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Explaining Individual Differences in Advantageous Inequity Aversion by Social-Affective Trait Dimensions and Family Environment

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Abstract

Humans are averse to both having less (i.e., disadvantageous inequity aversion [IA]) and having more than others (i.e., advantageous IA). However, the social-affective traits that drive individual differences in IA are not well understood. Here, by combining a modified dictator game and a computational model, we found in a sample of incarcerated adolescents ($N = 67$) that callous-unemotional traits were specifically associated with low advantageous but not disadvantageous IA. We replicated and extended the finding in a large-scale university student sample ($N = 2,250$) by adopting a dimensional approach to social-affective trait measures. We showed that advantageous IA was strongly and negatively associated with a trait dimension characterized by callousness and lack of social emotions (e.g., guilt and compassion). A supportive family environment negatively correlated with this trait dimension and positively with advantageous IA. These results identify a core set of social-affective dimensions specifically associated with advantageous IA.

Keywords

dictator game, computational model, advantageous inequity aversion, dimensional approach, family atmosphere

Humans are inequity averse. There are two types of inequity aversion (IA; Charness & Rabin, 2002; Fehr & Schmidt, 1999): Advantageous IA refers to negative responses to receiving more than others, while disadvantageous IA refers to negative responses to receiving less than others. Although both types of IA could lead to a state of equality, advantageous IA is regarded as a hallmark of a full-blown sense of fairness and morality (Tomasello, 2019). Some theorize that advantageous IA is a manifestation of a joint commitment and a sense of obligation that older children and adult human beings feel toward other members of the same moral community (Ci, 2009). This feeling serves as a cognitive and affective mechanism that curbs individuals' selfish motivations in the interest of harmonious interpersonal relationships and the common good (Tomasello, 2019, 2020).

Developmental and comparative studies have demonstrated that relative to disadvantageous IA, advantageous IA develops later in life (McAuliffe et al., 2017) and has only been consistently observed in humans (Brosnan & de Waal, 2014). Consistently, neuroimaging research has shown that advantageous and disadvantageous IA are associated with distinct underlying neural processes (Fliessbach et al., 2012; Gao et al., 2018; Güroğlu et al., 2014; R. Yu et al., 2014). These lines of research indicate that advantageous and disadvantageous IA may rely on

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dissociable underlying neurocognitive mechanisms (Gao et al., 2018; R. Yu et al., 2014). One way to further probe the underlying mechanisms is to examine the social and affective factors associated with advantageous and disadvantageous IA.

Although prior research on fairness-related behaviors and IA have documented individual differences of advantageous and disadvantageous IA (Engel, 2011; Gao et al., 2018; Tisserand et al., 2015; R. Yu et al., 2014), systematic investigations into the core social and affective factors that may distinguish advantageous and disadvantageous IA have been lacking. One possibility is that these two types of IA rely differently on the ability and tendency to take others' well-being into consideration (Tsoi & McAuliffe, 2020). Specifically, we hypothesized that other-regarding social-affective traits (e.g., empathic concern and guilt) and their antithesis (e.g., callousness and interpersonal manipulation) are associated with advantageous IA but not disadvantageous IA. We note that advantageous and disadvantageous IA in the strictest sense is a description of certain behavioral patterns in a specific economic game, and it may or may not be associated with aversive emotional responses (Binmore & Shaked, 2010; Fehr & Schmidt, 2010). We use these terms in their descriptive sense.

Other-regarding social-affective traits, such as empathic concern and guilt proneness, predispose individuals to be more attentive to the distress of others and motivate altruistic behaviors (Blair & Mitchell, 2009; Kimonis et al., 2019; Thielmann et al., 2020). For example, past research has shown that individuals with high guilt proneness are less likely to commit unethical behaviors (e.g., lying in negotiation) and are more likely to take reparative measures after transgression (Cohen et al., 2012; Cohen et al., 2011; Giner-Sorolla et al., 2011; Tangney et al., 2000). Similarly, numerous empirical studies have offered supportive evidence for the empathy-altruism hypothesis, which posits that at least some forms of empathy motivate observers to help victims for the sake of the victims' well-being (Batson, 2011; Batson et al., 2007; Davis, 2015; Dovidio et al., 1990; Penner et al., 2005; Stocks et al., 2009; Wilhelm & Bekkers, 2010; Zaki, 2019, 2020).

In contrast, deficits in prosocial affective traits, both in clinical and general populations, have been associated with antisocial behaviors and a lack of care and altruistic responses to others' distress (Blair, 2008, 2013; Blair et al., 2005; Glenn & Raine, 2014; Gregory et al., 2015; Yang et al., 2015). For instance, in general adult populations, self-reported psychopathic features have been associated with higher tendency to gain financial reward for oneself by harming another person in laboratory settings (Crockett et al., 2014), as well as more violent/aggressive behaviors in everyday life (Neumann & Hare, 2008). In adolescents, callous-unemotional (CU) traits have been shown to predict conduct problems, criminal offending, and delinquency (Frick & Viding, 2009). A recent meta-analysis reveals that CU traits are strongly and negatively associated with prosocial behavioral traits (Waller et al., 2020).

Although past research has established the link between social-affective traits and prosocial behaviors (or the lack thereof), two questions remain unclear. First, these previous studies have been primarily focused on behavioral outcomes and therefore remain agnostic about what underlying cognitive processes are influenced by prosocial emotions and social-affective traits. A seemingly prosocial behavior (e.g., allocating resources fairly) may be driven by multiple, sometimes conflicting underlying cognitive processes (e.g., an aversion toward inequality, guilt when getting more than one should, envy when the other party receives more than oneself). Specifically, in one of the most widely adopted experimental tasks for probing prosociality, namely, the dictator game (DG; Engel, 2011; Forsythe et al., 1994), participants decide how they want a pool of money to be divided between themselves and a receiver, while the receiver has to accept what is allocated to them. In a modified version of DG, participants face a series of binary choice in which one option is always a fixed fair division, while in the other option, the amount for the participants and the amount for the receiver are orthogonalized (for details, see Methods and Materials section). Combined with an established computational model for IA, this paradigm has the advantage of statistically dissociating advantageous and disadvantageous IA, thereby allowing us to examine the factors that drive individual differences in these two latent cognitive processes (Fehr & Schmidt, 1999; Gao et al., 2018).

Second, past research on the individual differences in fairness-related behaviors with adult populations has largely overlooked the link between the social-affective traits predictive of prosocial behaviors and features of the environment where these traits develop. The environments where individuals socialize (e.g., the individuals' family environment) play a key role in the development of the individuals' personality (Di Pierro et al., 2012; Hoffman, 1991; Loehlin & Nichols, 2012). An understanding of potential environmental antecedents of these social-affective traits may have implications for interventions aimed to bolster the development of the traits that are conducive to prosocial behaviors and discourage those that may hinder prosocial behaviors (Singer & Klimecki, 2014). To fill this gap, we explored the effect of a potential environmental factor—the extent to which family members are encouraged to express their thoughts and feelings, support, care, and empathize with each other (Ferguson & Stegge, 1995; Hinde, 2002; Stuewig & McCloskey, 2005; Tangney & Dearing, 2003). Indirect evidence from research on the relationships between parenting style and children's and adolescents' empathy-related traits, guilt proneness, and prosociality suggests that positive and emotionally responsive parenting facilitates the development of empathy, care, and a sense of guilt (Eisenberg & Valiente, 2002; Kochanska, 1991, 1997; López et al., 2008; Miklikowska et al., 2011). In this study, we test the prediction that a supportive family environment, as measured by a self-reported questionnaire (see Methods and Materials section for detail; Kang et al., 2001), is associated with more other-regarding social-affective traits, which in turn results in higher advantageous, but not disadvantageous, IA.

We carried out two studies to better understand the social-affective factors that drive individual differences in

advantageous (relative to disadvantageous) IA. In Study 1, we administered the modified DG to a sample of incarcerated adolescents ($N = 67$). The rationale of including this sample was to maximize the range of the distribution of CU traits, as it has been demonstrated that these traits have a wider distribution in institutionalized samples than in the general population (Byrd et al., 2013; Essau et al., 2006; Kimonis et al., 2008; Pihet et al., 2015). In Study 2, we aimed to replicate and extend the findings from Study 1 in a large sample of undergraduate students ($N = 2{,}250$) in a Chinese university. The size of this sample allows us to adopt a dimensional (or "trans-diagnostic") approach to personality traits in computational psychiatry (Gillan et al., 2016), running factor analysis on individual items from various partially overlapping questionnaires and using the resultant factor scores, rather than questionnaire total scores, as predictors of the latent cognitive processes underlying the DG choices.

Methods and Materials

Participants

Study 1. To examine how CU trait modulates prosocial motivation, we paid a visit to a correctional institution and administered a resource allocation task (modified DG; see below) to a group of 67 incarcerated male adolescent participants (mean age: 16.3 $\pm$ 0.8, age range = 14–17) in the institution. In the country where the data were collected, a correctional institution is a type of confined facility for juvenile offenders under the age of 18. The types of criminal offenses this sample of participants committed can be found in Online Supplemental Table S1. The procedure used in the present study was approved by the authors' university ethics committee and was administered as part of the institution's psychological intervention program. The size of the incarcerated sample was determined by who took part in the institution's psychological intervention program and was available on the day of data collection.

Study 2. First-year undergraduate students at a university in southeast China participated in the study as part of the university's mental health prescreening. The study was approved by the authors' university ethics committee. Participants gave their consent electronically prior to the experiment. A total of 4,888 participants completed the study as part of their mental health assessment program mandated by their university authority. Among them, 2,638 participants were excluded from data analysis due to failure in comprehension or attention check questions, leaving a sample of $N = 2{,}250$ (mean age: 18.2 $\pm$ 0.7; age range = 17–22; 1,679 were female; see below for detailed exclusion criteria). Note that adopting different exclusion criteria does not change the pattern of results (see Online Supplementary Material, p. 8). The sample size was determined by the number of first-year undergraduate students at the university where the data collection took place.

Table 1. Demographic and Personality Measures of the High and Low Callous-Unemotional (CU) Groups.

Measure	High CU *M* (*SD*)	Low CU *M* (*SD*)	*t* Value	*p* Value
Age	16.3 (0.8)	16.3 (0.8)	−0.18	.86
Education	2.1 (1.1)	2.0 (0.5)	0.30	.77
Father education	1.8 (1.0)	1.9 (1.3)	−0.56	.58
Mother education	2.0 (1.5)	1.6 (0.7)	1.24	.22
Family gross income	3.3 (1.5)	3.7 (1.4)	−1.02	.31
Callous-unemotional	10.3 (1.5)	8.3 (2.1)	4.63	<.001
IRI-perspective taking	1.9 (0.6)	2.2 (0.5)	−2.08	.04
IRI-empathic concern	2.1 (0.6)	2.6 (0.4)	−3.98	<.001
IRI-personal distress	2.2 (0.5)	2.1 (0.5)	0.98	.33

Note. IRI = Interpersonal Reactivity Index.

Experimental Design and Measurements

Overview. For Study 1, participants' CU traits were assessed prior to this experiment session via interviews conducted by trained research assistants (Essau et al., 2006; Kimonis et al., 2008; the Chinese version of the assessment scale was adopted from Chen [2013]). A high CU group ($N = 32$) and a low CU group ($N = 35$) were defined based on median split of the overall CU score (Table 1; cf. Pihet et al., 2015). A computer program was installed in the computers in the testing room. This program would present the DG task to the participants and record their responses (i.e., button press). For Study 2, participants first performed the modified DG task with an anonymous co-player who was also a participant in the same study session. The participants then completed several personality questionnaires and provided demographic information (see below for details). The task and the questionnaires were computerized and presented to the participants via an online survey platform (https://www.wjx.cn/).

Modified DG. We instructed the participants that they would be paired with an anonymous co-player in the same room. The participants' task was to allocate monetary points between themselves (hereafter, self) and the anonymous co-player (hereafter, other), in the form of binary choice (Figure 1; for participant payment, please see Online Supplementary Material, p. 6). Specifically, one of the two options always offered 10 points to each player. The other option came from a set of test options varying in the payoff of self (*Ms*) and the payoff of other (*Mo*; see Online Supplemental Figure S1 for the full list of options used in this study). Participants made a series of 50 choices and one of them would be randomly selected and made real at the end of the experiment. From the participants' perspective, in 48 of the 50 trials, the test option was either advantageous (i.e., $Ms > Mo$; Figure 1a) or disadvantageous (i.e., $Ms < Mo$; Figure 1b). The test options were generated, such that *Ms*, *Mo*, and the absolute inequity (i.e., $|Ms - Mo|$) were decorrelated (rs < .07, ps > .66; Gao et al., 2018; Saez et al., 2015). Two of the 50 trials were catch trials where

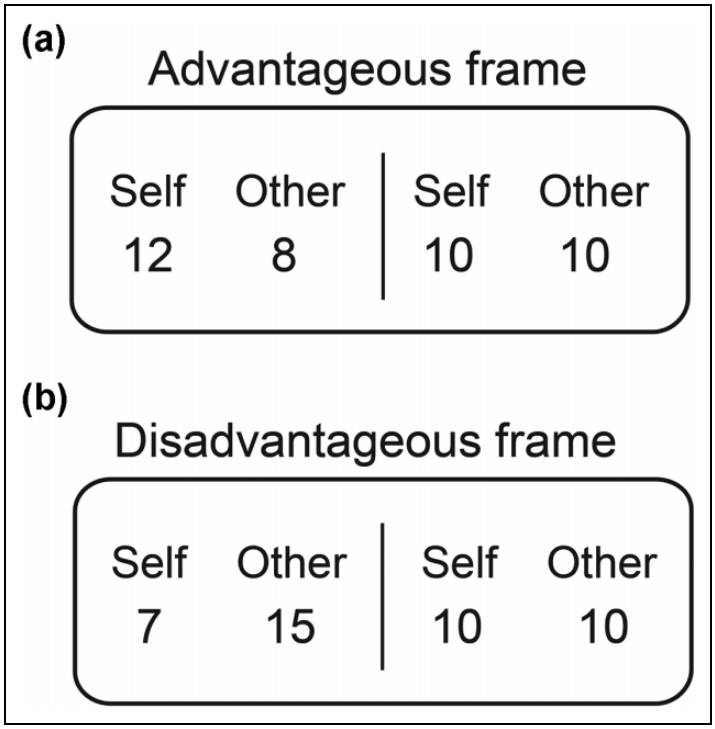

Figure 1. Binary choice in the modified dictator game. One of the two options was always a fixed, fair division where both self and other would get 10 points. The other option came from a set of test options varying in the payoff of the participants themselves (*Ms*) and the payoff of other (*Mo*). Example trials from the advantageous frame (a) and the disadvantageous frame (b) are shown.

the test option was also a fair division. Specifically, $Ms = Mo = 2$ for one, and $Ms = Mo = 18$ for the other.

Computational modeling of choice in the modified DG. We modeled participants' trial-by-trial choices by adapting a two-player IA model (Fehr & Schmidt, 1999; see also Charness & Rabin, 2002) that had been validated for these types of binary choice task (Gao et al., 2018; Sáez et al., 2015). This allowed us to quantitatively isolate two motivations underlying participants' choices:

$$U = Ms - q \cdot \alpha \cdot (Mo - Ms) - p \cdot \beta \cdot (Ms - Mo),$$

where *Ms* and *Mo* are participants' payoff and the recipient's payoff in a given option, respectively. p and q indicate whether the option involves advantageous inequity or "aheadness" ($p = 1$ when $Ms > Mo$, $p = 0$ otherwise) or disadvantageous inequity or "behindness" ($q = 1$ when $Mo > Ms$, $q = 0$ otherwise). Note that in some literature, the meaning of p and q is reversed (Gao et al., 2018). α and β are free parameters indicating the degree of disadvantageous IA and advantageous IA, respectively. We used a softmax function to convert utility difference between the two options ($\Delta U = U_{\text{unequal}} - U_{\text{equal}}$) into probability of choosing the unequal option:

$$P(\text{unequal}) = \frac{1}{1 + e^{-\lambda \Delta U}}.$$

Here, the inverse temperature parameter (λ) captures the steepness of the softmax function: Higher value means that the softmax curve is closer to a step function, which in turn indicates that the participant's choice is more sensitive to the change in utility difference. Given the relatively small sample and noisier choice behaviors of the incarcerated sample (see Online Supplementary Material, p. 7), we only estimated α and β at the group level for Study 1 (cf., Gao et al., 2018; Zhu et al., 2014). For Study 2, we estimated α and β for each individual participant. A maximal likelihood estimation was used to find the combination of free parameters that best fit the observations. Two hundred iterations were performed for the group-level estimation (Study 1), while 50 iterations were performed for each individual participant (Study 2). The computational model quite accurately predicted the participants' choices (69% for the high CU participants, 68% for the low CU participants, and 85% for the college student sample).

Self-reported personality questionnaires and demographic information. For Study 1, participants completed the Interpersonal Reactivity Index (IRI; Davis, 1983) on a separate day prior to the experimental session. For Study 2, participants completed a battery of personality questionnaires assessing their social-affective traits, including the IRI, a 30-item Self-Reported Psychopathy Scale (Bartels & Pizarro, 2011), the Guilt and Shame Proneness Scale (GASP; Cohen et al., 2011; Young et al., 2019), the Self-Compassion Scale (Neff, 2003), and the Toronto Alexithymia Scale (Bagby et al., 1994). Participants' attitudes and beliefs regarding justice and fairness were assessed using the General Belief in a Just World Scale

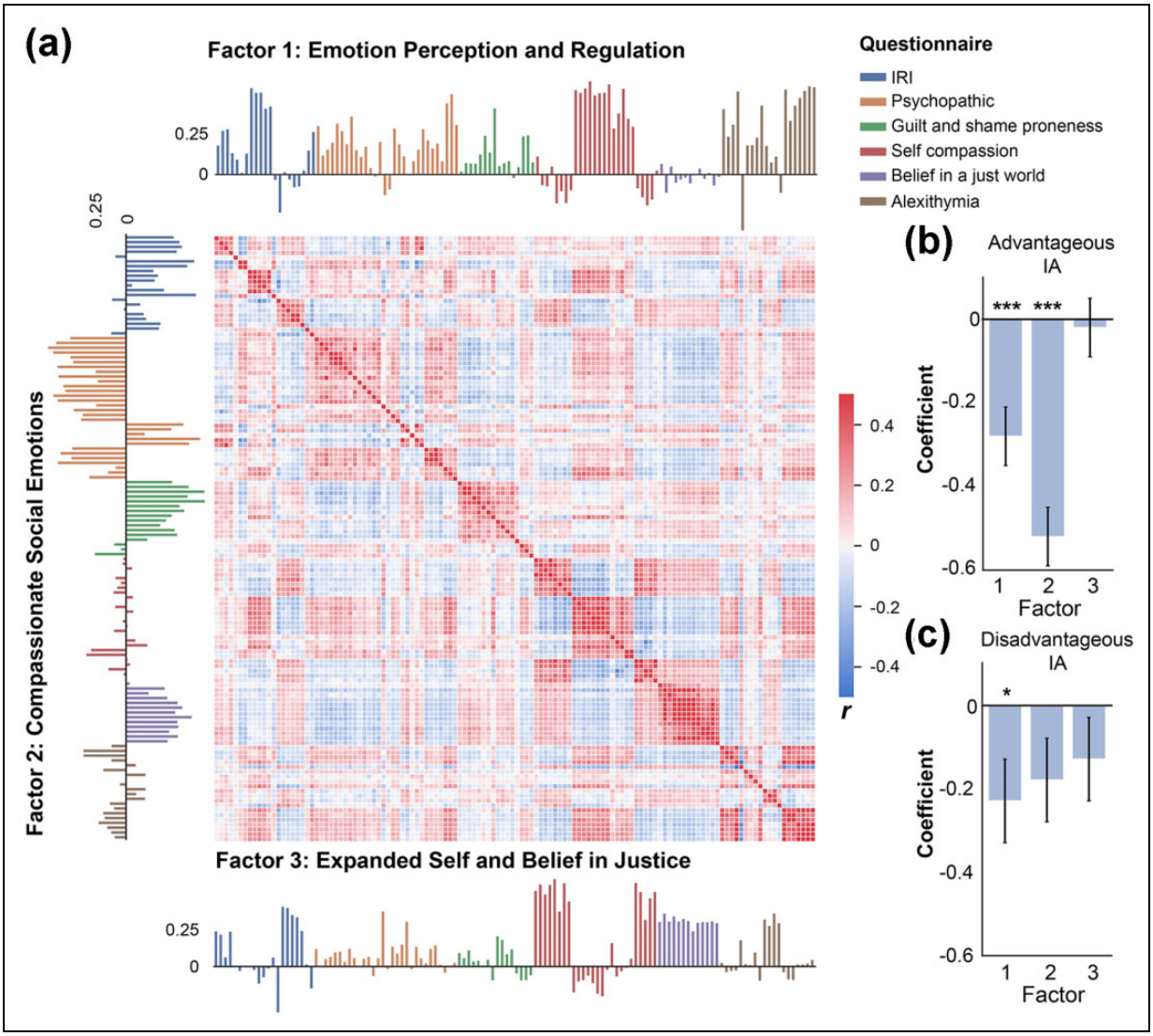

Figure 2. Results of factor analysis. (a) The correlation matrix of 126 individual questionnaire items and loadings of each item for the three factors. (b and c) Factor scores of each participant were entered into linear regression models for advantageous and disadvantageous inequity aversion (IA) parameters. Advantageous IA was negatively associated Factors 1 and 2. Disadvantageous IA was only significantly associated with Factor 1. Error bars indicate s.e.m. *$p < .05$. ***$p < .001$. s.e.m. = standard error of the mean.

(Dalbert, 1999). The Self-Rating Scale of Systemic Family Dynamics (SSFD; Kang et al., 2001) was included to assess participants' perception of their family environment. The SSFD characterizes the organization and patterns of communication and interaction within a family. The scale has four dimensions (see Online Supplementary Material, p. 2, for the original Chinese version and its English translation) and we specifically focused on the Family Atmosphere (FA) subscale, which indicates a caring and supportive FA (e.g., "My family members can easily express warmth and concern for each other"). Participants also provided demographic information, including their age, sex assignment at birth, whether they are an only child in their family, the highest education of their parents, the environment where they grow up (urban vs. rural), and their subjective social economic status. These variables were used as covariates in data analyses.

Data exclusion criteria for Study 2. Initially, we included three mechanisms to make sure that the participants understand the DG task and maintain sufficient attention throughout the task (Online Supplementary Material, p. 5). First, after the participants read the instruction for the DG task, they need to answer eight comprehension questions about the DG task. Second, we included two "catch trials" in the DG task, where one option is obviously more profitable than the other both for the participant (i.e., decider) and the recipient. Third, we inserted three attention check questions in the personality questionnaires that were obvious and objective. Participants who correctly answered all the comprehension check questions in the DG task and the attention checks in the personality questionnaires were included in data analysis. Our results are almost identical under different data inclusion criteria (Online Supplementary Material, p. 8).

Table 2. Associations Between Social-Affective Trait Dimensions and Inequity Aversion Parameters.

Variables	*B* (*SE*) and CI for Advantageous IA	*B* (*SE*) and CI for Disadvantageous IA	*B* (*SE*) and CI for Inverse Temperature
Factor 1: Emotion perception and regulation	−.28 (.07)*** [−0.42, −0.13]	−0.23 (.10)* [−0.42, −0.04]	.03 (.01)* [0.01, 0.05]
Factor 2: Compassionate social emotions	−.52 (.07)*** [−0.66, −0.38]	−0.16 (.10) [−0.35, 0.30]	.06 (.01)*** [0.03, 0.08]
Factor 3: Expanded self and belief in justice	−.02 (.07) [−0.17, 0.12]	−0.12 (.10) [−0.32, 0.07]	.01 (.01) [−0.01, 0.04]
Sex (male > female)	−.52 (.16)** [−0.84, −0.20]	−1.44 (.22)*** [−1.87, −1.007]	.19 (.03)*** [0.14, 0.24]
Age	.12 (.11) [−0.09, 0.33]	0.07 (.15) [−0.22, 0.35]	−.03 (.02) [−0.06, 0.01]
Single child (single > nonsingle)	−.15 (.15) [−0.44, 0.13]	−0.53 (.20)** [−0.91, −0.15]	.05 (.02)* [0.01, 0.09]
Urban environment (urban > rural)	.11 (.17) [−0.21, 0.44]	0.07 (.22) [−0.37, 0.51]	−.01 (.03) [−0.06, 0.04]
Father education	−.08 (.07) [−0.22, 0.06]	−0.21 (.10)* [−0.40, −0.03]	.02 (.01) [−0.06, 0.04]
Mother education	−.08 (.07) [−0.22, 0.06]	0.00 (.10) [−0.18, 0.19]	−.01 (.01) [−0.03, 0.01]
Socioeconomic status	−.05 (.05) [−0.15, 0.05]	0.12 (.07) [−0.02, 0.26]	−.00 (.01) [−0.02, 0.01]
N	2,250	2,250	2,250
R^2 [a]	.05	.05	.07

[a] Robust linear regression relies on weighted least squares, with the weights determined by an iterative process. The R^2 for robust linear regression should be interpreted with caution. Here, we reported the R^2 of corresponding standard linear mixed-effects models as an approximation. CI = confidence interval.
*p < .05. **p < .01. ***p < .001.

Results

All deidentified data and data analysis codes related to the results reported in this article can be accessed at https://osf.io/fge9v. We have reported all measures, conditions, data exclusions, and how we determined the sample sizes.

In Study 1, we tested the hypothesis that high CU trait is associated with advantageous, but not disadvantageous, IA. Supporting this hypothesis, the advantageous IA of the high CU group ($M \pm SD = 0.75 \pm 0.07$, credible interval [89% highest density interval] = [0.662, 0.863]) was almost 50% lower than that of the low CU group (1.14 ± 0.09, credible interval = [1.007, 1.253]; Online Supplemental Figure S2a and Table S2). This was not the case for disadvantageous IA (high CU group: 0.52 ± 0.10, credible interval = [0.344, 0.655]; low CU group: 0.59 ± 0.12, credible interval = [0.420, 0.773]; Online Supplemental Figure S2b). This pattern indicates that getting more than one's fair share is less of a concern for individuals with high CU than those with low CU, but they are equally averse to getting less than their fair share. The inverse temperature parameter of the high CU group (0.13 ± 0.02, credible interval = [0.116, 0.168]) was higher than that of the low CU group (0.10 ± 0.01, credible interval = [0.079, 0.115]; Online Supplemental Figure S2c).

In Study 2, we aimed to (1) conceptually replicate the differential effects of callousness-related traits on advantageous versus disadvantageous IA and (2) to examine the specificity of the effects of callousness-related traits in a larger noninstitutionalized sample. We found that the scores of the Callous Affect and Interpersonal Manipulation subscales of the self-reported psychopathy questionnaire (Bartels & Pizarro, 2011) were strongly and negatively correlated with advantageous IA. Moreover, the correlations with advantageous IA were significantly stronger (i.e., more negative) than those with disadvantageous IA (Online Supplemental Table S3). This pattern, however, was not specific to callousness-related traits. In fact, most of the social-affective personality traits that we measured showed a similar pattern (for details, see Methods and Materials section and Online Supplemental Table S3**)**. Given the conceptual and statistical overlap among the questionnaires, including their total scores in the same regression model to predict IA parameters is both uninformative and problematic.

To address this issue, we adopted a dimension approach to personality measures (Gillan et al., 2016) and used the composite dimensional scores to predict participants' behavioral preferences in the DG task. Specifically, we carried out a factor analysis on the 126 individual items from the six personality questionnaires. Using the Cattell–Nelson–Gorsuch test implemented by the "nFactors" package in R (Raiche & Magis, 2010), our analysis identified a three-factor latent structure (Figure 2a). Based on the highest loading items (|loading| > 0.25), we labeled the factors as "emotion perception and regulation" (Factor 1; Online Supplemental Table S4, an example item "Being in a tense emotional situation scares me,"

loading = 0.54), "compassionate social emotions" (Factor 2; Online Supplemental Table S5, an example item "I often have tender, concerned feelings for people less fortunate than me," loading = −0.31), and "expanded self and belief in justice" (Factor 3; Online Supplemental Table S6, example items "I try to see my failings as part of the human condition," loading = 0.57 and "I think basically the world is a just place," loading = 0.32).[1] Of particular interest, "compassionate social emotions" (Factor 2) picked up almost all the individual items from the Interpersonal Manipulation ($M \pm SD = 0.43 \pm 0.06$) and the Callous Affect (0.34 ± 0.11) subscales of the self-reported psychopathic questionnaire, and all the items from the GASP scale pertaining to guilt (-0.40 ± 0.09) and shame experience (-0.39 ± 0.09; Online Supplemental Table S7). Therefore, higher scores on this dimension indicate a *lack* of dispositional compassionate social emotions.

We next ran two robust linear mixed-effect models (R package "robustlmm"; Koller, 2016) to examine the association between the factor scores and the advantageous and disadvantageous IA parameters, which were estimated independently of the factor analysis. The scores of all the three factors were included in the same model. Demographic variables were also included as covariates (Table 2). Both Factor 1 and Factor 2, but not Factor 3, were significantly and *negatively* associated with the advantageous IA parameter (Table 2, Online Supplemental Table S8, and Figure 2b). For the disadvantageous IA parameter, only Factor 1 was significantly correlated (Table 2, Online Supplemental Table S8, and Figure 2c). Note that this latter association became nonsignificant under the most conservative data exclusion criteria, indicating that this effect was not as robust as the effects with the advantageous IA. Importantly, as the confidence intervals indicated, Factor 2 was significantly more predictive of advantageous IA than of disadvantageous IA. This differential predictive power, which was conceptually consistent with the finding of Study 1, was not observed for Factor 1 or Factor 3. We carried out a post hoc power calculation based on the association between Factor 2 score and advantageous IA ($f^2 = 0.014$). The size of the final analysis sample afforded a power of 99.9% in detecting this effect at $p < .05$.

Finally, we explored whether a supportive family environment leads to higher advantageous IA, via the mediating role of the social-affective factors that were predictive of advantageous IA. Family environment was indicated by the scores on the FA subscale of the Self-Reported Family Dynamics Scale (Kang et al., 2001). This subscale reflects the degree to which one's family is caring and supportive to its members (Cronbach's $\alpha = .89$). As Online Supplemental Table S3 shows, FA score was significantly positively correlated with advantageous IA and significantly more so than with disadvantageous IA. We ran a mediation model where FA score was entered as the independent variable, the scores of Factor 1 and Factor 2 as two parallel mediators, and the advantageous IA parameter as the dependent variable. An SPSS macro was used to evaluate mediation models (Hayes, 2013). For the mediation analysis, we also included covariates of no interests as stated above (Table 2). We found that Factor 1 and Factor 2 together fully mediated the relationship between FA and advantageous IA (direct effect: $B = -.19$, $SE = .13$, CI [−0.45, 0.07]). The mediation effects of Factor 1 ($B = .12$, $SE = .03$, CI [0.06, 0.19]) and Factor 2 ($B = .34$, $SE = .05$, CI [0.24, 0.45]) were significantly above zero (Figure 3). The mediation effect of Factor 2 was significantly stronger than that of Factor 1 (mean difference = 0.22, $SE = .06$, CI [0.09, 0.35]). Note that although both of the mediation effects are positive, they are "inhibitory," meaning that a positive family environment is negatively associated with the personality dimensions that are themselves "inhibitors" of advantageous IA, therefore "disinhibit" it.

Discussion

Utilizing a computational model, we demonstrated in a sample of incarcerated adolescents the contribution of CU traits to advantageous IA. In a follow-up study with a large-scale college student sample ($N = 2{,}250$), we conceptually replicated and extended the association between callousness and advantageous IA by adopting a dimensional approach to social-affective personality traits. We found that a trait dimension characterized as "compassionate social emotions" was most predictive of advantageous IA but was unrelated to disadvantageous IA.

Past research has documented that individuals with high callousness or low GASP are more likely to engage in unethical behaviors (Blair, 2013; Cohen et al., 2012; Waller et al., 2015). Replicating and extending those previous studies, here we revealed that it was the advantageous IA underlying the prosocial behavior that was modulated by this social-affective trait dimension. Interestingly, this social-affective trait dimension was not associated with either diminished or heightened disadvantageous IA. This suggests that this social-affective trait dimension, which is primarily concerned with one's own unethical behaviors, is dissociable from envy and reactive aggression, which is primarily concerned with unfairness and injustice inflicted on oneself (Costa & Babcock, 2008; Meehan et al., 2001; Walker & Jackson, 2017). It is the former that depends on the agent's sense of shared social commitments and has only been found in older children and adult human beings, but not in younger children or nonhuman primates (McAuliffe et al., 2015; Tomasello, 2020; Tsoi & McAuliffe, 2020; Ulber et al., 2017). With these correlational analyses, however, we do not intend to overinterpret our results as implying any direction of causality.

The items traditionally included in the subscales of the IRI (i.e., personal distress, empathic concern, and perspective taking) nicely mapped onto different latent factors, suggesting their dissociable roles in motivating prosocial behaviors. Specifically, personal distress strongly and consistently loaded positively on Factor 1, which is associated with lower advantageous IA. This is consistent with ample empirical evidence that personal distress is self-centered and promotes withdrawal; even when it motivates helping behaviors, the underlying

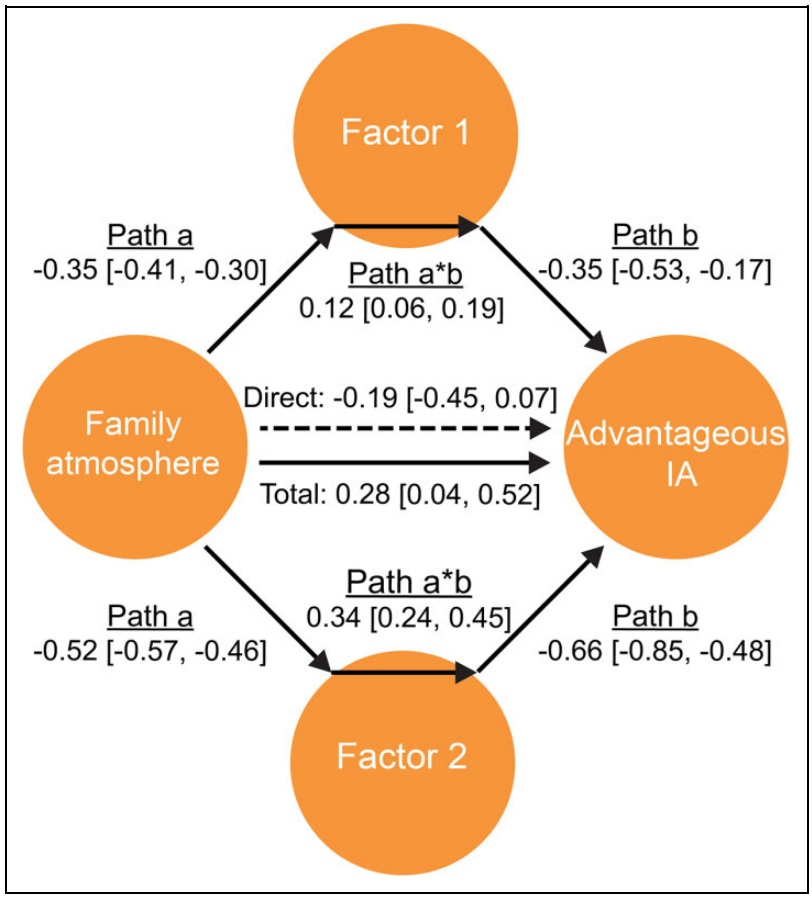

Figure 3. Results of the mediation analysis. Family atmosphere is positively associated with advantageous inequity aversion. This relationship is fully mediated by the two social-affective trait dimensions (i.e., Factor 1: "emotion recognition and regulation," Factor 2: "compassionate social emotions") that are predictive of low advantageous inequity aversion.

motivation is more to terminate one's own distress than to benefit the recipient (Batson, 2011; Batson et al., 1981). In contrast, empathic concern loaded negatively on Factor 2, which is associated with advantageous IA. Previous research has demonstrated that empathic concern, unlike personal distress, is other-regarding and has an approach tendency (Davis et al., 1999; FeldmanHall et al., 2015; Zaki, 2014).

It is interesting to compare the effect of the trait dimension represented by Factor 2 and episodic social emotions (e.g., guilt) on IA. For example, Gao et al. (2018) has demonstrated that when episodic guilt state was induced experimentally, individuals exhibited higher advantageous IA *and* lower disadvantageous IA. This is conceivable because retrospective guilt should not only discourage individuals from engaging in future transgression but also motivate individuals to make amend for existing transgression and damage (De Hooge, 2019; Kamau et al., 2013; H. Yu et al., 2014). In contrast, many of our social-affective trait measures are anticipatory in nature (Cohen et al., 2012). Our result lends support to a cognitive account of the prosocial function of social affective traits (i.e., compassionate social emotions), namely, individuals who anticipate more future social emotions (e.g., guilt, shame) find the prospect of unjustly getting better off than others more aversive (see also Gong et al., 2019). Future studies are necessary to ascertain the neurobiological links between behavioral tendency (e.g., advantageous IA), episodic social emotions (e.g., guilt), and social-affective traits (e.g., guilt proneness).

Our finding that a positive family environment is associated with social affective traits pertaining to compassionate social emotions provides evidence for the developmental observations that family environment and parental warmth play a key role in the proper development of prosocial emotions such as empathy and guilt (Ferguson & Stegge, 1995; Hinde, 2002; Tangney & Dearing, 2003; Zahn-Waxler & Kochanska, 1990). The novel contribution of our findings is that we revealed possible routes from family environment to prosocial behavioral preference via social-affective traits. However, it should be noted that these results are correlational and should be interpreted with caution. For example, the mediation results cannot rule out the possibility that participants low in social-affective trait have inaccurate and self-motivated perceptions or memories of their family interactions (Klein & Epley, 2016; Tasimi & Johnson, 2015). Rigorous developmental experiments are needed to establish the causal relationship

between positive family environment and compassionate social emotions.

To conclude, by combining computational modeling and a dimensional approach to personality measures, this well-powered study offers a cognitive account of how compassionate social emotions as a social-affective trait promotes prosocial behaviors—individuals high on this dimension are more careful not to be unfairly better off than others (i.e., advantageous IA). Moreover, we highlight the association between a positive family environment and the development of the trait of compassionate social emotions and provide evidence for an intermediate role of affective trait in the relationship between family environment and advantageous IA. Together, the results of this study suggest that the trans-diagnostic approach is not only useful in discovering dimensional markers of behavioral anomaly in psychiatry but is also applicable to ascertaining the specificity of social-affective trait dimension in predicting prosociality.

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Supplemental Material

The supplemental material is available in the online version of the article.

Note

1. Note that, for the first two factors, the scores indicate the opposite or the lack of the traits signified by their respective factor labels. For example, higher score on Factor 2 indicates a lack of compassionate social emotions. We decided not to label the factors this way to avoid wordy names.

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