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Original Article

Cite this article: ¥ F et al (2022). lt-lt nt n tnn n l fntnn - m l nlt th hmttnl ln ft¥f m lnt tn t Psychological Medicine 1-13. htt :// . 1 10.1017/ 003329172200277

• : 21 N m 2021

• : 6 J l 2022

A t : 8 A t 2022

Key words:

Emth; lt; nt nl fntn; mlmtn; -ml nlt ; lnttn

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Abstract

Background. Obsessive-compulsive personality disorder (OCPD) is a high-prevalence personality disorder characterized by subtle but stable interpersonal dysfunction. There have been only limited studies addressing the behavioral patterns and cognitive features of OCPD in interpersonal contexts. The purpose of this study was to investigate how behaviors differ between OCPD individuals and healthy controls (HCs) in the context of guilt-related interpersonal responses.

Method. A total of 113 participants were recruited, including 46 who were identified as having OCPD and 67 HCs. Guilt-related interpersonal responses were manipulated and measured with two social interactive tasks: the Guilt Aversion Task, to assess how anticipatory guilt motivates cooperation; and the Guilt Compensation Task, to assess how experienced guilt induces compensation behaviors. The guilt aversion model and Fehr–Schmidt inequity aversion model were adopted to analyze decision-making in the Guilt Aversion Task, respectively.

Results. Computational model-based results demonstrated that, compared with HCs, the OCPD group exhibited less guilt aversion when making cooperative decisions as well as less guilt-induced compensation after harming others.

Conclusion. Our findings indicate that individuals with OCPD tend to be less affected by guilt than HCs. These impairments in guilt-related responses may prevent adjustments in behaviors toward compliance with social norms and thus result in interpersonal dysfunctions.

Introduction

Personality disorders have pervasive impacts on subjective well-being, quality of life, and socioeconomics (Tyrer, Reed, & Crawford, 2015). Of the 10 currently recognized personality disorders, obsessive-compulsive personality disorder (OCPD) is the most common with a prevalence range of 2.1–7.9% (APA, 2013). A national epidemiologic survey in the USA showed that the prevalence of lifetime OCPD was 7.8% in the community (Grant, Mooney, & Kushner, 2012). In China, the prevalence of OCPD among patients with psychotic and non-psychotic disorders was reported to be 6.6% and 14.6%, respectively (Wang et al., 2021).

According to the DSM-5, OCPD is 'a pervasive pattern of preoccupation with orderliness, perfectionism, and mental and interpersonal control, at the expense of flexibility, openness'. These tendencies can have marked psycho-social consequences, especially with respect to establishing and sustaining close relationships (APA, 2013). The negative impacts of OCPD behaviors tend to become more pronounced the longer they persist. In a longitudinal study investigating the interpersonal impairments of several personality disorders, including OCPD as well as schizotypal, borderline, and avoidant personality disorders, participants' social relationships with parents, life partners, and friends were evaluated prior to treatment, after 1 year of treatment, and after 2 years of treatment. The OCPD group was the only diagnostic group that did not show significant improvements in any of these three social relationship realms after treatment (Skodol et al., 2005).

Empathy is an important psychological process that facilitates pro-social behaviors (Decety, Bartal, Uzefovsky, & Knafo-Noam, stubbornness, hostility, and misunderstanding in interpersonal communication, ultimately impairing interpersonal relationships (Cain, Ansell, Simpson, & Pinto, 2015; Hummelen, Wilberg, Pedersen, & Karterud, 2008). Recently, the link between mental processes and behaviors has been attracting more attention. A core function of empathy in social interactions is to induce the feeling of guilt. Guilt is a moral emotion that functions positively in interpersonal relationships by stimulating prosocial behaviors such as apologizing, compensation, and cooperation (Baumeister, Stillwell, & Heatherton, 1994; Ketelaar & Tung Au, 2003; Tangney, Stuewig, & Mashek, 2007). It is induced when a personal moral rule or social standard has been violated, especially when one is aware that they have inflicted harm, loss, or distress upon others. Guilt requires an inherent capacity for empathy that enables one to recognize another person's suffering (Hoffman, 1982). In neuroimaging studies, both guilt and empathy have been shown to elicit similar areas of activation, such as the insula (Moll & de Oliveira-Souza, 2007; Morey et al., 2012; Takahashi et al., 2004). Moreover, patients with damage to empathy-related brain regions display diminished guilt (Koenigs et al., 2007). Thus, we hypothesize that, due to a deficiency in their ability to empathize, individuals with OCPD may exhibit less guilt-related responses than healthy controls (HCs), which may result in OCPD-associated interpersonal dysfunctions (hypothesis 1).

However, higher than typical levels of guilt are common to many mental disorders, including major depression (Ghatavi, Nicolson, MacDonald, Osher, & Levitt, 2002), other mood disorders (Zahn, de Oliveira-Souza, & Moll, 2013), and notably obsessive-compulsive disorder (OCD) (Shafran, Watkins, & Charman, 1996; Shapiro & Stewart, 2011). OCD patients have been shown to exhibit particularly strong responses of guilt, commonly triggered by a perceived inflated responsibility for interpersonal transgressions (Shafran et al., 1996; Shapiro & Stewart, 2011). Moreover, it has been shown that the level of guilt experience correlates directly with OCD symptom severity (Chiang, 2013). Indeed, researchers have proposed that guilt may contribute to the occurrence and maintenance of OCD symptoms in that guilt-related fears of improper behavior may further augment obsessive-compulsive thoughts and behaviors (Mancini & Gangemi, 2004; Nissenson, 2007).

It has been suggested that OCPD may be a candidate member of the obsessive-compulsive spectrum, since OCPD resembles OCD in terms of phenomenology, comorbidity, neurocognition, and treatment response characteristics (Fineberg, Sharma, Sivakumaran, Sahakian, & Chamberlain, 2007; Stein et al., 2016; Thamby & Khanna, 2019). Although how guilt contributes to the formation and maintenance of OCD is well discussed, few studies have investigated guilt in OCPD from a social-emotional response perspective (Pinto, Eisen, Mancebo, & Rasmussen, 2007). It is not yet known whether individuals with OCPD have guilt responses similar to individuals with OCD. Given the commonalities between these two disorders that have been identified in previous studies, we aim to test a second, and contradictory, hypothesis that as a candidate member of the obsessivecompulsive spectrum, OCPDs may be associated with more intense guilt-related responses than HCs (hypothesis 2).

Previous studies conducted with healthy participants have suggested that guilt may affect interpersonal decision-making in two ways, namely that the anticipatory guilt may have a promoting effect on cooperative behaviors, while the experienced guilt may

Empathy is an important psychological process that facilitates have a promoting effect on compensation behaviors (Battigalli & pro-social behaviors (Decety, Bartal, Uzefovsky, & Knafo-Noam, Dufwenberg, 2007; Bauineingd)@397((w).2(n)]I5(Sh@204.2(s)(h)2204(.,)]T 2016). A lack of empathy in individuals with OCPD may5leadatedus, coeindiioth6.3 gnterilt)0(r)3(g)-377f(a)25847.1(s)1(ti)18.T*[(Oonal)01577]

Diagnostic Questionnaire-4 (PDQ-4; Bagby & Farvolden, 2004). Those who obtained a composite score \geq 5 on the OCPD subscale were considered clinically relevant and invited to be evaluated. Secondly, OCPD was diagnosed by a psychiatrist using the structured clinical interview for DSM-IV axis II personality disorders (SCID-II; First, Benjamin, Gibbon, Spitzer, & Williams, 1997a). Meanwhile, to exclude the influences of other mental disorders, participants with current or past mental disorders were excluded using the structured clinical interview for DSM-IV axis I disorders (SCID-I, First, Spitzer, Gibbon, & Williams, 1997b). A total of 46 people (22 women, 48%; 20.4 ± 1.4 years) were diagnosed with OCPD and constituted our OCPD group.

The HC participants were collected from the randomly recruited 8303 undergraduates described above, whose scores in all subscales of PDQ-4 were lower than the cutoffs (Bagby & Farvolden, 2004). Individuals who had a past or ongoing history of a SCID-I diagnosis based on a clinical interview by a psychiatrist were excluded (First et al., 1997b). A randomly selected group of 67 (38 women, 57%; 21.9 ± 1.3 years) of the remaining participants constituted the HC group.

All 113 participants (46 OCPDs and 67 HCs) completed questionnaires to collect clinical and psychological information and then completed the Guilt Aversion Task; five participants were excluded from the data processing due to a failure to understand the instructions. The remaining 108 participants (42 OCPDs and 66 HCs) were included in the final analysis of the Guilt Aversion Task. Due to the relatively long duration of the task and the potential risk of inflicting pain upon others in the Guilt Compensation Task, 29 participants dropped out, leaving a total of 79 participants (42 OCPDs and 37 HCs) in the final analysis of the Guilt Compensation Task. The study was approved by the Institutional Ethical Board of the Second Hospital of Xiangya, Central South University, and participants provided written informed consent before testing. To reduce the Hawthorne Effect (Sedgwick, 2012), all participants were unaware of grouping information and the study purpose during the experiment.

After enrollment and grouping, participants were numbered and led to the laboratory to complete questionnaires and perform the Guilt Aversion Task and the Guilt Compensation Task. The experimenter could identify group association based on participant numbers. Because this was a single-blinded experiment, there was a potential risk of the Experimenter Effect (Kintz, Delprato, Mettee, Persons, & Schappe, 1965). However, several factors mitigate this concern. First, all of the procedures and instructions were standardized. Additionally, and most importantly, we posed two contradictive hypotheses based on previous evidence: (1) individuals with OCPD exhibit decreased level of guilt-related responses compared to HCs due to an empathy deficiency; v. (2) similar to people with OCD, individuals with OCPD are inclined to have an elevated level of guilt-related responses. All of the experimenters knew these two hypotheses and they could not predict which hypothesis would be supported before or during the experiment. Moreover, the experimenters were not allowed to analyze the data until the data collection had been completed. The background condition of these two contradictive hypotheses thus abates explicit or implicit experimenter influences on the participants to behave in accordance with the hypotheses, which to some extent exclude the Experimenter Effect.

For the questionnaires, *a priori* power analysis was conducted using G*Power version 3.1 (Faul, Erdfelder, Lang, & Buchner,

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2007) for sample size estimation. The prior effect size was determined based on the data from a published study (Cain et al., 2015) (N = 50), which compared OCPD to HC groups using the Interpersonal Reactivity Index (IRI). The effect size in this prior study was 0.70, considered to be medium according to Cohen's (1988) criteria. With a significance criterion of $\alpha = 0.05$ and power = 0.80, the minimum sample size needed to obtain a similar effect size was N = 34 for an independent sample t test. Thus, for questionnaire analyses, the obtained sample size of 46 OCPD participants and 67 HCs was adequate to test the statistical hypotheses. For the interactive tasks, because there are no previous studies that have investigated guilt-related responses in OCPD participants using this method, we could not determine prior effect sizes for our interactive tasks and thus could not perform a power analysis or sample size determination prior to data collection. Nevertheless, we conducted post-hoc power analyses for our main results, i.e. the Bayesian t tests for parameters estimated from computational modeling. The results suggest that the sample size in our experiment was adequate to draw our main conclusions (see details in Methods and Results).

Procedures

Overview

Guilt is derived from the violation of a personal moral rule or a social standard, especially when individuals are aware that they have inflicted harm, loss, or distress upon others (Baumeister et al., 1994). Previous studies have suggested two aspects of guilt, the anticipatory guilt and the experienced guilt. The anticipatory guilt describes the phenomenon that, when making decisions, individuals can anticipate the feeling of guilt that may be caused by their inappropriate actions, and thus altering their actions in ways that maintain and strengthen relationships with others, e.g. cooperation (Charness & Dufwenberg, 2006; Reuben et al., 2009). Meanwhile, after harming others, the experienced guilt may motivate one to compensate for past actions in order to restore relationships with the victim (Gao et al., 2018; Ketelaar & Tung Au, 2003). Both the anticipatory guilt and the experienced guilt promote prosocial behaviors and facilitate interpersonal relationships (Baumeister et al., 1994). We employed two decision interactive tasks that were established by previous studies to measure the effects of these two aspects of guilt, respectively. The Guilt Aversion Task (Fig. 1a, b) was implemented to investigate the effect of anticipatory guilt on cooperative behaviors (Nihonsugi et al., 2015) and the Guilt Compensation Task (Fig. 1c) was implemented to investigate the effect of experienced guilt on compensation behaviors (Gao et al., 2018). Three psychometric instruments (described below) were used to measure clinical and psychological information.

Questionnaires

The Chinese versions of the questionnaires described below were confirmed to be valid and reliable in the Chinese population (Rong, Sun, Huang, Cai, & Li, 2010; Wang, Wei, Wang, Jiang, & Peng, 2015; Wang, Zhan, & Yan, 2016).

Obsessive Belief Questionnaire (OBQ-44)

The OBQ-44 is a 44-item self-report measure that assesses obsessive beliefs. Each item is rated on a seven-point Likert scale. The OBQ-44 has three subscales: responsibility and threat estimation; perfectionism and intolerance for uncertainty; and importance

and control of thoughts (Obsessive Compulsive Cognitions Working Group, 2005).

Interpersonal Reactivity Index (IRI)

The IRI is a 28-item self-report measure that consists of four seven-item subscales accessing the following aspects of empathy: perspective taking (the tendency to spontaneously adopt the psychological point of view of others), fantasy (the tendency for individuals to transpose themselves imaginatively into the feelings and actions of fictitious characters in books, movies, or play), empathic concern (other-oriented feelings of sympathy and concern for the misfortunate of others), and personal distress instead, then the investor A and investee B receive y_A and y_B , respectively (condition y). If the investor A chooses Out, then the investor A and the investee B receive monetary payoffs of z_A and z_B , respectively (condition z), and the trial ends. Figure 1*a* shows an example of the payoff matrix in the Guilt Aversion Task.

The payoffs have several features: (1) for the investor A, $x_A > z_A > y_A$; and (2) for the investee B, $y_B > x_B > z_B$. Thus, to maximize their income, the investor A should choose In and expect that the investee B chooses Cooperate. However, if the investor A chooses In but the investee B chooses Defect, the investor A's payoff will be the least of the three conditions. For the investee B, the Defect option always has a higher payoff than the option Cooperate, but it may make one feel guilty for disappointing the investor A.

The Guilt Aversion Task was consisted of two parts. In part I, the participant experienced the decision-making process of investor A, deciding whether to choose In or Out under the above-described payoff matrix (Fig. 1a) and predicting the probability that the investee would cooperate. Through part I, which consisted of 20 trials, the participant thus gained a better understanding of the task rules. The participant was informed that their choices in part I were unrelated to and would not influence those of the next part. In part 2, which consisted of 35 trials, the participant completed the formal task as investee B (Fig. 1b). For each new trial, the participant was told that they would be paired with a new and randomly assigned anonymous investor A who chose In and provided a belief of the probability that the participant (investee B) would chose Cooperate, τ_A . The participant then chose Cooperate or Defect under the given payoff matrix and having knowledge of the investor A's τ_A , indicated by a pie chart. Only the data from part II, in which the participant played the role of investee B, were included in the data analysis (Nihonsugi et al., 2015).

The Guilt Compensation Task

This task (Fig. 1c; Gao et al., 2018) measures the experience of guilt and to what extent the experienced guilt facilitates compensation. The participant was told that they would be playing with three other anonymous players. Each trial began by informing the participants that they were randomly and anonymously paired with one of three co-players. In half of the trials, the participant performed a dot estimation task (Self trials); in the other half of the trials, the participant waited for their co-player to make an estimation (Other trials). If the answer was correct, no one would receive pain stimulation, and the current trial terminated. If either of them responded incorrectly, the co-player in the current trial had a 50% probability of receiving pain stimulation (Pain trials and No-pain trials), determined by the computer program. At the end of each incorrect trial, the participant would act as a dictator in the dictator game (DG) and make four sequential monetary binary choices to determine the payoffs for themselves and for the co-player. This DG gave the participant a chance to compensate the co-player in this trial. This formed a 2 (Agent who performed dot estimation task: Self v. Other) by 2 (Outcome for the co-player: Pain v. Nopain) within-participant design. The Self_Pain condition was the critical condition to induce guilt. The other three conditions controlled for confounding factors, such as empathy for the co-player and regret for providing a wrong estimation. The Agent-Outcome interaction effect [i.e. (Self_Pain - Other_Pain) > (Self_Nopain - Other_Nopain)] was the guilt effect that we focused on (Gao et al., 2018). The experiment consisted of 72 trials, including 12 trials for each of the above four conditions and 24 correct trials. Each condition consisted of 48 monetary binary DG choices (four per trial).

In the DG, each of the four serial binary choices consisted of two options representing the payoffs that the participant and the co-player would earn. One option was an equal allocation (i.e. 10 points for me, and 10 points for the co-player). The other option was an unequal allocation with different values in each trial – either an advantageous inequity frame (i.e. allocating more to self than to the co-player) or a disadvantageous inequity frame (i.e. allocating more to the co-player than to self). For further details about the Guilt Compensation Task and the DG, see Gao et al. (2018).

After completing the Guilt Compensation Task, the participant was asked to rate how guilty they felt under each of four conditions on a seven-point Likert scale.

Monetary incentive

Participants who completed both the Guilt Aversion Task and the Guilt Compensation Task received a base payment of 300 RMB and those who completed only the Guilt Aversion Task received a base payment of 200 RMB. Additionally, participants were informed that, after the experiment, one choice in each of the two tasks would be randomly selected to determine additional bonuses to themselves and their corresponding co-players. This monetary incentive can make participants more active and focused during the performance of the task. Given that participants made decisions that could influence their own as well as others' payoffs, these potential monetary costs to some extent mitigate the social display effects (Larsen & Fredrickson, 1999; Nisbett & Wilson, 1977). This arrangement has been proven to be effective in previous studies on guilt-related behaviors (Gao et al., 2021, 2018).

Computational modeling

In line with previous studies on anticipatory guilt and experienced guilt, the guilt aversion model (Nihonsugi et al., 2015) and Fehr–Schmidt inequity aversion model (Fehr & Schmidt, 1999; Gao et al., 2018) were adopted respectively for the Guilt Aversion Task and the Guilt Compensation Task, to capture the influences of anticipatory guilt and experienced guilt in decision-making.

The quilt aversion model

The guilt aversion model (Nihonsugi et al., 2015) assumes that an individual dislikes disappointing another's belief. Thus, if investor A chose In in the Guilt Aversion Task, then the participant (investee B) was faced with the pressure of the investor A's expectation for cooperation with a belief magnitude of τ_A . Therefore, the participant's perceived investor A's expectation of repayment was represented as the multiplicative product of investor A's belief that the participant would choose Cooperate (τ_A) and investor A's payoff (x_A) when the participant did chose Cooperate: $\tau_A \cdot x_A$. The difference between that expectation of repayment (i.e. $\tau_A \cdot x_A$) and the investee A's payoff when the participant selecting the Defect option (y_A) – represented as $\tau_A \cdot x_A - y_A$ – was thus taken as a measure of how much the participant believed that they would disappoint investor A by choosing Defect. In other words, the difference $\tau_A \cdot x_A - y_A$ was adopted as a representation of the magnitude of guilt that the participant anticipated. In addition, the participant could also consider inequity aversion in the task, which assumed a social preference for equitable payoffs, and one's utility of an action decreased when the allocation of monetary payoffs was unequal (see details in Nihonsugi et al., 2015

To further support our model-based results, the relationship between guilt aversion parameter (γ) and the cooperation rate in the Guilt Aversion Task was examined using Pearson correlation. In the Guilt Compensation Task, a 2 (Agent: Self *v*. Other) × 2 (Outcome: Pain *v*. Nopain) × 2 (Group: OCPD *v*. HC) three-way analysis of variance (ANOVA) was used to assess the group differences in the experienced guilt and the guilt effect on behavior (i.e. monetary compensation, reflected by the difference between the chosen payoffs for self and the co-player). Effect size was reported as partial η^2_{partial} . Analyses were conducted in R 4.0 (R Core Team, 2020) with a significance level of p < 0.05.

Results

Demographics and questionnaire

The demographic and psychometric characteristics of the participants are presented in Table 1. This pattern of results remained the same if we used the data of 108 participants of the Guilt Aversion Task or used the data of 74 participants of the Guilt Compensation Task. As expected, OCPD participants had higher obsessivecompulsive traits than HCs, as reflected by OBQ-44 sub-scores, including those for responsibility/threat estimate ($t_{112} = 2.36$, $p_{\rm corr} = 0.036$, Cohen's d = 0.45), importance/control of thoughts $(t_{112} = 4.16, p_{corr} < 0.001, Cohen's d = 0.80)$, and perfectionism/ certainty ($t_{112} = 2.69$, $p_{corr} = 0.019$, Cohen's d = 0.51). There were no significant differences in demographics between the two groups [gender, $\chi^2_{(1, N_p=113)} = 0.84$, p = 0.360, Cramer's V = 0.09; whether an only child, $\chi^2_{(1, N = 113)} = 0.89, p = 0.482$, Cramer's V = 0.06; or habitation, $\chi^2_{(1, N=113)} = 0.27$, p = 0.602, Cramer's V = 0.05]. Likewise, there were no significant differences in guilt proneness between the two groups (guilt NBEs, $t_{112} = 1.26$, $p_{corr} = 0.236$, Cohen's d = 0.24; and guilt-repair, $t_{112} = 0.93$, $p_{corr} = 0.355$, Cohen's d = 0.18).

We observed significant differences between the two groups in

(i.e. monetary compensation, reflected by the difference between the chosen payoffs for self and the co-player; Fig. 3*b*). Result showed no significant difference between the two groups in post-task self-reported guilt under the four conditions of the Guilt Compensation Task ($F_{1, 77} = 0.09$, p = 0.759, $\eta_{partial}^2 < 0.01$), suggesting that individuals with OCPD may experience the same level of guilt as HC participants during this task.

There was a significant Agent × Outcome × Group interaction effect with respect to the amount of compensation ($F_{1, 77} = 4.57$, p = 0.036, $\eta_{\text{partial}}^2 = 0.06$). Simple two-way interaction post-hoc tests performed separately for each group revealed a significant interaction between Outcome and Agent (a guilt effect) in the HC group ($F_{1, 36} = 11.55$, p = 0.002, $\eta_{\text{partial}}^2 = 0.11$); this effect was not observed in the OCPD group ($F_{1, 41} = 0.05$, p = 0.825, $\eta_{\text{partial}}^2 < 0.01$). These results suggest that the experienced guilt induced significant compensation behaviors in the HC group, while this guilt effect was reduced or absent in OCPD participants.

The previous study using the Guilt Compensation Task has shown that, when experiencing guilt, healthy population tend to exhibit an increased advantageous inequity aversion and decreased disadvantageous inequity aversion during monetary allocation (Gao et al., 2018), a predisposition that promotes compensation to victims. Therefore, to probe the influence of OCPD on this tendency, we used computational modeling to estimate group-level advantageous inequity aversion (α) and disadvantageous inequity aversion (β) across four conditions. The 2 (Agent: Self or Other) × 2 (Outcome: Pain or Nopain) interaction effects (i.e. the guilt effect) on advantageous inequity aversion (α) and disadvantageous inequity aversion (β) are represented visually in Fig. 3c. It was determined that the experienced guilt contributed less to increases in advantageous inequity aversion (α) in the OCPD group than in the HC group ($BF_{10} = 5.39$), providing moderate evidence for the alternative hypothesis, albeit with relatively weak power (0.60). Additionally, we found that the experienced guilt contributed less to decreases in disadvantageous inequity aversion (β) in the OCPD group than in the HC group (BF₁₀ > 100), providing extremely strong evidence for the alternative hypothesis (power = 1.00). Thus, although the level of experienced guilt after inflicting harm on others was similar between the two groups, the experienced guilt contributed less to

compensation behaviors in the OCPD group than in the HC group, largely driven by the group difference in disadvantageous inequity aversion.

Our computational models performed well in terms of both posterior predictions and parameter 77TD[(30)19.1(v)16.4(ery)20.6(.)-486.

life that promotes prosocial behaviors. The responses of two aspects of guilt – anticipatory guilt and experienced guilt – were measured respectively, by combining two social interactive tasks with computational modeling approach. Our computational modeling results of these guilt-related responses provide advanced evidence that (1) OCPDs are less affected by anticipatory guilt, and thus cooperate less in interpersonal relationships, and (2) OCPDs are less affected by experienced guilt and thus make fewer compensations to victims, despite that they reported same level of guilt feeling as HCs. The current study provides a proof of the principle that computational modeling can be used to help elucidate complex social behaviors that characterize psychiatric conditions and to help deepen our knowledge about mental disorders. Anticipatory guilt regulates individuals' social behaviors before

et al., 2009). Thus, our group-level computational modeling results showed that a reduced influence of anticipatory guilt in individuals with OCPD led to less cooperation during social decision-making.

Experienced guilt regulates behavior after decisions have been made and interpersonal transgressions have occurred, and thus may lead the guilty party to take actions that restore social relationships (Baumeister et al., 1994; Gao et al., 2021, 2018; Yu et al., 2020). In some circumstances, violations of a social norm, failing to live up to others' expectations, or harming others' interests are unavoidable. Although the OCPD participants in the present study reported the same level of experienced guilt as HCs, their inequity aversion (especially the disadvantageous form) was altered less when experiencing guilt, suggesting that they clinically, our observation provides a potential index that may distinguish OCPD and OCD in future clinical practice. Future research may directly compare these two groups to draw more specific conclusions. Secondly, the heterogeneity of OCPD was not considered due to the limited sample size. Individuals with OCPD exhibit a heterogeneous interpersonal profile suggestive of two distinct interpersonal subgroups: aggressive and pleasing (Solomonov, Kuprian, Zilcha-Mano, Muran, & Barber, 2020). Whether and how this heterogeneity could affect the guilt experience and guilt-related behaviors are as of yet unknown, calling for future investigations. Thirdly, our use of an incentivized setting, wherein participants' decisions affects the fortunes of others as well as themselves, may mitigate moral displays due to social desirability (Larsen & Fredrickson, 1999; Nisbett & Wilson, 1977). However, on the one hand, we used post-task self-ratings to assess experienced guilt in the Guilt Compensation Task. Although the way of post-task self-ratings has been shown to be effective previously (Chang et al., 2011; Gao et al., 2018; Yu et al., 2017, 2014), concerns remain regarding participants' introspection and memory abilities and a potential social desirability bias (Larsen & Fredrickson, 1999; Nisbett & Wilson, 1977). On the other hand, individuals knowing that their answers were destined for research could have influenced their answers. In fact, lack of direct and implicit measurement of emotions is a general limitation for studies on guilt and other social emotions, as no effective and predictive physical (e.g. facial expressions) or physiological (e.g. skin conductance responses) measures have been established. This situation calls for the refinement and development of techniques in future studies.

Conclusion

Compared with HCs, OCPD participants tended to be less affected by guilt: they exhibited less guilt aversion when making cooperative decisions, and they exhibited less guilt-induced compensation after harming others. These impairments in guiltrelated responses may prevent adjustments in behaviors toward compliance with social norms and thus result in interpersonal dysfunctions.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S003329172200277X

Acknowledgements. We thank all co-authors who helped complete this study, also we are particularly grateful to every participant in our study.

Author contributions. Fan Xiao: investigation, formal analysis, data curation, visualization, writing – original draft. Xiaoxue Gao: conceptualization, methodology, funding acquisition, writing – review and editing. Hongbo Yu: conceptualization, methodology. Lejia Fan, Xinlei Ji, Jiahui Zhao, Shulin Fang, Panwen Zhang, Xinyuan Kong, Qinyu Liu: investigation, data curation. Xiaolin Zhou: supervision, conceptualization, resources, writing – review and editing. Xiang Wang: supervision, funding acquisition, conceptualization, resources, writing – review and editing.

Financial support. This work was funded by the National Natural Science Foundation of China (grant number 31671144, 31900798), Hunan Provincial Natural Science Foundation of China (Grant No. 2019JJ40362), and the Research Foundation of the Education Commission of Hunan Province (Grant No. 2017jy77). Dr. Xiaoxue Gao is supported by Young Elite Scientists Sponsorship Program by China Association for Science and Technology (2021QNRC001). Dr. Xiaoxue Gao and Dr. Xiaolin Zhou are supported by the Research Project of Shanghai Science and Technology Commission (20dz2260300) and the Fundamental Research Funds for the Central Universities.

Conflict of interest. None.

Ethical standards. The authors assert that all procedures contributing to this work comply with the ethical standards of the Institutional Ethical Board of the Second Hospital of Xiangya, Central South University.

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