Psychological Medicine

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Understanding guilt-related interpersonal dysfunction in obsessive-compulsive personality disorder through computational modeling of two social interaction tasks

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C . . . a . . : Xiao F et al (2022). Understanding guilt-related interpersonal dysfunction in obsessive-compulsive personality disorder through computational modeling of two social interaction tasks. Psychological Medicine 1–13. https://doi.org/10.1017/S003329172200277X

Received: 21 November 2021
Revised: 6 July 2022
Accepted: 8 August 2022

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Empathy; guilt; interpersonal dysfunction; moral emotion; obsessive-compulsive personality disorder; social interaction

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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 (self-oriented feelings of personal anxiety and unease in tense interpersonal settings) (Davis, 1980).

Guilt proneness

instead, then the investor A and investee B receive $_A$ and $_B$, respectively (condition). 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, $_A >$ $z_A >$ $_A$; and (2) for the investee B, $_B >$ $_B \geq$ $_B$. 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. 1*a*) 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

To further support our model-based results, the relationship between guilt aversion parameter (γ

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 decisions are made and interpersonal transgressions happen, which promotes social relationships by driving behavioral adjustments to align with social norms (Baumeister et al., 1994; Charness & Dufwenberg, 2006; Reuben et al., 2009). For example, in the Guilt Aversion Task where participants decided how much to return to their co-player, self-interest predominated when the co-player expected little from the participant, while the effect of self-interest was relatively diminished when the co-player expressed confidence in the participant'

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

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.

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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 guilt-related responses may prevent adjustments in behaviors toward

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