



# Stress pulls us apart: Anxiety leads to differences in competitive confidence under stress



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**Summary** Social competition is a fundamental mechanism of evolution and plays a central role in structuring individual interactions and communities. Little is known about the factors that affect individuals' competitive success, particularly in humans. Key factors might include stress, a major evolutionary pressure that can affect the establishment of social hierarchies in animals, and individuals' trait anxiety, which largely determines susceptibility to stress and constitutes an important determinant of differences in competitive outcomes. Using an economic-choice experiment to assess competitive self-confidence in 229 human subjects we found that, whereas competitive self-confidence is unaffected by an individual's anxiety level in control conditions, exposure to the Trier social stress test for groups drives the behavior of individuals apart: low-anxiety individuals become overconfident, and high-anxiety individuals become underconfident. Cortisol responses to stress were found to relate to self-confidence, with the direction of the effects depending on trait anxiety. Our findings identify stress as a major regulator of individuals' competitiveness, affecting self-confidence in opposite directions in high and low anxious individuals. Therefore, our findings imply that stress may provide a new channel for generating social and economic inequality and, thus, not only be a consequence, but also a cause of inequality through its impact on competitive self-confidence and decision making in financially-relevant situations.

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## 1. Introduction

Social competition is a major driving force in evolution and an essential organizing principle for the interactions between individuals and societies. In most social species, the outcome of competitive encounters with conspecifics determines individuals' social rank along with access to resources, and greatly influences physiology and health (Sapolsky, 2005). Despite the important consequences of contest competition on social organization and health, the factors that affect individuals' competitiveness beyond physical traits (such as size, age or gender) or previous social experience (e.g., winner and loser effects) are largely unknown.

In humans, an important attribute that strongly affects competitive decisions is the degree of confidence in one's abilities (Taylor and Brown, 1988). Biases in self-confidence (i.e. over- and underconfidence) can greatly affect individuals' well-being and position in society (Taylor and Brown, 1988) as well as eventually impacting society at different levels, from financial markets to international politics. Given its pervasiveness (Bernardo and Welch, 2001; Johnson, 2004), most studies have so far focused on the phenomenon of overconfidence—the belief that one is better than others in excess of what is justified by the data (Hoffrage, 2004). Although overconfidence can lead to suboptimal decisions with potential negative consequences in the short-run [e.g., losing contests (Camerer and Lovallo, 1999), engaging in costly wars (Johnson and Fowler, 2011), making audacious economic decisions (Barber and Odean, 2001; Malmendier and Tate, 2005, 2008) or providing inaccurate and potentially catastrophic expert judgments (Plous, 1993)], it can also bring important advantages to the individual in the long-run. Overconfidence can convey psychological benefits, such as increasing task motivation and persistence, or increasing utility from having a positive self-image (Bénabou and Tirole, 2002; Köszegi, 2006; Pajares, 1996) and self esteem (Alicke, 1985). Moreover, at the interpersonal level, overconfident individuals are perceived by others as more competent and are, in turn, conferred higher status (Anderson et al., 2012; Burks et al., 2013). Despite evidence that confidence levels in individuals and societies can vary under changing circumstances (Moore and Cain, 2007), little is known about the factors—both environmental and individual—that explain the variation in self-confidence in competitive settings. Evolutionary models have emphasized a critical role for environmental constraints, with overconfidence prevailing when the ratio between the benefits from contested resources and the cost of competition is high and underconfidence prevailing when this ratio is low (Johnson and Fowler, 2011).

Recently, acute stress was shown to facilitate the development of social subordination during competitive encounters in animals (Cordero and Sandi, 2007) and to affect decision-making in both animals (Graham et al., 2010; Shafei et al., 2012) and humans (Buchanan and Preston, 2014; Pabst et al., 2013). A role for stress might be particularly relevant in humans, as social and economic life is marked by increasing inequality and rising stress (Atkinson and Piketty, 2007). However, although a great deal of research has identified the negative impact of social and economic inequality in stress and health, and highlighted

stress as mediator of a wide range of health problems derived from social inequality (Wilkinson and Pickett, 2006), there is no information as to whether stress may itself cause systematic differences in social and economic outcomes. Such situations may arise, for example, if stress would differentially affect financially relevant decision-making in different subpopulations. Attempts to ascertain the contribution of personality in individuals' self-confidence have documented a lack of predictive power for some personality traits (e.g., openness, agreeableness and conscientiousness; Burks et al., 2013; Schaefer et al., 2004) but suggested that trait anxiety might play a role depending on the context (Schaefer et al., 2004). We thus hypothesized that acute stress exposure would impact competitive self-confidence in humans, with the outcome depending on the individuals' trait anxiety.

We tested this hypothesis with an economic choice experiment that involves a decision based on a self-confidence judgment of participants regarding their cognitive abilities. Participants, who had been characterized for trait anxiety and performance in a timed cognitive ability (CA) test one week before the experimental session, were asked to make economic decisions either under control conditions or under acute stress elicited using the Trier Social Stress Test for groups (TSST-G; von Dawans et al., 2011, 2012). Given that uncertainty has been postulated to be essential for under- and overconfidence biases (Johnson and Fowler, 2011), the experimental sessions involved two successive choice-experiments, to investigate participants' performance under high and low levels of uncertainty.

## 2. Materials and methods

### 2.1. Participants

Healthy male and female participants were recruited at the University of Lausanne and Ecole Polytechnique Fédérale de Lausanne (EPFL). They were screened for several exclusion criteria, including current medication usage, pregnancy, or breastfeeding; experiencing a major life change or an unusual amount of stress; smoking more than five cigarettes per day; or having a history of medical or psychiatric illness, insomnia, night shift work, or a history of drug or alcohol abuse. Two separate experimental cohorts were scheduled for data collection. Participants completed the sessions in groups of five or six. The final sample size was 229 participants, randomly assigned to either the stress ( $n=109$ : 41 females, 68 males) or control ( $n=120$ : 48 females, 72 males) conditions.

Participant demographics are listed in Tables 1 and S1. An additional group of 55 participants was recruited separately to play the role of second movers in some of the economic games. The second movers, who did not have to take any decisions, received a cash payment depending on whom they were paired with (mean payment = CHF 21.80). This study was approved by the Hautes Etudes Commerciales (HEC) Ethics Committee of the University of Lausanne.

### 2.2. Experimental procedures

The procedure is outlined in Fig. 1A. One week before the experimental session, participants completed an

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