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RESEARCH ARTICLE

The effect of acute stress response on conspiracy theory beliefs

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Abstract
The endorsement of conspiracy theories may be increased by subjectively perceived stress. Yet, it is not known whether this correlation is caused by the effects of the acute stress reaction on the brain or other psychological, social, or methodological factors. The effect of an experimentally induced acute stress reaction on conspiracy thinking was tested on a sample (n = 115) of students of medicine. Although the stress procedure caused a substantial increase in salivary cortisol, there was no significant effect on endorsing conspiracy theories or adopting conspiracy interpretations of novel information. The results confirmed no effect of the acute stress reaction on conspiracy thinking, suggesting it may be absent or weaker than expected. The study demonstrated the viability of psychophysiological experimental design in conspiracy research and may inspire further examination of the physiological mechanisms underlying susceptibility to conspiracy theories.

Keywords: Conspiracy theories; stress; cortisol; Maastricht Acute Stress Test

Introduction

Conspiracy theories (CTs) wield significant influence across diverse domains encompassing health, politics, and the workplace (Douglas et al., 2015). Believing in COVID-19-related CTs is associated with diminished apprehension of the pandemic's severity, reduced adoption of preventive measures like mask-wearing, and decreased intent to undergo vaccination within the United States (Romer & Jamieson, 2020). In their analysis across 17 European countries, Syropoulos and Gkinopoulos (2023) found that lower levels of institutional trust and higher levels of CT beliefs predict vaccine hesitancy even after accounting for demographic variables. Given the profound significance of CTs on public health, social cohesion, and politics, it is crucial to understand all factors that contribute to their prevalence. By uncovering these underlying mechanisms, we can better address the spread of CTs, mitigate their harmful effects, and promote more informed decision-making in society.

The scholarly examination of CTs generally falls into two distinct approaches (Nefes, 2015, 2017). The first approach emphasizes the irrational nature of CTs, viewing them as belief systems that distort

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reality rather than providing accurate explanations of events. This perspective associates CTs with the dissemination of disinformation by fringe and extremist groups, implying a pathological aspect to these beliefs (e.g.,(Hofstadter, 1965; Robins & Post, 1997)). Conversely, a more modern perspective regards CTs as rational attempts by individuals to explore alternative explanations and make sense of complex realities (e.g.,(Gray, 2010; Knight, 2000)). While various studies demonstrate many factors relating to the beliefs in CTs all around the world, there is a gap of research in the scholarship with regards to exploring the physiological mechanisms that may underlie heightened susceptibility to conspiracy theory beliefs.

Our study contributes to fill a critical gap in the literature by investigating, for the first time, the influence of cortisol on individuals' tendencies to believe in CTs. The paper begins by highlighting the theoretical gaps in our understanding of the physiological mechanisms that may affect conspiracy beliefs. It then details the methods, experimental procedure, and key findings. Finally, the paper concludes with a discussion of the results and their broader implications.

Physiological mechanisms associated with conspiracy theory beliefs

During periods of heightened stress, individuals may exhibit a proclivity for embracing CTs (Douglas et al., 2019; Lantian et al., 2017; J. W. Van Prooijen, 2019). Numerous CTs emerge during times of crisis (Nefes, 2014). Moreover, experiencing elevated perceived stress levels correlated with the belief in CTs among adults in the United States (Swami et al., 2016) and in Italy (Simione et al., 2021). The belief in CTs may be influenced by stress, and this effect could arise from the impact of biological stress on the brain. For instance, the influence of cortisol on hippocampal activity could affect memory processes related to conspiracy explanations (Duch, 2021; Hermans et al., 2014) or the propensity to less complex learning and reasoning mechanisms under stress might be involved (Moravec et al., 2018; Schwabe, 2017). Nevertheless, the correlation between perceived psychological stress and conspiracy beliefs does not automatically imply a causal effect of cortisol on conspiracy thinking. First, the relationship between the self-reported life stress and the physiological stress reaction indexed by cortisol levels is weak (Halford et al., 2012; Lazarides et al., 2020). Second, Swami et al. (2016) studied the link between the stress perceived in the last month and the endorsement of conspiracy theories. Yet, the endorsement of popular CTs used in the study may have reflected stable opinions developed months or years before, independently of the stresses of the last month. Thus, factors such as personality traits, sociodemographic status, social groups, and political beliefs could simultaneously affect the propensity to perceive own life as stressful and conspiracy beliefs, inflating the observed correlation between these two constructs. Indeed, conspiracy thinking correlates with trait rather than state anxiety (Krüppel et al., 2023), linking endorsement of CTs to individual rather than external factors. Third, the correlation between self-reported stress and CTs might be caused by situational and response factors affecting responses to stress-related as well as conspiracy-related surveys. For example, the momentary emotional status of the respondents or their response styles might simultaneously affect their responses to different survey scales, resulting in inflated or spurious correlations (Podsakoff et al., 2003; Tourangeau et al., 2000). Accordingly, the scholarship could benefit from empirical studies that examine the relationship between stress and conspiracy theory beliefs.

Our research addresses this gap in the scholarship by exploring how acute stress responses influence conspiracy beliefs. In our experimental study, we utilize the Maastricht Acute Stress Procedure (MAST) to induce biological stress, characterized by elevated cortisol levels. Aligned with prior academic literature on CTs (Duch, 2021; Swami et al., 2016; J.-W. van Prooijen et al., 2018), we expect that inducing stress will heighten reported agreement with conspiracy theory statements. Additionally, we aim to differentiate whether acute stress levels impact the expression of agreement with existing CTs or the adoption of conspiracy explanations in response to novel information. This distinction mirrors Swami et al.'s (2011) categorization of real-world and fictitious CTs, where the former pertains to circulated conspiracy accounts and the latter involves fictional theories created by researchers. For

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assessing agreement with the former, we present items summarizing existing CTs, such as those related to the Russia-Ukraine War. To examine the adoption of novel conspiracy explanations, we introduce brief fictional narratives describing an event with two alternative explanations, one of which is conspiratorial. In so doing, we investigate whether acute stress is a factor that increases the likelihood of adopting a conspiracy explanation when encountering a new situation (Duch, 2021). Our hypotheses are as follows:

1. Acute stress reactions will amplify individuals' inclination to express agreement with CTs.
2. Acute stress reactions will heighten individuals' inclination to favor a conspiracy explanation when interpreting a new situation.

Methods

Stress induction and cortisol analysis

The MAST is a standardized procedure for experimental initiation of stress reactions in humans, including the experimental and control variants. Experimental MAST combines physical and psychosocial stressors as both are processed differently in the brain and was confirmed to be efficient in eliciting subjective, autonomic, as well as glucocorticoid responses to stress (Smeets et al., 2012). In this procedure, participants face an unpredictable situation, alternating between sinking their hand into cold water (physical stressor) and a counting task requiring them to quickly subtract 17 from 4-digit numbers with harsh, critical supervision and negative feedback while being allegedly recorded on video (social stressors). The control procedure replicates the stress variant without causing stress: lukewarm water is used instead of the cold one, an uncomplicated counting task is carried out without negative feedback, no video recording is simulated, and polite supervision is offered. To validate the MAST procedure, salivary cortisol and blood pressure and pulse will be measured repeatedly before and during the experiment. Salivary samples will be collected using Salivette tubes. Salivary cortisol, a well-established stress biomarker (Hellhammer et al., 2009; Strahler et al., 2017), will be analyzed using ELISA in a commercial laboratory.

Experimental procedure

Prior to the experiment, participants were instructed to refrain from eating, smoking, and consuming anything except water for at least 2 hours before the study to minimize external influences on cortisol levels. Further, they were asked to avoid caffeine intake, heavy exercise, and substantial stressors on the day of testing. To minimize the effect of circadian fluctuations of cortisol (Hofstra & de Weerd, 2008), the testing will be done during afternoon hours (1 pm–6 pm).

Upon arrival, the participants were encouraged to drink a glass of water to aid saliva secretion. They received an explanation of the study and an informed consent form, followed by the baseline (t0) cortisol and blood pressure measure. Then, the participants were pseudo-randomly assigned to the experimental or control group and underwent the MAST procedure in one of two separate rooms. Following the MAST procedure and blood pressure measurement (t1), they moved to another room, where cortisol and blood pressure measures were taken (t2). Consequently, during the expected peak of cortisol levels 5–40 minutes after finishing the MAST (Quaedflieg et al., 2013, 2017, 2022; Smeets et al., 2012), the novel conspiracy explanations survey was presented, followed by the conspiracy items survey. After their completion, the last measures of cortisol and blood pressure were taken approximately 30 minutes after the end of the MAST procedure (t3). The participants were debriefed and encouraged to ask questions. The study was approved by the Ethical Committee of University Hospital Pilsen and Faculty of Medicine in Pilsen, Charles University (ref. 49/23).

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Sample

In total, 143 general medicine students from Charles University, 20–25 years old, participated in a "psychophysiological study" for their psychology class credit. Data from 7 participants were excluded due to missing or insufficient saliva samples (see Data collection section in Appendix for details). Of the sample with admissible saliva samples (n = 136; 73 in the intervention group), 15 were excluded due to insufficient cortisol response (as dictated by the design, all from the intervention group) and 6 for lack of consistency in their answers (5 in the intervention group). Moreover, 2 participants were excluded from the Conspiracy Survey due to multiple missing items. Hence, the analyses were conducted on a sample of 115 (53 in the intervention group; 75 females) and reduced to n = 113 (51 in the intervention group, 73 females) for the conspiracy survey. No personal details other than sex and those necessary to apply inclusion and exclusion criteria were collected.

The sample size was determined to be 58 per group after applying all exclusion criteria via apriori power analysis with a requirement to detect an effect size corresponding to 7% of the variance in the conspiracy beliefs being explained by stress with 90% statistical power. The statistical power was confirmed by retrospective sensitivity analysis using G*Power 3 (Faul et al., 2007) (see Power Analysis in the Appendix for details). Because the study induces stress experimentally in a relatively homogeneous sample and measures the conspiracy beliefs in a standardized laboratory setting, it magnifies the effects of stress compared to its effects in daily life. Thus, it is plausible to expect that any smaller effect would have negligible impact on interindividual differences in endorsing CTs outside the laboratory.

Exclusion criteria

To prevent medical factors affecting cortisol levels, exclusion criteria inspired by general recommendations and previous studies (Hellhammer et al., 2009; Kuhlmann & Wolf, 2005; Quaedflieg et al., 2022; Strahler et al., 2017) were applied: pregnancy, hormonal contraception, prescription medication or illegal drugs or acute illness in the week before testing, average alcohol intake above 20 glasses per week, regular smoking. Moreover, those substantially departing from the pre-experimental requirements (caffeine intake in the last 6 hrs, sugar intake or heavy exercise in the last 2 hrs etc) were excluded. Additional exclusion criteria were based upon the results of the participants. First, from the experimental group, those who do not show a satisfactory increase in cortisol level following the MAST procedure will be excluded. Specifically, the difference between the baseline (t0) cortisol level and cortisol levels in any of the two later samples (t2 or t3) will need to reach at least 1.5 nmol/l (Miller et al., 2013) for the participant to be included in the experimental group. Second, those not passing the attention check in the questionnaires were excluded (see Psychometric tools; missing responses necessary for the attention check were ignored).

Psychometric tools

The conspiracy survey comprises single-sentence conspiracy statements drawn from prior studies (Brotherton et al., 2013; Enders et al., 2021; Stojanov & Halberstadt, 2019) and covering various topics excluding medical CTs (see the Appendix I for the list of items). Participants rated these statements on a 6-point Likert scale ranging from "strongly disagree" through "disagree" and "rather disagree" to "strongly agree." The mean response was used after we established that the in-sample internal consistency was sufficient (Cronbach's alpha = 0.95).

The novel conspiracy explanations are paragraph-long narratives invented by the authors based on stories used in existing literature (Imhoff & Lamberty, 2017; Lantian et al., 2017). Each story presents an open conspiracy theory (Räikkä, 2018): a fictional controversy with a mainstream and a conspiracy explanation, satisfying the conflict and the conspiracy criterion. Each story is complemented with three items probing how likely different aspects of the conspiracy explanation are according to the participant, acknowledging some of the nuances of conspiracy beliefs (Raab et al., 2013). A six-point Likert scale will

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be used again, ranging from "very unlikely" through "unlikely" to "slightly unlikely" to "very likely." The mean response was used after we established that the in-sample internal consistency was sufficient (Cronbach's alpha = .92). The stories and items are presented in the Appendix.

The attention check involved rephrasing three conspiracy survey items and presenting them again. Participants with a mean difference larger than 1 point on a 1–6 Likert scale between the original and the repeated items or discrepancies of more than 2 points in any response were excluded.

Statistical analysis

The analysis was conducted in R version 4.3.0, using the tidyverse framework (RStudio Team, 2022; Wickham et al., 2019). The analytic script and the datafile (see Datafile in the Appendix for details) are available along with the preregistered protocol of the study on https://osf.io/37s6a.

Participants lacking cortisol responses or response consistency were excluded from the analysis. A two-way repeated measures ANOVA (time × group) was employed to confirm the cortisol increase following stress induction. We have used the function *anova_test* from the *rstatix* package (Kassambara, 2020), employing a Type III sum of squares. The main analysis involved a one-tailed Welch t-test (Delacre et al., 2017) for each of the two dependent variables (conspiracy survey and novel conspiracy explanations) to examine anticipated differences in scores between the experimental and control groups for conspiracy items and stories. The threshold for statistical significance was set to $p = .05$. Considering the difference between these two variables (i.e., tapping responses about existing beliefs a vs formation of novel ones), no correction for multiple comparisons was made. Additionally, a post-hoc exploratory analysis was conducted to estimate the size of the possible effect from our data using the *cohens_d* function of the *rstatix*.

A preregistered sensitivity analysis was conducted to assess the robustness of our main findings. Specifically, the main analysis was repeated with the dependent variables converted to binary variables to account for potential bias resulting from the extreme response style. A one-tailed Welch t-test was used on items binarized by setting all "agree" or "likely" responses to 1 and all "disagree" or "unlikely" to 0. As a further sensitivity check, the main analysis was repeated using the Mann–Whitney U test to account for the effects of potential outliers.

Results

The conspiracy survey measures had excellent internal consistency (both alphas > .90) and were positively correlated ($r = .68$; $p < .001$). Cortisol has increased in the intervention group ($F(214,2) = 38.10$; $p < .001$) and differed before ($t(85.02) = 5.15$; $p < .001$) and after ($t(83.35 = 8.67$; $p < .001$) filling the surveys, but not on baseline ($t(82.99) = 1.50$; $p = .14$; see Figure 1). We found a significant effect of the interaction between the group and time on systolic ($F(183,3) = 3.47$; $p < .05$) but not diastolic ($F(183,3) = .17$; $p = .92$) blood pressure and on pulse ($F(183,3) = 4.10$; $p < .01$). The systolic blood pressure was higher in the intervention group immediately after finishing the stress procedure ($t(65.89) = 2.62$; $p < .05$), but not on the baseline ($t(109.86) = 0.36$; $p = .72$) or at t2 ($t(110) = 1.70$; $p = .09$) or at t3 ($t(107.91) = 0.72$; $p = .48$). The pulse was faster in the intervention group immediately after finishing the stress procedure ($t(60.92) = 3.08$; $p < .01$) and at t3 ($t(93.89) = 2.56$; $p < .05$), but not on the baseline ($t(97.06) = 1.40$; $p = .16$) or at t4 ($t(90.72) = 1.07$; $p = .29$). The mean time difference from finishing the MAST procedure (t1) was 4.85 minutes to the second cortisol measurement before filling out the surveys (t2) and 28.92 minutes till the final cortisol measurement after the surveys were finished (t3).

We did not reject the null hypotheses for the group differences in conspiracy survey ($t(108.82) = 0.54$; $p = .30$) or novel conspiracy explanations ($t(111.14) = 1.37$; $p = .09$; see Figure 2). Exploratory post hoc analysis estimates the effect of acute stress on conspiracy items to $d = 0.10$ (CI = [−0.29; 0.46]) and on novel conspiracy explanations to $d = 0.26$ (CI = [−0.09; 0.64]). We reached the same conclusion in the sensitivity analysis using binarized outcome variables ($t(103.30) = 0.59$; $p = .28$ for conspiracy items and

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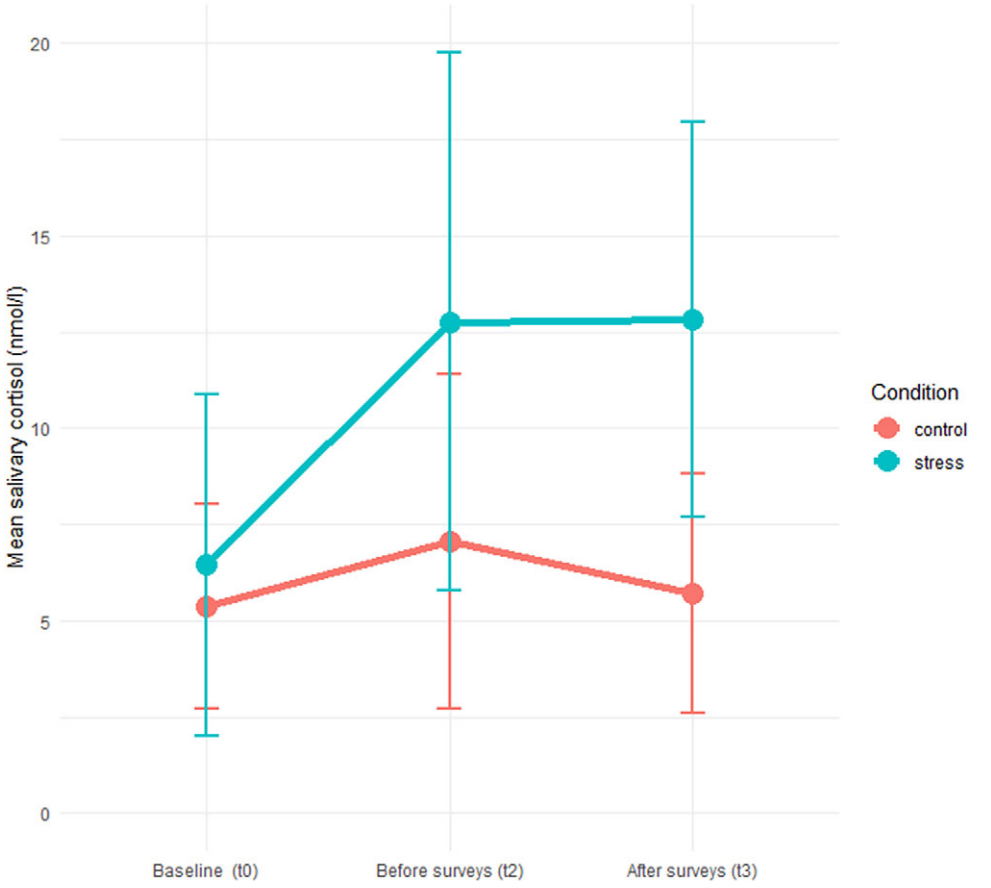

Figure 1. Cortisol levels by group and time. The salivary cortisol levels, within the expected range for both groups at the baseline (t0), increased in the intervention group following the MAST procedure (t2) and remain elevated until the surveys were filled by the participants (t3). Error bars display the standard deviation.

$t(110.31) = 0.52$; $p = .30$ for novel conspiracy explanations) and Mann–Whitney test (W = 1510; $p = .68$ for conspiracy items and W = 1389; $p = .15$ for novel conspiracy explanations).

Discussion and conclusions

We did not find statistically significant effects of acute stress reactions on agreement with CTs in this study. Despite a substantial increase in salivary cortisol in the stress group, we found no difference in either of the two measures of conspiracy beliefs. The evidence on psychophysiological processes implies that the effects of acute stress on cognition (FeldmanHall et al., 2015; Margittai et al., 2016; Sandi, 2013; Shields et al., 2016) are likely to impact the evaluation of CTs (Duch, 2021). Yet, our results imply that these effects may be weak or absent, particularly for the endorsement of existing CTs. Even in a homogenous sample intentionally stressed by a standardized experimental procedure in laboratory settings, we were unable to confirm an effect large enough to cause an increase of at least 7% of the interindividual differences in endorsing CTs. These results implicate that the correlation observed between subjectively perceived stress and endorsement of conspiracy items across different subjects by Swami et al. (2016) is unlikely to be fully mediated by the physiological stress reaction.

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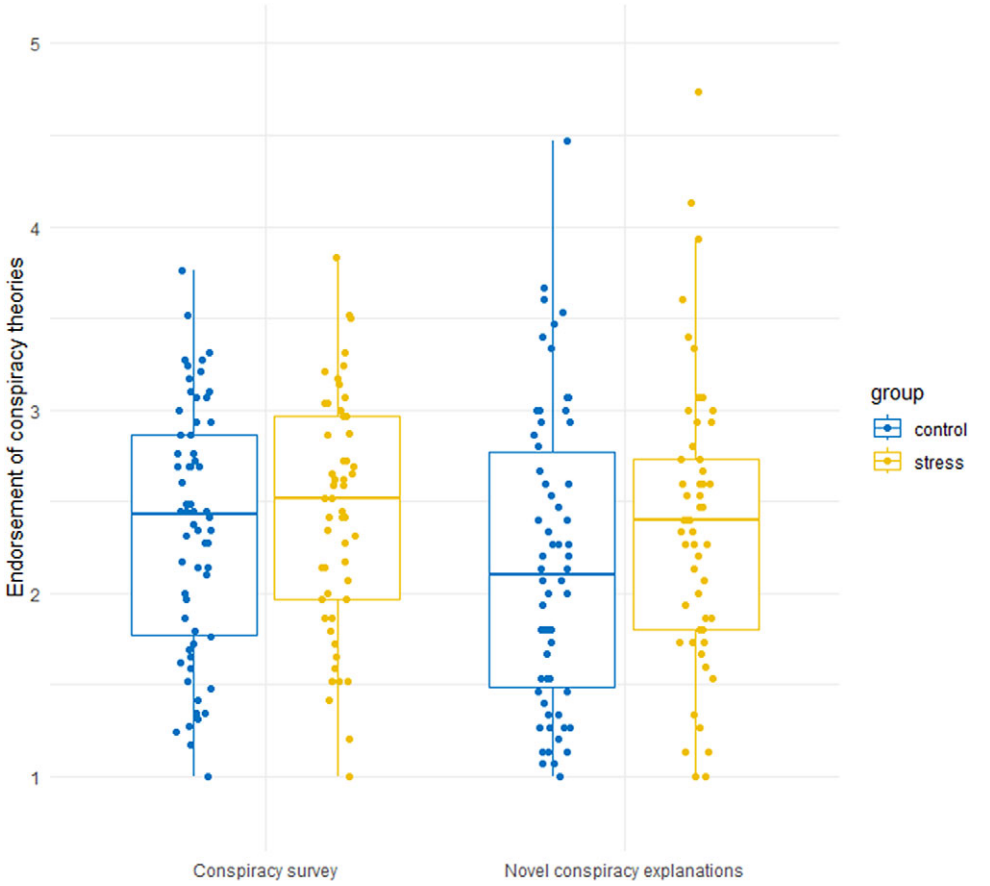

Figure 2. Mean answer to the conspiracy theory items (left) and novel conspiracy explanations items (right) by group. The mean responses (coded from 1 for "strongly disagree" to 6 for "strongly agree") of individual respondents are displayed as dots; boxplots display group interquartile ranges.

Despite not finding a significant relationship between acute stress and beliefs in CTs, the study contributes to the scholarship in two interrelated ways. First, it shows that perceived stress should be investigated separately from the physiological stress reaction, as their effects on beliefs in CTs may differ. In other words, the academic literature on CTs could benefit from a more nuanced examination of stress. Second, the study highlights potential situational and response biases in solely survey-based research on CTs, as momentary emotional states and response styles might influence survey responses. In this regard, measuring acute stress response through hormonal levels opens a new path in political science and sociology, allowing future studies to triangulate their findings and provide a more detailed analysis of the relationship between types of stress and agreement with CTs. Given the rapid contemporary advancements in technologies to measure physiological states, the social scientific literature on and beyond CTs could benefit from these measures.

It should be noted that the generalization of our null results is limited by the setting of the experiment: the nature of the stress procedure, the operationalization of conspiracy beliefs, and the specifics of the sample. With respect to the first, we examined the effects of stress in 30 minutes after applying the stressing procedure and demonstrated that cortisol salivary levels were significantly increased before and after filling the surveys. Yet, the effects of acute stress on the brain and cognition may differ in reaction to different stressors and in timescales ranging from seconds to days or even weeks (Joëls & Baram, 2009; Quaedflieg & Schwabe, 2018). Therefore, our study cannot rule out potential effects of acute stress on

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conspiracy beliefs present in stages of the stress response different than those reflected by this study. However, relevant effects of stress on cognition are linked particularly to the cortisol peak about 5–40 minutes after stress. For instance, cognitive control affects conspiracy thinking (Kantorowicz-Reznichenko et al., 2022; Pisl et al., 2021; Stoica & Umbreș, 2020), while the effects of acute stress on cognitive control are mediated by cortisol (Margittai et al., 2016; Yu, 2016). Similarly, the memory processes theorized to mediate the effects of stress on conspiracy thinking (Duch, 2021) are also linked to cortisol (Quaedflieg et al., 2013, 2022; Quaedflieg & Schwabe, 2018; Smeets et al., 2019). Furthermore, it is plausible to expect that the effects of acute stress response in the first minutes may be too brief and elusive and the long-term effects too weak to cause substantial effects on human propensity to CTs. In sum, there is little evidence suggesting that other effects of acute stress response affect conspiracy thinking more strongly than those measured in this study.

With respect to the conspiracy measures used, we confirmed no effect of acute stress on the endorsement of existing CTs presumably known to the participants or on conspiracy interpretations of novel information. These results imply that acute stress affected neither the social processes influencing the readiness to express agreement with CTs nor the cognitive processes underlying the acceptance of conspiracy explanations when facing novel information. Our collection of diverse items might have failed to capture effects related to specific topics or groups of CTs. For instance, acute stress might have specific effects on CTs related to matters personally affecting the respondents, as stress may orient attention towards threats (McHugh et al., 2010; Posner & Petersen, 1990), perhaps triggering the need for the existential functions of CTs (Douglas et al., 2019). Furthermore, situational factors could moderate the effects of stress. For example, acute stress might increase inclination to shared conspiracy explanations in social situations when these function to increase belonging to a group (Douglas et al., 2017, 2019). Yet, it is plausible to assume that if the relationship between acute stress and conspiracy thinking was strong, it would have been reflected in our data.

Finally, the sample of students of medicine may have specific cognitive and/or social characteristics affecting which processes and predictors are relevant for their decision whether to endorse a conspiracy explanation. Therefore, our study does not rule out the effect of cortisol on conspiracy thinking when certain moderating factors are present, such as specific cognitive habits (Bensley et al., 2022; Dagnall et al., 2015) or strategies to cope with stress (Marchlewska et al., 2022). Indeed, higher education, an increased tendency to analytical thinking, or exposure to public campaigns against CTs could have prevented the effects of cortisol on cognition from fully translating into conspiracy thinking. Thus, the effect of acute stress on CTs could be stronger in the general public compared to our sample and perhaps particularly strong in some specific populations.

In our experiment, a standardized stressing procedure provenly eliciting significant physiological stress responses has not manipulated the conspiracy beliefs of a sample with little sociodemographic differences in a measurable manner. Thus, our study demonstrates that the surge of cortisol following exposure to a stressful event does not largely increase neither the acceptance of conspiracy explanations in novel situations nor the general endorsement of popular CTs. Yet, acute stress responses might substantially affect conspiracy beliefs under specific circumstances, in specific populations, or with respect to specific topics. Further studies using similar designs should complement our results, as the present study confirmed the viability of psychophysiological experimenting in conspiracy research.

Data availability statement. The data, coding files and other materials, and pre-registration are publicly available at: https://osf.io/37s6a/.

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Competing interest. Authors have no conflicts of interest to declare.

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