regression based models and can therefore handle any combination of continuous and discrete variables. In the analysis, condition (aggressive/control) and gender (man/woman) were entered as discrete between-subjects factors, whereas 2D:4D was entered as a continuous between-subjects factor. Our dependent measure was participants’ allocation of resources in the dictator game.

The expected interaction will be further inspected: (1) by exploring correlations between allocation and 2D:4D for the different aggression cue conditions separately and (2) by exploring simple main effects for empirically determined low and high 2D:4D groups. Note that the correlations we report are always partial correlations controlling for gender. In line with literature, we separated our samples into three 2D:4D groups based on the lower (below percentile 33.3), middle, and upper (above percentile 66.6) thirds of the distribution and left out the middle group (see e.g. Giesler, Josephs, & Swann, 1996).

Results

Study 1

In accordance with previous literature (e.g. Lippa, 2006; Manning, 2002; Romano, Leoni, & Saino, 2006), 2D:4D was significantly lower for men \((M = 0.948\text{ and } SD = 0.030)\) than for women \((M = 0.964\text{ and } SD = 0.029; t(119) = 2.90, p < .01)\). More importantly, we found a significant interaction between 2D:4D and condition \((F(1, 111) = 8.00, p < .01, \eta^2 = .07)\) on allocation levels in the dictator game. In accordance with hypothesis 1, the correlation between 2D:4D and allocation level was negative in the control condition \((r = -.29, p < .05)\). Thus, in a neutral situation, low 2D:4D people are more likely to act prosocially in the dictator game than high 2D:4D people. However, in accordance with hypothesis 2, there was a positive relationship between 2D:4D and allocation level in the aggression condition, although the correlation was just above the conventional significance cut off \((r = .23, p = .08)\). Thus, after an aggression prime, low 2D:4D people seem to be less likely to act prosocially in the dictator game than high 2D:4D people. Main and interaction effects of gender on allocation levels did not approach significance \((all F_s < 0.43, p > .51)\). The ANOVA with the two extreme 2D:4D groups revealed that low 2D:4D people tended to give more in the control \((M = 37.33, SD = 15.46)\) than in the aggression \((M = 26.00, SD = 18.47)\) condition \((F(1, 72) = 3.56, p = .06)\). In contrast, high 2D:4D people tended to give less in the control \((M = 28.08, SD = 20.02)\) than in the aggression \((M = 41.12, SD = 21.72)\) condition \((F(1, 72) = 3.89, p = .05; \text{see Figure 1})\), a pattern we come back to in the general discussion.

Study 2

In accordance with previous literature (e.g. Lippa, 2006; Manning, 2002; Romano \textit{et al.}, 2006), 2D:4D tended to be lower for men \((M = 0.956\text{ and } SD = 0.050)\) than for women \((M = 0.967\text{ and } SD = 0.032; t(89) = 1.74, p < .09)\). More importantly, we found a significant interaction between 2D:4D and condition \((F(1, 82) = 7.79, p < .01, \eta^2 = .09)\) on allocation levels in the dictator game. In accordance with hypothesis 1, there was a negative relationship between 2D:4D and allocation level in the control condition, although the correlation was just above the conventional significance cut off
of .05 ($r = -.26, p = .08$). However, in accordance with hypothesis 2, the correlation between 2D:4D and allocation level was positive in the aggression condition ($r = .35, p < .05$). Main and interaction effects of gender on allocation levels did not approach significance (all $Fs < 0.43, p > .51$). The ANOVA with extreme 2D:4D groups revealed that low 2D:4D people tended to give more in the control ($M = 33.20, SD = 20.38$) than in the aggression ($M = 19.13, SD = 23.55$) condition ($F(1, 52) = 2.96, p = .09$). In contrast, high 2D:4D people tended to give less in the control ($M = 18.96, SD = 18.95$) than in the aggression ($M = 32.21, SD = 20.07$) condition ($F(1, 52) = 2.94, p = .09$; see Figure 2).

**Discussion**

The ratio of the length of the second (index) to the fourth (ring) finger (2D:4D), a putative negative correlate of prenatal testosterone, has recently become a popular variable for studying effects of prenatal androgenisation in humans (Hönekopp, Bartholdt, Beier, & Liebert, 2007). We show in a neutral context that 2D:4D is negatively related to prosocial ‘fairness-concerned’ decisions in a dictator game: our data suggest that, compared to high 2D:4D people, people with a low 2D:4D (an index of high prenatal testosterone exposure) seem to be more likely to act prosocially in the control condition. This is consistent with the findings of Millet and Dewitte (2006) that people with a lower 2D:4D have a preference for the normative fair split in a public good game and with the evidence of Van den Bergh and Dewitte (2006) that men with a lower 2D:4D set minimum acceptance levels that are closer to the equal split. The present manuscript gives more credibility to the interpretation of the findings of both papers in terms of a negative relation between 2D:4D and willingness to abide with the social
norm (= giving the fair share). In addition, we manipulated the presence of an aggression cue in the two studies. We show that the relationship between 2D:4D and prosocial behaviour in the dictator game is inverted when participants are exposed to an aggression cue. When participants with a low 2D:4D have been exposed to an aggression cue, they are more likely to abandon fair decision-making and to act in an antisocial (‘aggressive’) manner (cf. Millet & Dewitte, 2007). The fact that the moderation does not depend on the specific manipulation testifies to the robustness of our interpretation in terms of the aggressive content of the cues. Consequently, our studies demonstrate that a subtle cue related to aggression is able to change not only the strength, but also the sign of the relationship between 2D:4D and prosocial behaviour in the dictator game.

Until now, most research has been devoted to exploring linear relationships between 2D:4D and other variables and typically yielded modest correlations. It remains unclear how important 2D:4D really is in explaining human behaviour. In our opinion, an important avenue for future research is focusing on interactions with situational cues. We agree with and add support to the remark of Van den Bergh and Dewitte (2006) and Millet and Dewitte (2007, 2008) that context effects may be responsible for the fact that some results are hard to replicate. Accordingly, we call for future research with a focus on interactions between 2D:4D and context cues which may attenuate or strengthen the link between 2D:4D, other personality variables, and relevant human behaviour.

Across the two studies we found that high 2D:4D people tend to become more prosocial after exposure to aggression cues, which goes against the general main effect that aggression leads to aggression, which has been supported by a lot of evidence (see e.g. Bushman & Anderson, 2001, 2002), and which often inspires public policy recommendations with respect to the occurrence of violence in video games or music.
videos. Understanding why high 2D:4D people become more prosocial after exposure to aggression cues may inspire the design of environments in which the aggression-aggression link is suppressed or inverted for the majority of people. Our findings trigger the question what might drive the positive effect of an aggression cue on prosocial behaviour. We consider the possibility that an aggressive response to an aggressive act might be maladaptive in many cases, for instance when your opponent is stronger. There is some evidence that low 2D:4D men are stronger than high 2D:4D men (Fink et al., 2006). When you are not strong enough, pleasing the aggressor may be more adaptive than fighting him or her (cf. the proverb ‘if you can’t beat them, join them’). With respect to the mechanisms, the positive relationship between 2D:4D and agreeableness as reported by Luxen and Buunk (2005) may support the interpretation of our surprising finding. It has been shown that agreeable individuals are able to short-circuit the cue-aggression sequence, and that they might do so by recruiting prosocial thoughts in response to aggression primes (Meier, Robinson, & Wilkowski, 2006). In our studies, high 2D:4D people might recruit prosocial thoughts in reaction to the aggression prime. As a consequence, these prosocial thoughts may not only counteract the aggression prime effect, but even overrule the aggressive reaction as they became more prosocial after exposure to this prime.

In search for an explanation for the pattern of our findings, we also would like to give attention to a possible role of estradiol. The findings of prior studies point to a positive relationship between serum estradiol concentration in adults and 2D:4D (Manning et al., 1998; McIntyre, Chapman, Lipson, & Ellison, 2007b). Lutchmaya et al. (2004) also found that the ratio of testosterone to estradiol in amniotic fluid is significantly related to 2D:4D: low 2D:4D ratios are associated with high fetal testosterone in relation to fetal estradiol levels, and high values of 2D:4D with low fetal testosterone and high fetal estradiol levels. These findings point to the possibility that individuals with low 2D:4D respond to aggression (and maybe other, such as sexual) cues by reflexively increasing T relative to E. Individuals with high 2D:4D may respond to aggression cues by decreasing T relative to E. Thus, a logical next step would be to determine whether 2D:4D predicts the production of both T and/or E when individuals are exposed to cues of an aggressive nature.

Another possibility that has to be taken into account is the idea that lower allocation levels in the dictator game might not necessarily signal aggression, but also dominance. This is consistent with the view of Mazur and Booth (1998) who emphasized the possibility that testosterone might be not related to aggression per se, but to the achievement or maintenance of high social status. Accordingly, it has been found that testosterone is related to leadership rather than to antisocial behaviour in boys who definitely did not have deviant peers, which suggests that high testosterone might be associated with socially valued characteristics in prosocial environments (Rowe et al., 2004). Recent findings of Millet and Dewitte (2008) also point to the importance of social status for low 2D:4D individuals. Interpreting our findings from a social dominance perspective, both higher levels of prosocial behaviour in a neutral situation and lower levels of prosocial behaviour in an aggressive environment might serve as a manner to maintain or obtain a high social status in that specific environment, which might be an interesting avenue for future research.

It seems also valuable to investigate the role of circulating testosterone levels in the presented effects as 2D:4D is related to circulating testosterone levels (see e.g. Falter et al., 2006; Manning et al., 1998). It has been shown that an aggression cue might induce an increase in testosterone levels (Klinesmith, Kasser, & McAndrew, 2006) and
that low 2D:4D people are also more sensitive to testosterone (Manning et al., 2003). However, it seems to be difficult to reconcile increases in circulating testosterone levels with our pattern of results as high 2D:4D people become more prosocial after exposure to an aggression cue. Nevertheless, research looking into the interaction between circulating testosterone levels, 2D:4D, and aggression cues in relation to agreeableness and prosocial thoughts (or other plausible mechanisms) seems to be an interesting and fruitful approach for future work.

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