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# Stress and strategic decision-making in the beauty contest game

Johannes Leder<sup>a,b,\*</sup>, Jan Alexander Häusser<sup>b</sup>, Andreas Mojzisch<sup>b</sup>

<sup>a</sup> Center for Empirical Research in Economics and Behavioral Sciences (CEREB), University of Erfurt, 99089 Erfurt, Germany

<sup>b</sup> Institute of Psychology, University of Hildesheim, 31141 Hildesheim, Germany

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**Summary** Often, economic decisions do not only depend on one's own preferences, but also on the choices of others and therefore require strategizing (i.e., thinking about what others might think). In experimental economics, this has been modeled by the beauty contest game. Another typical feature of economic decisions is that they are often carried out under stress. Therefore, in the present study, we aimed to examine the influence of stress on decision-making in the beauty contest game. Participants were randomly assigned to either the Trier Social Stress Test for Groups (TSST-G) or a placebo version of the TSST-G (control condition). Then, participants played four rounds of a standard beauty contest game. As a biomarker of stress, salivary cortisol was measured. As predicted, participants under stress chose higher numbers in the beauty contest game than non-stressed participants, indicating less strategizing. This effect was mediated by the stress-induced increase in cortisol.

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## 1. Introduction

Strategic decisions in the world of business are often carried out under stress. One prominent example is stock-market brokers who have to make important financial decisions under high time constraints while experiencing enormous competitive pressure. The outcome of such decisions is affected by two types of uncertainty: structural and strategic

uncertainty. While structural uncertainty is a function of distributions of payoffs determined by probabilities, strategic uncertainty is a function of choices made by other actors, which influence the outcome of a choice. Thus, strategizing (e.g., thinking about what other actors might think and do) besides the analysis of risks and returns is another crucial aspect of successful economic decisions, because such choices are affected by structural as well as strategic uncertainty.

The importance of strategizing is underlined by the finding that asset prices are affected by what an actor assumes other actors to expect about the relationship between return and risk of an asset (Shiller, 2005). Hence, public information is overweighted in relation to private information when pricing an asset (Allen et al., 2006). For this reason, knowledge and the consideration of public opinion is crucial to make

\* Corresponding author at: Center for Empirical Research in Economics and Behavioral Sciences (CEREB), University of Erfurt, Nordhäuser Str. 63, D-99089 Erfurt, Germany. Tel.: +49 17696601967; fax: +49 3617372209.

E-mail address: [johannes.leder@uni-erfurt.de](mailto:johannes.leder@uni-erfurt.de) (J. Leder).

advantageous trading decisions. In sum, as stated by Keynes (1936; p. 156), “professional investment may be likened to those newspaper competitions in which the competitors have to pick out the six prettiest faces from a hundred photographs, the prize being awarded to the competitor whose choice most nearly corresponds to the average preferences of the competitors as a whole; so that each competitor has to pick not those faces which he himself finds prettiest, but those which he thinks likeliest to catch the fancy of the other competitors, all of whom are looking at the problem from the same point of view. It is not a case of choosing those which, to the best of one’s judgment, are really the prettiest, nor even those which average opinion genuinely thinks the prettiest. We have reached the third degree where we devote our intelligence to anticipating what average opinion expects the average opinion to be. And there are some, I believe, who practice the fourth, fifth and higher degrees”.

How does stress influence economic decision making? The effects of stress on decision-making received considerable attention in the past (Starcke and Brand, 2012; Driskell and Salas, 1996). Previous research suggests that stress leads to disruptive decision making because under stress individuals consider less options and make quicker choices (Chajut and Algom, 2003; Keinan, 1987), are less likely to consider possible contingencies (Johnston et al., 1997), take longer to learn cost-benefit associations of choice options (Preston et al., 2007) and insufficiently adjust from automatic responses (Kassam et al., 2009; Porcelli and Delgado, 2009). Under structural uncertainty, when choice options involve risk, people who are stressed differ in their choice behavior compared to non-stressed individuals. Men generally seem to be more risk seeking when stressed, while women become risk averse (Lighthall et al., 2009; van den Bos et al., 2009; Preston et al., 2007). Independent of gender, stressed individuals, when facing losses, choose as if more risk seeking but, when facing gains, they become more risk averse; thus, the reflection effect is more pronounced (Porcelli and Delgado, 2009).

While these findings give insight into stressed individuals’ behavior under structural uncertainty, they do not touch strategic uncertainty, which is given when outcomes of choices are contingent on other actor’s decisions. This study experimentally examines the impact of stress when making choices under strategic uncertainty. The experimental paradigm used is the beauty contest game.

### 1.1. The beauty contest game

To capture Keynes’ idea and test it experimentally, behavioral economists developed the so-called beauty contest game. In the beauty contest game, a number of players simultaneously choose a given number  $x_i$  in the interval  $[0,100]$ . The average of all the numbers chosen by the players is calculated and multiplied by a multiple  $p < 1$  (e.g.,  $p = 2/3$ ). The player whose number is closest to that target number (i.e.,  $2/3$  of the average) wins the game and receives a prize (Ho and Camerer, 1998; Nagel, 1995). When assuming that all players are fully rational, the Nash-equilibrium of the beauty contest game with the parameters given above would be zero. However, research shows that people barely choose zero but pick a number that reflects their reasoning about what other players will do and what

would be the appropriate response to other players’ behavior (Ho and Camerer, 1998; Nagel, 1995). Thus, it is assumed that a player’s behavior is the result of iterated steps of reasoning about other players’ choices. It has been shown that the model of iterated steps of reasoning describes the behavior of subjects in a beauty contest well, and that individuals differ regarding the depth of reasoning they apply (for a summary see Bosch-Domènech et al., 2010).

Each step of reasoning is referred to as level and individuals differ in regard of how many iterated steps of reasoning they carry out. Playing the beauty contest game for the very first time, individuals who carry out no steps of reasoning (so-called level-0 players) pick random numbers. In contrast, level-1 players assume that all others behave as level-0 players, which have a mean of the numbers picked around 50, and therefore, level-1 players pick a number around  $50 \cdot p = 33.3$ . In the same vein, level-2 players suppose all other players to show level-1 reasoning, and therefore choose  $50 \cdot p^2 = 22.22$ . Level-3 players choose  $50 \cdot p^3 = 14.81$  and so forth. In many cases, beauty contest games are played repeatedly over multiple rounds with the same parameters. It is assumed that, in all rounds after the first round, players will adapt to the feedback they receive from the previous game. Thus, level-0 players choose the mean of numbers picked by the group in the previous round ( $m_{t-1}$ ), whereas level-1 players will choose  $p \cdot m_{t-1}$  and so forth (Kocher and Sutter, 2005; Nagel, 1995).

The beauty contest game has been employed in numerous studies to examine strategic decision-making. For example, research shows that the general cognitive ability, such as general intelligence (Burnham et al., 2009), and working memory (Rydval et al., 2009) are associated with higher levels of strategizing. Moreover, the beauty contest was employed to examine individual versus group decision-making (Kocher and Sutter, 2005; Sutter, 2005), and recently it was used to study the neural correlates of higher level reasoning (Coricelli and Nagel, 2010). Surprisingly, however, the influence of stress and associated neuroendocrine responses on behavior in the beauty contest game has not been explored yet. The present study aimed to fill this void.

Two processes seem to be responsible for disrupted decision making under stress: impaired feedback processing and learning (Starcke et al., 2008), and impairments of executive functioning (Porcelli and Delgado, 2009; Schoofs et al., 2009). Hence, in the present study we predicted that stressed individuals would choose higher numbers in the beauty contest game, reflecting a lower level of strategic thinking, than individuals who are not stressed, because (a) areas in the prefrontal cortex associated with executive functioning are taxed when playing the beauty contest game (Coricelli and Nagel, 2010) and (b) because learning after receiving feedback according to other actors’ behavior is crucial when playing multiple rounds of a beauty contest game.

### 1.2. The present study

In order to induce stress, we used the group version of the Trier Social Stress Test (TSST; Kirschbaum et al., 1993), the TSST-G (von Dawans et al., 2011). The TSST is a standard protocol for the experimental induction of stress, and leads to a robust increase in cortisol, reflecting the activation of the

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