The Effects of Different Social Stress Conditions on Human Decision Making

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Abstract

As it became evident during the current global health crisis (COVID-19), decisions nowadays become increasingly associated with fear, anxiety, and stress. Due to the far-reaching consequences a decision might have, the appraisal of stress by the decision maker can have a crucial impact on our society as well. However, neuropsychological findings suggest that when humans are subject to a stressful situation, perceiving it as a challenge instead of a threat could induce moderate instead of high stress levels. This, in turn, provides increased cognitive capacity and could, therefore, contribute to more favorable decisions of the individual. Thus, a one-factor between-groups design was employed to investigate the effects of stress in challenging, threatening or control conditions on participants decision-making performance. Fourteen women and 22 men participated in an online experiment. Self-assessment measures were employed as an indication for the experienced stress of the 20 to 27-year-olds. The dependent variable, decision-making, was measured by the Iowa gambling task (IGT). In contrast to initial expectations, we found no significant differences in IGT-performance, depending on the stress-condition of participants. However, results indicate that there was a higher variance in responses and a reduced stressful effect for the threat condition than intended. These results and the established context suggest that, in general, the utilized online video-chat was not sufficiently immersive to create equally challenging or threatening situations for the conditions. Consequently, it appears as this shallow stress-induction left more space for personal characteristics to interact with the individual's reaction to stress. Particularly, the factor Age was found to account for some of these within-group variances. After all, this paper explains the effects of different social stress conditions embedded in a contextual framework about the effects of stress on cognitive functions.

Keywords: stress, emotion, reappraisal, decision-making, Iowa gambling task, online, pfc, amygdala, age, challenge, threat

The Effects of Different Social Stress Conditions on Human Decision Making

Making decisions is a fundamental property of our everyday lives. Whether it is in a social, occupational or private context, decisions are of crucial importance in every human life. Since they will lead to short or long-term consequences for the decision maker and the involved individuals (Starcke & Brand, 2012). Accordingly, a single decision has the potential to exert an enormous impact on society as a whole. This was also the case during the concurrent COVID-19 pandemic. Throughout the past months, executives all over the world were confronted with the decision about whether to lock down societal and business-related processes to protect public health. Such critical decisions are undoubtedly troublesome and various factors are incorporated during the process of making the decision.

Obviously, the situation itself is one undeniable factor which affects the individual's decision. Especially right now, as the sharp pang of the pandemic (COVID-19) is sweeping across the world and triggers fear, anxiety, and stress among people, decisions become increasingly associated with aroused emotions and stress (Montemurro, 2020). Interestingly, contemporary research indicates that even the mere anticipation of stress and negative emotions can produce similar harmful effects on cognitive functioning as an actual, external stressor. Through forecasts about potential affective and cognitive outcomes, individuals begin to feel stressed, which in turn affects their cognitive abilities involved in decision making (Hyun, Sliwinski, & Smyth, 2019; Neupert, Neubauer, Scott, Hyun, & Sliwinski, 2018; Smyth, Zawadzki, & Gerin, 2013). To illustrate, doctors and other executives all over the world anticipated highly stressful situations during the rise of the pandemic as they got informed about the soaring prevalence in other countries. Accordingly, the mere apprehension of the presumable affective and cognitive impact of the situation could impede the cognitive functioning of these crucial individuals to society. Therefore, since stress is developing into a daily companion in this globally connected world, it appears of major significance to study its effects on such essential processes like decision making.

A considerable amount of literature is already published about the effects of anticipated stress on decisions making. In general, studies found that when participants anticipate the threat of a shock (Keinan, 1987) or made anxious by a secondary task (Cumming & Harris, 2001), they exhibit impaired decision-making ability. Preston, Buchanan, Stansfield, and Bechara (2007) build up upon this by suggesting impaired decision-making ability through a reduced emotional learning capacity of stressed individuals. Among other studies, they vindicate that emotional affect is a crucial component to execute sophisticated decisions. Nevertheless, the interpretation of an (anticipatory) stressful situation can be quite different for each individual (Tomaka, Blascovich, Kibler, & Ernst, 1997). That is why a growing body of literature has focused on variables which interact with the individual's stress response. The two most prominent factors found were gender (Mather, Gorlick, & Lighthall, 2009; Preston, Buchanan, Stansfield, & Bechara, 2007; van den Bos, Harteveld, & Stoop, 2009; Wemm & Wulfert, 2017) and age (Amirkhan & Auyeung, 2007; Uhr, Tehler, & Wester, 2018). Taken together, these findings suggest that an anticipatory stressor can reduce individuals' emotional learning capacity and thereby impairs their decision-making. Furthermore, the entire process is possibly differentiated by influential factors such as gender and age.

By now it has become clear that specific variables interact with the human stress response. But more practically important: can we ourselves consciously interact with our stress response? The entire framework of cognitive behavioural therapy tackles this question by evaluating cognitive reappraisal as a particularly effective strategy for the down-regulation of negative emotion (Jamieson, Mendes, & Nock, 2013) Specifically, one study found the performance-inhibiting consequences of a social threat eliminated when the threat was reframed as a challenge (Alter, Aronson, Darley, Rodriguez, & Ruble, 2010). Accordingly, a challenge state is suggested to result in superior performance by promoting the interpretation of emotions (i.e., more facilitative for performance) and more favorable emotional responses (i.e., lower negative and higher positive emotions) because people feel capable to conquer the upcoming stressors (Crum, Akinola, Martin, & Fath, 2017; Fink, 2016; Moore, Vine, Wilson, & Freeman, 2012). In contrast, while challenges are mostly positively evaluated, threatening situations seem to be more negatively evaluated because they demand more resources than the perceiver has available (Blascovich, Mendes, Hunter, & Salomon, 1999; Thoman, White, Yamawaki, & Koishi, 2008). Although, virtually the same task can be interpreted as a challenge or a threat, dependent on a range of situational factors (Keller & Bless, 2008). It is, therefore, the context of the situation and the individual's perception of available resources which ultimately decide whether people feel challenged or threatened.

The above-described differentiated behavioural outcomes suggest that a challenging and a threatening interpretation of a situation result in differentiated stress levels. Acknowledging the importance of decisions and how easy these appear to be influenced by situational factors, this research focuses on the application of cognitive reappraisal in a stressful situation to improve individuals decision-making performance. Specifically, this study proposes differentiated outcomes in individual's decision making by suggesting distinctive cognitive effects due to the re-interpretation of a stressful situation. Hence, this paper deals with the central question: “To what extent does decision-making performance differ when individuals feel not stressed, threatened or challenged?”.

Theoretical framework

The following outline aims to provide a comprehensive understanding of cognitive reappraisal and its effects on individual’s decision-making. To tackle the above-described concerns, first, we need to present a sketch of the nature of decisions. In general, fundamental cognitive functions like an individual's working memory or attention supply the foundation for high-order cognitive processes like decision making (Ramos & Arnsten, 2007). So that, reduced resources of these constituents diminish the ability to execute elaborate decisions (Wang & Ruhe, 2007). Besides, emotional factors have a powerful influence on decisions. Especially in the face of uncertainty, so-called emotional markers are meant to provide intuitive and implicit information about which choice could be advantageous in the current context (Bechara, Damasio, & Damasio, 2001; Hawthorne, Weatherford, & Tochkov, 2011). Damasio (2005) was the first one to describe these somatic markers and his position has been affirmed in numerous experiments using the Iowa Gambling Task. To illustrate, this task demands implicit learning of emotional markers to make more profitable decisions in the long run (IGT; Bechara, Tranel, & Damasio, 2000). Overall, research of the last two decades acknowledged basic cognitive and emotional processes as substantial to the process of decision making.

Nonetheless, stress is not only a psychological but also a biological response. Thus, we experience stress psychologically when we perceive a situation where we believe to not have the resources to deal with. That, in turn, affects many cognitive and neurological processes, by altering brain cells in the central nervous system (Ferreira, 2019). The prefrontal cortex (PFC) is a key structure during these processes as it is well-positioned to participate in mechanisms underlying stress adaptation and pathology. For instance, the PFC possesses extensive bidirectional connections to the amygdala; the key region for stress and emotional value (McKlveen et al., 2013). This bidirectional connectivity enables both areas to dynamically interact with each other.

On the one hand, there is the PFC which is essential to any high-order, cognitive processes. It regulates the activity of other cognitive processes in a flexible and goal-directed manner and has a significant modulatory role towards other brain areas (Arnsten, Raskind, Taylor, & Connor, 2015; Veer et al., 2012). For instance, during therapeutic techniques like cognitive reappraisal, the PFC actively uses top-down regulation towards emotion-generating systems (e.g. amygdala) to regulate affective extremes (De Houwer & Hermans, 2010; Gross, 1998; Sinha & Li, 2007; Veer et. al, 2010; Veer et al., 2012). On the other hand, since the connections between the PFC and amygdala are bidirectional, increased amygdala activity is also able to inhibit the PFC. Hence, during conditions of acute stress, the perceived control of individuals decrease due to a shift away from deliberative, PFC-dependent processes, towards more automatic, reflexive subcortical-dependent processes (Fink, 2016; Preston et al., 2007; Starcke & Brand, 2012). Notably, the original stressor is not the determining factor for this shift in brain activity, but the subjective interpretation and anticipation of that stressor are what defines the involvement of subcortical amygdala activity (Grupe & Nitschke, 2013; Nitschke et al., 2009). Consequently, the individual's interpretation within a stress reaction ultimately defines an individual's neurological-dependent reaction.

However, the amygdala not only interacts with the PFC but is also crucial for the person's initial stress reaction. Specifically, once a stressor is perceived, the amygdala sends a distress signal to the hypothalamus – the relay centre of the brain (Bergström, 1964; Roozendaal, Barsegyan, & Lee, 2007). This, in turn, releases two specific stress pathways. First, the hypothalamus stimulates the sympathetic nervous system, triggering the adrenal glands to release epinephrine and norepinephrine into the bloodstream (Bergström, 1964; Roozendaal et al., 2007). As recent studies indicate, Norepinephrine (NE) can lead to a performance shift in decision making (Starcke & Brand, 2012). Specifically, high levels of NE impair the PFC, while moderate levels of NE are proposed to strengthen prefrontal cortical functions (Ramos & Arnsten, 2007; Starcke & Brand, 2012). Therefore, moderate levels of norepinephrine, released by the appraisal of a moderately stressful situation in which individuals feel capable to overcome the expected stressors (challenge), should facilitate an individual's performance on cognitive tasks like decision making.

The second stress pathway involves a more expansive response, which is produced by the Hypothalamic-pituitary-adrenal (HPA) axis. Specifically, the distress signal of the amygdala arrives at the anterior pituitary and initiates a cascade of hormonal events, eventually releasing glucocorticoids from the adrenal cortex (Ferreira, 2019). Several brain areas possess glucocorticoid receptors, and, in general, research argues for a facilitating cognitive effect during moderately elevated glucocorticoid levels (de Kloet, Oitzl, & Joëls, 1999; Lupien & McEwen, 1997). In contrast, a deleterious cognitive effect is suggested with very high or very low levels of glucocorticoids (Lupien & Lepage, 2001). Furthermore, some studies point out that there can be differentiated neuronal effects of stress due to confounding variables like age and gender (Preston et al., 2007; Uhr et al., 2018; van den Bos et al., 2009; Wemm & Wulfert, 2017). However, before-mentioned findings regarding stress-related neurotransmitters, hormones and behaviour contribute to the hypothesis that generally, when individuals perceive a situation as moderately stressful and feel capable to conquer the upcoming stressors, it should enhance their decision-making ability.

Purpose of this research

The presented theoretical framework explains how fundamental neuronal changes might result in different behavioural effects during stress-related situations. The current research aims at investigating these differentiated behavioural effects by measuring participants decision-making ability after they got confronted with either a threatening, a challenging or a control situation. These situations will be provoked by letting participants anticipate either a challenging situation, where they still feel capable of succeeding, or a personal threatening evaluation which is supposed to be perceived as demanding more resources than the participant has available (Alter et al., 2010). During the control condition, individuals will not be confronted with any anticipatory situation. These altered perceptions of a situation are proposed to induce distinct neuronal stress-levels with subsequent different behavioural effects. Self-report questionnaires are implicated to indicate the participant‘s subjective experience of stress. The resulting cognitive changes should manifest itself in the individual’s decision-making ability, measured by the amount of favorable deck choices on the Iowa gambling task.

H1: Participants in the *challenge* condition choose more favourable decks in the Iowa gambling task compared to participants in the *threat* condition

H2: Participants in the *threat* condition choose less favourable decks in the Iowa gambling task compared to participants in the *control* or *challenge* condition

Method

Design

A one-factor between-groups design was employed. There were three levels of the independent variable ‘Stress-condition’ (control vs. challenge vs. threat) whose effects were assessed on the dependent variable, namely Iowa gambling task performance.

Participants

This was a convenience sample aggregated from student study participation in exchange for SONA points and personal contacts by asking students for voluntary participation. Participants were healthy adults (N= 36, M_{age} = 23.11; SD = 1.80) between 20 – 27 years. None of them had any pathological condition or was on medication. However, two participants were excluded from the study, as they decided to drop out during the threat condition. In total, there were 14 women and 22 men, randomly assigned to the control (*n*=12), challenge (*n*=12) or threat (*n*=12) condition. The experiment was approved by the University of Twente's Ethics committee, and all participants gave informed consent in compliance with institutional guidelines.

Materials

Measures. Two specific measures were used to assess participants' perceived stress. First, the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) was used to assess anxiety and subjective feelings of distress. Spielberger and Sydeman (1994) defined anxiety as feelings of unease, worry, tension, and stress. Which makes this questionnaire suitable to provide indications about individuals perceived stress at a certain specific moment. The STAI questionnaire consists of a Trait and a State subscale, with 20 items each. All items are rated on a 4-point scale (e.g., from "Almost Never" to "Almost Always"). Higher scores indicate larger anxiety and experienced distress.

The Trait-subscale is used to determine an individual's general susceptibility to stress. Particularly, Spielberger and Sydeman (1994) defined trait anxiety (T-anxiety) as "feelings of stress, worry, discomfort, etc. that one experiences on a day to day basis". Usually, that is observed in how people feel across typical, everyday situations (Aldao & Nolen-Hoeksema, 2012). Trait anxiety items include for example: "I worry too much over something that really doesn't matter" and "I am content; I am a steady person." Cronbach's alpha for the Trait subscale in the present study was .90. Next, the State-subscale was utilized to define an individual's stress level at a given point of time. The validity of this subscale was originally derived by questioning individuals about their subjective experience in situations characterized by high state stress, including classroom examinations, military training programs, etc. (Kennedy, Schwab, Morris, & Beldia, 2001). State anxiety items include: "I am tense; I am worried" and "I feel calm; I feel secure." Cronbach's alpha for the State subscale in the present study was .92.

Additionally, the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) was employed to assess variations in positive and negative affect as a response to a socio-emotional stress induction. Thereby, we were aiming to receive an indication for the individual's affective state, which is a significant indicator whether an individual perceives the situation as challenge or threat (Crum et al., 2017; Fink, 2016; Moore et al., 2012). The questionnaire comprises two subscales, namely one for positive and one for negative affect with ten items each. The items require the participant to rate his or her present mood state (e.g., enthusiasm, anxiousness, enthusiastic, lonely) on a Likert-type scale from 1 (very slightly or not at all) to 4 (very much). Participants were instructed to indicate to what extent they felt in a given way at the present moment. The PANAS has been validated on a college sample and has good internal consistency ranging from .83 to .90 for Positive Affect, and .85 to .90 for Negative Affect (Watson & Clark, 1999). In the present study, Cronbach's alpha for this questionnaire was .90.

Iowa Gambling Task. The Iowa Gambling Task (IGT) is one of the most commonly used decision-making tasks. Various studies suggest that it is a valid and reliable measurement for decision-making in clinical (Bechara, Damasio, Damasio, & Anderson, 1994; Bechara et al., 2000; Brogan, Hevey, & Pignatti, 2010; Shurman, Horan, & Nuechterlein, 2005) and non-clinical populations (Overman & Pierce, 2013; Preston et al., 2007; Van den Bos et al., 2009). The IGT simulates real-life decision making as participants must weigh the risks and benefits of their choices by paying attention to the wins and losses of each deck. In the IGT, most picks result in both: a win and a loss. Yet, every choice inevitably comprises a win, so that participants always win a certain amount, which is only sometimes accompanied with a loss. Specifically, there are two decks (A and B) which generate relatively higher financial profits but also occasionally higher losses, resulting in a net loss if chosen too often. The other two decks (C and D) have proportionately smaller immediate gains, although the losses are smaller as well, resulting in an overall net gain if chosen more frequently. The goal of the game is to learn these competencies and win as much money as possible.

Overall, there were 100 trials over which participants had to learn the implicit rules of the game and detect the profitable decks. Research suggests that especially the latter trials, particularly after trial 40, provide a better index of adaptive decision making (Preston et al., 2007). In support of this, several clinical and non-clinical studies found that better criterion and construct validity was achieved when the last 60 trials of the IGT were used (Bechara et al., 2001; van den Bos, Houx, & Spruijt, 2006; Wemm & Wulfert, 2017). The Iowa gambling task was derived from the PEBL Test Battery written by utilizing the Psychology Experiment Building Language (PEBL) (Mueller & Piper, 2014). The game uses the same payoff scheme as the inventor's version (Bechara et al., 1994). The original payoff scheme of the Iowa Gambling Task is depicted in Table 1.

Table 1

Payoff Scheme of the Iowa Gambling task

	Deck A	Deck B	Deck C	Deck D
Gain	$100	$100	$50	$50
Loss	$150-$350	$1250	$50	$250
Gain/Loss frequency (10 trials)[1]	5:5	9:1	5:5	9:1
Number of net losses (10 trials)	5	1	0	1
Long-term-outcome (10 trials)	-$250	-$250	$250	$250

Note. Retrieved from " Iowa gamblingtask: There is more to consider than long-term outcome. Using a linear equation model to disentangle the impact of outcome and frequency of gains and losses. " by A. Horstmann, A. Villringer, & J. Neumann, 2012, *Frontiers in Neuroscience, 6 (May)*

Procedure

Due to the current COVID-19 pandemic, this study needed to be changed to bypass physical contact with the participants[2]. First, after starting the video call via skype, all the participants got introduced to the general purpose of the experiment and filled out the informed consent, implemented in the online questionnaire. Participants were assured that they can drop out of the study at any given time. Then, to receive an initial indication of the individual's emotional arousal, valence and their general susceptibility to stress, the STAI-Trait, STAI-State and PANAS questionnaire were employed. Short after this baseline measurement followed the 'reveal period' in which participants of the experimental conditions were told about the prospective expiration of the experiment. During the 'reveal period', the control group was informed that the experiment will end after the last draw. The two experimental conditions were told that they have to hold a presentation after the gambling task.

To be more concrete, participants in the experimental conditions (challenge and threat) were assured that the study investigated the effects of gambling on their subsequent decisions made during a presentation. Therefore, they were familiarized with a presentation they have to hold right after the Gambling task, concerning the topic “What I dislike about my body and

[1] Notably, ‘Gain’ is defined as a win not accompanied by a loss and therefore resulting in a net gain. However, ‘Loss’ is always defined as a win, accompanied by a loss, resulting in either a net loss (Deck A, B or D) or no loss or gain (Deck C).

[2] Initially, this study was designed to be carried out in an environment involving physical interaction between the participant and experimenter. Physiological measures like participants’ heartbeat and their galvanic skin response were planned to represent an objective indicator for the physiological experienced stress of participants. However, due to COVID-19, this study required to be carried out in a virtual environment without any physical interaction and any opportunities to receive physiological measures.

physical appearance" (Levenson, Sher, Grossman, Newman, & Newlin, 1980). Furthermore, the two experimental conditions were explicitly told that other persons will join the video chat and that the participants have to speak on the topic for 5 min. They would also be judged on "clarity, organization, articulation, openness, and defensiveness". However, these were just hypothetical presentations to induce stress due to an anticipatory situation. Specifically, every group faced the initial baseline measurement, the "reveal period", 50 draws on the Iowa gambling task, followed by another assessment through the STAI-State and PANAS questionnaire and finalized by another 50 draws of the IGT.

The difference between the two experimental conditions solely consisted of the context and intent of the task. The threat condition was meant to perceive the presentation as an evaluative threat. They were told that another administrative person of the university will join the presentation and work as an external observer. Participants were informed that, by utilizing a specific, unknown schema, the observer will judge whether the presentation was honest, authentic and natural. This unknown schema was meant to demand more resources than the perceiver has available. In contrast, the challenge condition was designed to let participants feel capable to succeed in the upcoming presentation (Blascovich et al., 1999; Thoman et al., 2008). Participants were told that two other persons with problems about their weight, physical appearance and self-esteem will join. Specifically, by presenting one's own dislikes, it was the participant's challenge to let other persons realize that they are not the only ones having negative thoughts about themselves.

After this 'reveal period' which served as stress induction, the Iowa gambling task was administered to investigate the differences in anticipatory stress on decision-making. The method for administering the IGT was the same as described in prior studies (Bechara et al., 2000) except where noted. Due to the nature of the skype interview, some changes had to be implemented. Participants had to sit in front of their computer displaying four card decks, screen-shared via skype. They were directed to verbally pick one card at a time from any deck they choose. Since the experimenter had to physically pick these cards for the participants, no video or audio transmission from the experimenter was permitted during the gambling task to diminish any (implicit) influences on the participant.

As pointed out before, after the 50th pick in the IGT, the STAI-State and PANAS questionnaires were administered again to investigate the participants' conscious interpretation of the situation during the decision-making task. After participants filled out the second questionnaire, they played another round of the Iowa Gambling Task, with the same set-up as before. Finally, after these last 50 draws, experimental participants were told that the presentation was not going to follow, and every participant got debriefed by explaining the actual intention of the study.

Data analyses

To assess the data, various quantitative analyses were performed using SPSS Version 26. The overall context of this paper promoted a specific set of analysis. Due to the fact that the questionnaires utilize Likert-scales with no clear metric space between the response options, non-parametric tests were utilized. First, to verify that the stress manipulation worked out as intended, we examined whether there were significant differences in participants reported stress and affect, within the conditions, by using a Wilcoxon Signed-Ranks Test, and between the conditions, by utilizing a Kruskal-Wallis test. Next, a Kruskal Wallis Test was employed to investigate the main prediction of this experiment; whether there are significant differences between the Stress-conditions' decision-making performance. Lastly, an additional set of exploratory analyses, consisting of two generalized linear models, was employed to test whether there was an interactive relationship between the individual's stress reaction and their personal tendencies/characteristics. Therefore, we tested a mediation model, which utilized the subjective, explicit perception of stress as a mediator. Next, we tested an interaction model between Age and the Stress-condition which aims to explain potential diversity within the conditions through Age as a confounding factor. The statistical significance was set at $p < 0.05$ for all the analyses.

Results

Manipulation Analyses

The first set of analyses examined the impact of the hypothetical stressful situation on self-reported stress for the two experimental conditions. A Kruskal-Wallis test for independent samples confirmed that there were no significant difference between the stress conditions among participants baseline questionnaire scores (control, challenge, threat) on Trait anxiety, χ^2 (2) = .89, *p* = .64, State anxiety, χ^2 (2) = .36, *p* = .84, positive affect, χ^2 (2) = .06, *p* = .97 nor on negative affect, χ^2 (2) = 1.34, *p* = .51. Hence, all of the conditions started on the same level of self-reported stress, affect and general susceptibility to stress.

Next, a Wilcoxon Signed-Ranks Test was run to confirm that there was no increase in stress within the control condition and that experimental participants were more stressed after the stress-induction compared to their baseline measurement. For the control group, the output indicated that the median for the State-anxiety post-stress induction (*Mdn* = 38.50, *SE* = 6.46) was not significantly higher than the pre-stress induction (*Mdn* = 33.00, *SE* = 7.93) *z* = 58.50, *p* = .13. Furthermore, significant differences in State-anxiety scores between pre- and post-stress induction were found in both experimental conditions. The data revealed that the median for state-anxiety in the challenge condition (*Mdn* = 34.50, *SE* = 10.52) differed significantly after the stress-induction (*Mdn* = 47.50, *SE* = 12.24) z = 66.00, $p < 0.01$. Also, for the threat condition, state-anxiety scores (*Mdn* = 34.50, *SE* = 8.64) were significant higher after the stress-induction (*Mdn* = 39.50, *SE* = 9.14) z = 56.50, p = .04. This indicates that the stress-induction for the two experimental conditions was successful. There was a significant increase in state-anxiety for both conditions, while the control condition did not experience any significant increase of subjective stress.

Furthermore, the Wilcoxon Signed-Ranks Test got utilized to examine the PANAS for statistically significant within-group differences. Particularly, no significant differences were found between pre- and post-positive affect for any of the conditions; control, z = 25.00, p = .76, challenge, z = 20.50, p = .15, threat, z = 24.00, p = .86. Therefore, the mood induction did not change any of the condition's reported positive affect significantly. However, the Wilcoxon Signed-Ranks Test indicated that there was a significant increase in pre-and post-negative affect for the challenge group, z = 55, p = .01, as the median increased significantly between pre-stress induction (*Mdn* = 11.5, *SE* = 2.71) and post-stress induction (*Mdn* = 18.00, *SE* = 5.73). Although, there was no significant difference in negative affect observed for the control, z = 26.50, p = .92, or threat condition, z = 31.00, p = .31. Overall, these results indicate a significant increase in stress and negative affect for the challenge condition, and a significant increase in stress, but not negative affect for the threat condition. None of the groups differed significantly on scales of reported positive affect. Also, the control group did not show any significant increase on any mood scale.

Finally, a Kruskal-Wallis Test was conducted to examine whether there were statistically significant differences in anxiety, positive and negative affect scores between the conditions, after the hypothetical stress situation was introduced. Unexpectedly, the test showed no significant differences between the conditions after the stress induction for any mood score; whether it was state anxiety, $\chi 2$ (2) = 3.41, p = .18, negative affect, $\chi 2$(2) = 5.66, p = .06, nor positive affect, $\chi 2$ (2) = 1.06, p = .59. These results indicate that the anticipated stress situation did not result in significant differences in stress levels among the groups. Yet, by examining the boxplots for post-stress-induction state-anxiety scores and negative affect (Figure 1 and 2), it becomes evident that the highest median for the distress scales is occupied by the challenge condition (Negative affect; *Mdn* = 18.50, *SE* = 5.73; State-anxiety; *Mdn* = 47.50, *SE* = 12.24). Furthermore, this condition displays the lowest median on the positive affect scale (*Mdn* = 27.00, *SE* = 9.08). Overall, these results indicate that participants within the challenge stress-condition experienced the highest distress and lowest positive affect, while the threat stress-condition did not differ markedly from the control condition among any scale.

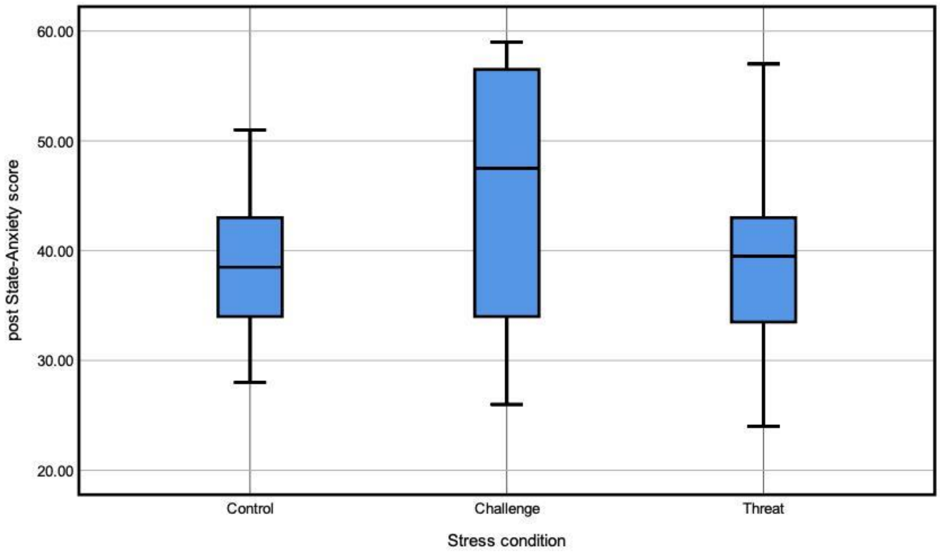

Figure 1. Differences in anxiety for the Stress-conditions. This Boxplot illustrates medians of post-state-anxiety scores among the control, challenge and threat condition

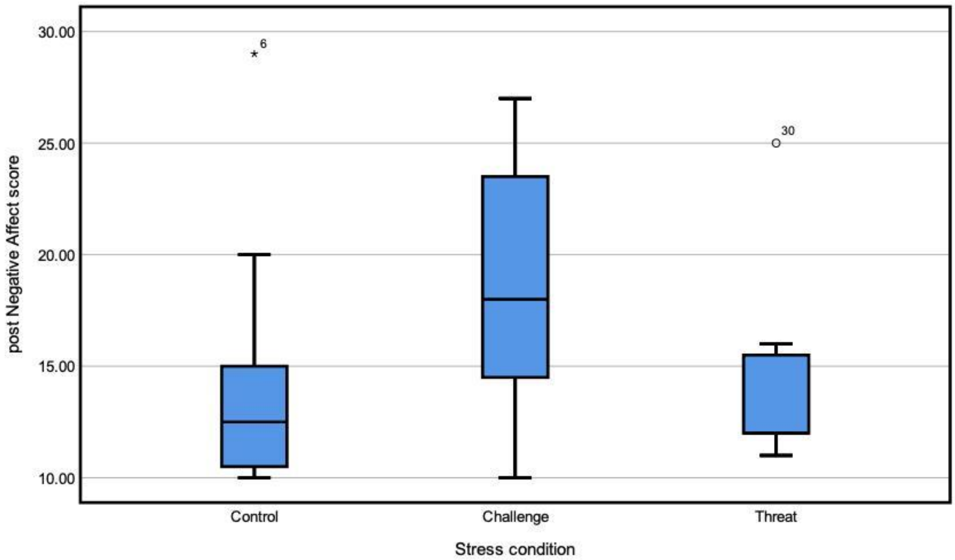

Figure 2. Differences in negative affect for the Stress-conditions. This Boxplot illustrates medians of post-negative-affect scores among the control, challenge and threat condition

Predictive Analysis

Subsequently, the dependent variable, namely the number of favorable decks chosen, was investigated. Due to the extensive support by literature, only the last 60 trials (performance phase) of the IGT contributed to the data for the analysis, while the first 40 trials (learning phase) were neglected to increase criterion and construct validity for decision making performance (Bechara et al., 2001; van den Bos et al., 2006; Wemm & Wulfert, 2017). The decks C and D constituted the more favorable decks in the long run (see Table 1). Therefore, the dependent variable was constituted by count data about how often the participant chose one of the more favorable decks (C or D) out of the last 60 draws of the IGT.

On average, participants chose 30.56 times (*SD* = 9.38) a favourable deck (C or D) with a minimum value of 16 favourable choices and a maximum value of 60 out of 60 favourable choices. The value of skewness (*M* = 1.06, *SD* = 0.39) indicates that the distribution is highly skewed and therefore non-normally distributed. This non-normal distribution of the data set got further confirmed by two tests of normality, the Kolmogorov-Smirnov test, *D* (36) = .16, *p* = .02 and Shapiro-Wilk test, *D* (36) = .93, *p* = .03. Specifically, these significant p-values indicate a compelling lack of fit towards a normal distribution. Therefore, a factorial ANOVA was not suitable to examine if there are any significant differences among the conditions.

Instead, a Kruskal Wallis Test was conducted to determine whether there was a statistical difference between the control, challenge and threat condition in the dependent variable. Surprisingly, no statistical difference was found between the conditions for the amount of favourable decks chosen, χ^2 (2) = 1.70, *p* = .43. The boxplot in Figure 3 displays the median and quartiles for each condition. Out of 60 draws, the control group chose *Mdn* = 23.50 times (*SE* = 14.08) one of the more favourable decks, while the challenge condition (*SE* = 6.76) and threat condition (*SE* = 5.67) both chose *Mdn* = 30.50 times one of the favourable decks. Eventually, there was no significant effect of the hypothetical situation induced by the different conditions on participants' IGT-performance. That suggests that the stressor did not unilaterally affect the performance phase in experimental participants

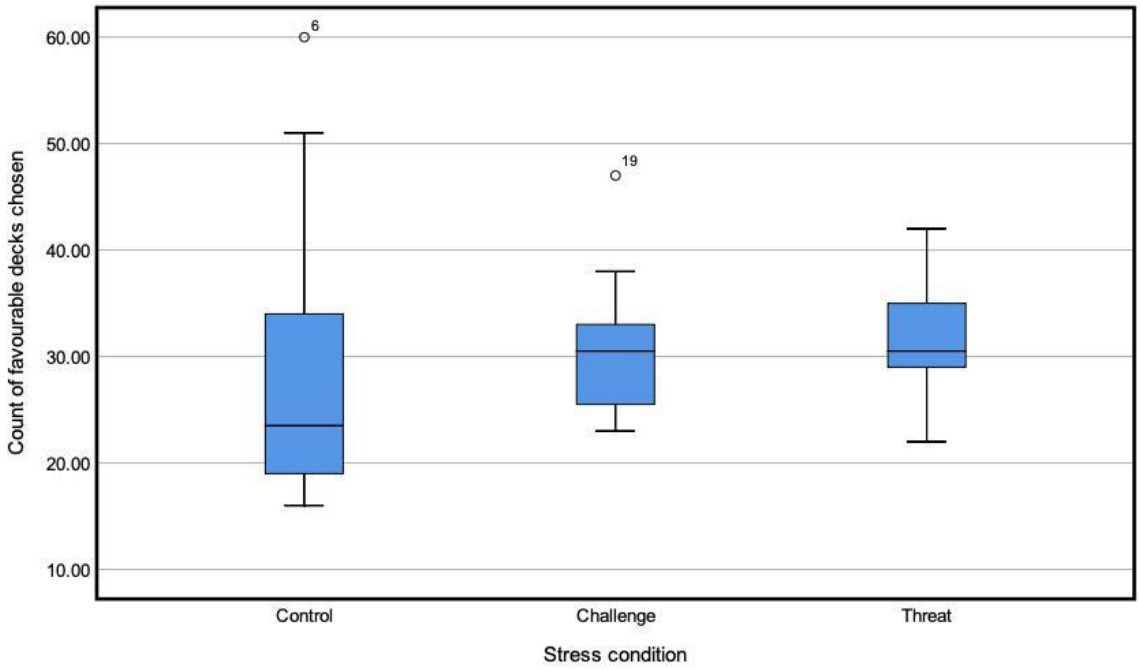

Figure 3. Differences in the number of favourable decks chosen for the Stress-conditions. This Boxplot illustrates medians for the dependent variable among the control, challenge and threat condition

Explorative analysis

It was suggested that the subjective interpretation of a stressor mediates the human stress response. Therefore, this study planned to utilize anxiety and affect scores as indicators for an individual's subjective interpretation. However, since there was no significant effect from the independent variable (stress-condition) on any of the mediators (State-anxiety, Positive and Negative affect), there was no need to describe a non-significant mediation analysis within the scope of this paper (for the mediation analysis, see Appendix A).

In the final part of the analyses, an interaction model tested the main effects of the participants' Stress-condition and Age plus the interaction effect of both factors on the number of favourable decks chosen by the participants. The likelihood ratio chi-square test indicates that the full model was a significant improvement in fit over the null (no predictors) model, p = .01. Within this model, the Stress-condition of a participant was a significant predictor of the number of favourable decks chosen, b= 1.68, SD = .53, $p < 0.01$. For every one-unit increase in the Stress-condition, the predicted log count for favorable decks chosen by the participant increased by 1.68, when the predictor Age was zero. Age was also a significant predictor of the number of favourable decks chosen, b= .08, SD = .03, $p < 0.01$. For every one-unit increase on Age, the predicted log count of favorable decks chosen by the participant increased by .08, when the Stress-condition was zero. Lastly, the interaction between the induced Stress-condition and Age was found to be a significant predictor of the number of favourable decks chosen as well, *b* = -.07, *SD* = .02, $p < 0.01$. Therefore, for every one-unit increase in participant's Age, the predicted log function of favourable decks chosen, dependent on the Stress-condition of the participant, decreased by .07 (Shang, Nesson, & Fan, 2018). Thus, the interaction of Age and individuals Stress-condition results in a significant decrease in gambling performance.

Accordingly, younger individuals presented the best IGT-performance within the threat condition, while they displayed their worst performance during conditions of no-stress. Contrastingly, older individuals within the threat condition demonstrated their poorest performance, while they revealed their best performance under no-stress conditions (see Figure 5). The challenging condition shows a similar trend as the threat condition, but with a smaller slope. This suggests the individual's age as one factor confounding the interpretation and subsequent reaction (measured by the IGT) of an individual towards a stressor.

Interestingly, in support of Age being just one amongst other confounding factors, the Goodness of Fit test, revealed an overdispersion, *Value/df* = 2.13, which indicates the presence of greater variability in a data set than would be expected based upon the applied statistical model. Still, adjustments of the distribution (e.g. negative binomial distribution) did not yield better results for the Goodness of Fit, *Value/df* = .09, than the above-described model. Therefore, the observed overdispersion appears to be caused by the fact that not all critical, confounding factors are measured. Thus, the incapacity to account for other confounding (internal or external) factors during the experiment, could have caused the variability within the data set. However, despite the unusual variation within the data, it shows a trend of interaction.

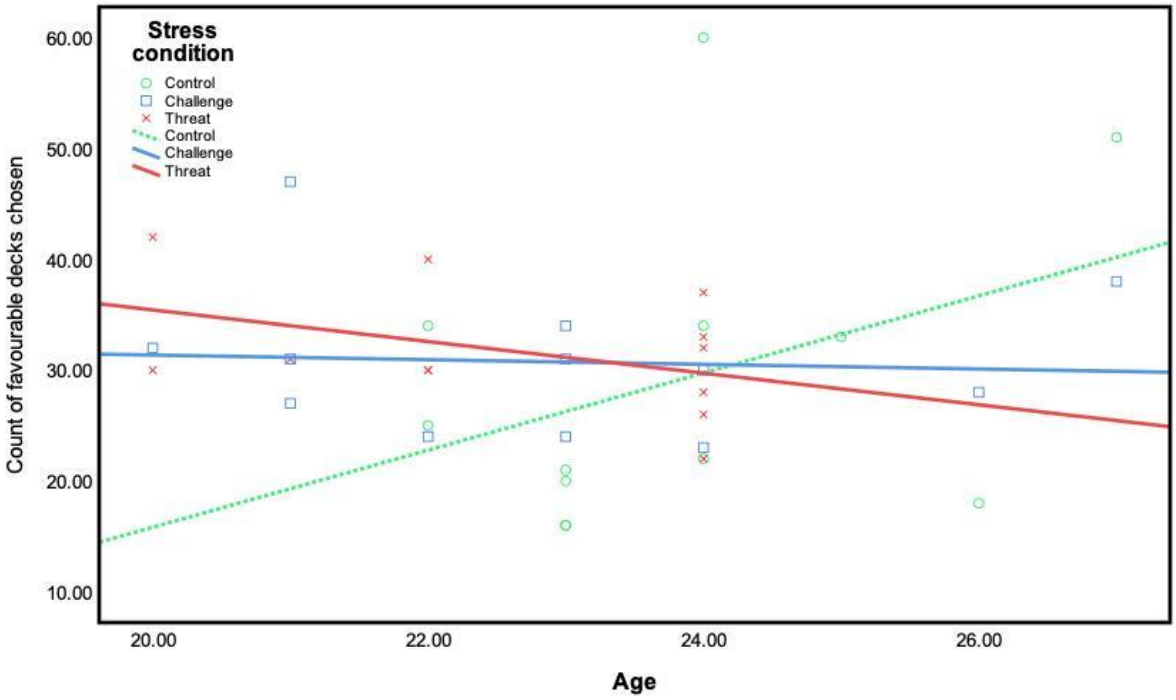

Figure 5. Interaction between stress condition and age. This Scatter dot displays the effect of each Stress-condition by Age measured via the number of favorable decks chosen on the IGT.

To summarize, the results have revealed a significant increase in state anxiety for both of the experimental conditions, excluding the control condition. Moreover, negative affect increased significantly, but only in the challenge condition. No significant differences in any of the mood scales between the conditions have been observed after the stress induction. Furthermore, results indicate that there was no significant difference between the conditions in the dependent variable of IGT-performance. Consequently, both of the hypotheses (H1, H2) will be rejected. Next, the conceptual model of anxiety and affect scores mediating the effect of the condition was proven to be non-significant. While the generalized linear model revealed that there was a significant interaction effect between the Stress-condition and Age on the dependent variable of IGT-performance.

Discussion

The current research aimed at investigating the effects of stress in challenging, threatening or control conditions on participants decision-making performance. Overall, the hypothetical situations did provoke some stress inflation, but not in the intended direction. Even though there was a significant increase in anxiety between pre- and post-stress-induction for the challenge and threat condition, this study did not find a significant difference between the stress-conditions on any scale. Surprisingly, the challenge, instead of the threat condition displayed the highest central tendency for distress (state-anxiety and negative affect). This increased negative evaluation of the situation advocates that the challenge condition could have been perceived rather as a threat than a challenge (Blascovich et al., 1999; Thoman et al., 2008). In general, the responsibility and ambiguity of helping two suffering human beings seemed to induce more stress and negative emotions than an anticipated evaluation by a professor with no personal relation to the participants (Griffin, Hogan, Lambert, Tucker-Gail, & Baker, 2010; Grupe & Nitschke, 2013; Tomaka et al., 1997; Trotman, Williams, Quinton, & van Zanten, 2018). Although this inverted effect appeared to be variable for each individual in this study. In total, results suggest that the challenge condition was not entirely perceived as a challenge and the threat condition not entirely as a threat.

These findings restate the importance of establishing a reliable context to induce threatening or challenging stressful situations. In total, there was little control about the situation, an imprecise established context and not throughout defined stress situations which possibly denied individuals to feel throughout immersed within the situation. This lack of realism, spatial presence, and involvement could have produced a diminished and consequently differentiated stressful effect on the experimental conditions (Alghamdi, Regenbrecht, Hoermann, & Swain, 2017; Griffin et al., 2010). To be more precise, the reduced effect of the stress induction could imply that no brain activity shift towards the more automatic and reflexive, subcortical-dependent processes was created. So that, each participant could have freely associated a different representation with the anticipated stressor, which was guided by their previous experiences (De Houwer & Hermans, 2010; Henson, Eckstein, Waszak, Frings, & Horner, 2014; Starcke & Brand, 2012; Villada, Hidalgo, Almela, & Salvador, 2016). Therefore, the non-immersive stress-induction of this online experiment could be one explanation for the increased variability in responses to the situations. Thus, no significant, unilateral effect of the stress condition itself was found, neither on individuals reported stress-level nor on their gambling performance.

Consequently, with increased importance on the personal interpretation of the stressor, it can be suggested that the individual interpretation mediates the human stress response. Therefore, some additional exploratory models were tested. Against initial suggestions, results indicate that the effect of the Stress condition on IGT performance was not mediated by the reported anxiety and affect scores of the participants. These findings plus recent literature propose that the anxiety and affect questionnaires have not been sufficient enough to represent the whole picture of the individual’s interpretation of a stressor. Instead, the questionnaires only captured the explicit, conscious experience of the individuals.

Specifically, as Villada et al. (2016) suppose that the subjective interpretation of a stressor is not only represented by the psychological experience of a situation, but also by unconscious physiological indicators. Therefore, future studies would need to include physiological measures as well to accurately test the planned mediation model about whether participants' personal interpretation of a situation mediates their stress response.

Besides, another exploratory model was tested. The aim was to see whether a personal factor, such as age, influences an individual's stress reaction and could, therefore, account for the differentiated effects in IGT-performance within a participant's Stress-condition. Interestingly, the interaction between Age and the Stress-condition was found to have a significant effect on gambling performance. The model suggests that with increased Age, stress has a more detrimental effect on individuals decision-making performance. Yet, due to the evident overdispersion, it appears that there are still some unaccounted factors for the variability in responses within this model. Hence, these results re-establish the importance of personal characteristics in stressor interpretation and reaction and specifically suggest Age as one of these personal factors. Although caution must be applied when generalizing these results because of the restricted sample size.

Whilst this study did not confirm any effect of rephrasing a stressful situation, it offers a framework about how and what kind of individual characteristics interact with the human stress response. Overall, there was too little control about the situation and subject at hand to determine straightforward effects for rephrasing a stressful situation. As there was no immersive, entirely unambiguous situation, possibly partly due to the online nature of the experiment, it left increased space for an individual's personal interpretation of the situation, resulting in high variability within the data. These findings confirm that there is considerable flexibility within the human stress perception and reaction, dependent on the situation and personal tendencies (De Houwer & Hermans, 2010; Henson et al., 2014; Starcke & Brand, 2012; Villada et al., 2016). Overall, it appears like the intensity of the situation determines the extent of involvement of personal tendencies within stressor-reactions. These tendencies, in turn, can be captured with distinct psychological, but also physiological concepts to predict an individual's reaction more precisely (Villada et al., 2016). Taken together, the significance of personal tendencies within different social stress conditions becomes more understandable.

With these insights, it would be possible to build upon the two-factor theory of emotion. Specifically, Schachter and Singer (1962) state that the experienced emotion is based on two factors: physiological arousal and cognitive labelling. Accordingly, when emotion is manifested, physiological arousal occurs, and the person utilises the immediate environment to seek for emotional cues to label the physiological arousal. The present study makes several noteworthy contributions to this model. First, it highlights that the situation itself may influence the initial intensity of the emotional effect and the subsequent involvement of individual tendencies. Accordingly, in a non-immersive situation like an imagined challenge, instead of being forced into automatic information-processing due to neurological changes, the individuals could have contributed more focus to their physiological arousal and/or used an imagined environment to interpret the situation. This results in a higher variance as each individual holds a different tendency to interpret and react to stressors. Thus, this paper extends the theory with an additional factor interacting with both: the cognitive labelling and physiological arousal, namely the individual's personal tendencies to stress. These tendencies could, therefore, be represented by specific psychological (e.g. anxiety sensitivity) and physiological concepts (e.g. cortisol reactivity) (van den Bos et al., 2009; Villada et al., 2016). However, further research is required to establish that these concepts can accurately predict an individual's interpretation of a stressful situation and/or their subsequent reaction to stress.

Furthermore, this research points out that personal tendencies towards stressful situations can be confounded by individual characteristics, such as age. This is in line with previous studies which already suggest age to affect the individual's personal tendency about how to approach a stressor (Uphill, Rossato, Swain, & O'Driscoll, 2019). In the present study, older individuals exhibited decreased decision-making performance under conditions of stress and increased performance when there was no stress at all. Overall, it seems as when individuals age, they face various types of stressors and develop preferences for how to approach them (Henson et al., 2014; Rudolph & Hammen, 1999). Notably, some studies found that the elderly gain significant increases in problem-solving (Amirkhan & Auyeung, 2007; Uhr et al., 2018). This could have lead to a decreased capacity for emotional processing in the IGT, since these increases in problem-solving, plus the stressful conditions could have overused the individuals overall cognitive capacity needed to process emotional markers (Zebrowitz, Boshyan, Ward, Gutchess, & Hadjikhani, 2017). Still, with such a small sample size, caution must be applied, as the findings might not find universal application.

Limitations

Finally, several important limitations need to be considered. As no physical contact was permitted during the emergence of COVID-19, we needed to utilize a video-chat for data collection. This resulted in insufficient physical and theoretical control of the experiment. The general problem with an online research was that it was hard to account for individual differences. At large, the hypothetical stress situation was not immersive enough to produce an automatic stress reaction. This created the opportunity for participants to freely associate the stressor with their own discrete experiences, resulting in considerable variation in the perception of the situations. Therefore, possibly exaggerated by the small sample size, the non-enveloping nature of the experiment left it open for to interpret the situations in various ways.

To illustrate, the challenge condition could have been interpreted as a threat instead of a challenge depending on the individual’s prior experiences. Both situations were not throughout defined which left considerable space open for interpretation. Furthermore, recent literature supports the view that situations can be both: challenging and threatening which results in mixed outcomes, whether it is psychological, physiological or behavioural (Uphill et al., 2019). Consequently, the psychological interpretation of a stressful situation arises to be more complex than a binary spectrum between challenge and threat which straightly leads to either moderate or high-stress levels. Rather, as it seems to be the case in this study, stressful situations can be individually perceived as a unique mixture of challenge and threat which results in mixed cognitive and behavioral effects.

Moreover, since it was impossible to include any measurements about the autonomic arousal of participants, there was one missing determinant for clear assumptions about the effects of the hypothetical, stressful situations. The utilized self-report questionnaires alone were less sufficient in providing an overall picture of the individual‘s stress state. Specifically, the questionnaires only supplied information about the participant's conscious evaluation of the situation, but not their implicit physiological one. Therefore, there was no complete picture of the individual's affective experience present, thus, it was not ensured that individuals experience the same intensity of stress within the conditions. As there was no control about the environment and no appropriate indicator for individual‘s overall stress level, participants could have encountered different stress conditions than it was intended.

Next, regarding the overall set up of the experiment, there remain some points to contemplate. First, since the experiment was conducted at different times on the day, it is quite likely that participants had different baseline physiological stress levels, which were not reported in their subjective questionnaire measurement. Prior studies already pointed out the impact of circadian variability on individual’s cortisol levels (Stone et al., 2001). Yet, since no physiological measurements were employed this study was unable to represent these physiological differences. Second, we have to be quite cautious to generalize the results of this study, because of the small sample size. Especially, the interaction effect between age and the stress-condition requires additional support. Since the significant effect could have been caused by some specific outliers. However, this experiment was carried out on a small scale which argues for the sole exploratory focus of these additional set of analyses.

Finally, we will consider the validity of the Iowa gambling task as an indicator of human decision making. Several studies already came up with the conclusion that the long-term outcome (counts of favourable decks chosen) alone is not able to account for the choice behaviour on the IGT. Horstmann, Villringer and Neumann (2012) concluded that the penalty-reward-structure of the decks also influences decision making. Specifically, subjects preferred choices associated with high-frequency gains to those with low-frequency gains, regardless of the long-term outcome. This was also observable during the experiment of this study. Some individuals stuck to the decks with high-frequency gains despite a constant loss of a huge amount of money. Still, the original IGT assumes that participants focus only on the long-term outcome of the decks and ignore all other features. Therefore, the IGT, and specifically its long-term outcome, maybe not the most accurate measure to quantify human decision making.

Future Research

Consequently, four major objectives result for future research to engage in. First, regarding online-based research, especially in those interconnected times we live right now, such quick and practical opportunities for data acquisition should not be neglected. Society could benefit enormously from online research, as experiments via video chat are rather low in cost and time. Although, further studies in this field would be of great help to investigate how online designs could deal with the apparent loss of control about the situation. One probable solution would be to establish a more controlled situation. For example, a completely standardized process which provides attention to the trivial aspects of the experimental situation could create a more immersive and straightforward stress induction. Overall, future online studies should strive to create comparable conditions for each participant, even when they reside in different environments.

Second, related to individual’s stress appraisal, it appears crucial to incorporate physiological measures in addition to psychological measures. As this research shows, accounting only for the psychological interpretation of a stressor provides an incomplete picture of the influences which affect an individual's cognition. Thus, simply the psychological interpretation was unable to account for individuals subsequent behaviour. Moreover, future studies could also add brain scans to gather deeper insights into the interactions between proposed brain areas during such specific situations. Additionally, since the sample of the study only includes individuals in their '20s, the observed interaction of age and individuals' stress reaction could be caused by neurological changes during PFC maturation, happening until the age of approximately 25 (Arain et al., 2013). In this case, using brain imaging techniques on an adequate sample size could provide significant insights about changes in connectivity which could have caused the interaction between age and stress.

Third, when exploring the topic of human decision making, further, more refined measurements are required. As the review about the IGT reveals, new thoughts about the conceptualization of decision-making need to be stimulated since it is a more complex process than proposed by most experimental tasks. As many aspects interplay with each other during a situational decision, one needs to think about which specific aspect requires to be investigated. Future studies need to consider how to measure decision making adequately according to the scope of their paper. One main distinction could be made in terms of whether to investigate consequences on real-life situations or rather focusing the interest on one specific aspect of decision-making (e.g. long-term-outcome or penalty/reward structure).

Lastly, when concentrating on cognitive reappraisal and its effect on decision-making, future studies could carry out a similar experiment as described in this paper, merely with more control. For example, utilizing a bigger, stratified sample to account for gender differences and other personality variables, implementing physiological measures and brain imaging techniques and utilizing another, more refined decision-making task than the IGT, could simplify the observation of an effect of cognitive reappraisal. Additionally, more refined concepts about individual tendencies to stress are needed to accurately predict an individual's reaction to stress. Evidence suggests one needs to account for both tendencies: the psychological, but also the physiological tendency about how an individual reacts to a stressor. Finally, future studies should also account for, and explore, further interacting factors with the human stress perception and reaction. Such factors could include age, gender, upbringing, social-economic status and other control variables.

Conclusion

All in all, this paper highlights the fact that stress is a subjective response, determined by the situation and the individual itself. Future investigators of this topic need to account thoroughly for both factors to make accurate predictions, especially with such a complex behavioural outcome as decisions. That means, when trying to predict an individual's decision, the overall bodily response (physiological and psychological) and the potential effects of the situation need to be taken into account to accurately predict peoples very own personal interpretation and subsequent reaction to a stressful situation. Furthermore, as this research and other studies suggest, individual tendencies are dependent on some specific confounding variables like age and gender. This paper exposed how these implicit determinants can exert significant effects on human cognition and its subsequent behaviour. Thus, it provides a framework for more accurate future experiments within the topic of cognitive stress-reactions.

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Appendix A

Mediation analysis

New variables about the stress-induction's effect were acquired by computing the difference between participants pre-and post-reported; state-anxiety, negative and positive affect scores. A mediation model was carried out to investigate whether the effect of the participant's stress condition on the count of favourable decks chosen (C, D) was mediated by the subjective affect reported of participants. Since the dependent variable, count of favourable decks, was non-normal distributed, bootstrapping methods were employed to correctly investigate whether reported affect mediates the effect of participants induced stress-level.

Multiple regression analyses were conducted to assess each component of the proposed mediation model. First, it was found that the stress level induced by the different conditions was positively, yet non-significantly associated with participants IGT-performance (B = 1.392, t (35) = .687 p = .496). It was also found that stress-level was non-significantly related to state-anxiety (B = 1.399, t (35) = .753, p = .456), negative affect (B = .185, t (35) = .178, p = .859) and positive affect (B = -.067, t (35) = .753, p = .456). Lastly, results indicated that the mediators, state-anxiety (B = -.084, t (35) = -.264, p = .793), negative affect (B = .758, t (35) = 1.535, p = .135) and positive affect (B = .622, t (35) = 1.476, p = .150), were also non-significantly associated with the dependent variable IGT-performance. Figure 4 displays the results within the conceptual model.

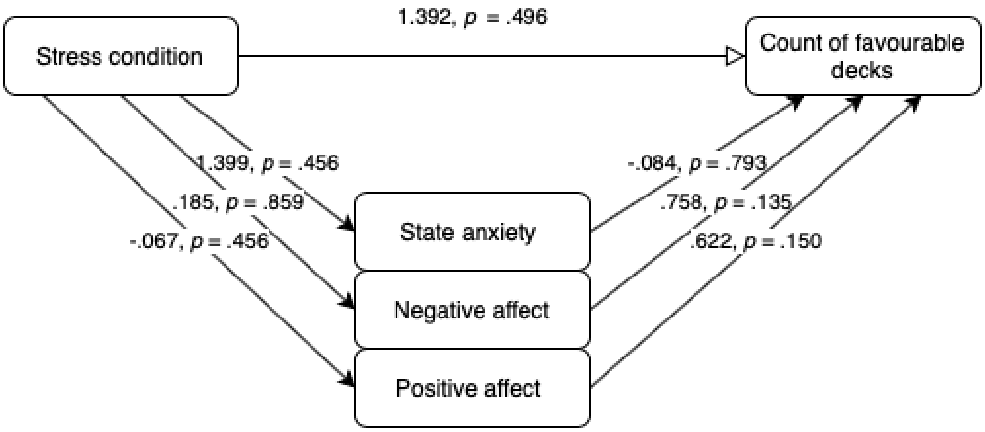

Figure 4. Conceptual model of the hypothesized mediation. This model uses reported affect and anxiety as indication for the subjective interpretation of the stressor

Mediation analyses were tested to confirm that there was no mediation from the proposed mediating factors, using the bootstrapping method with bias corrected confidence estimates (MacKinnon, Lockwood & Williams, 2004; Preacher & Hayes, 2004). In the present study, the 95% confidence interval of the indirect effects was obtained with 5000 bootstrap resamples (Preacher & Hayes, 2008). Interestingly, results of the mediation analysis disconfirmed the mediating role of affect in the relation between anticipated stress levels and IGT performance, for any of the affect scales, state-anxiety (*B* = -.035; *CI* = -1.803 to .736), negative affect (*B* = .088; *CI* = -.972 to 2.304), and positive affect (*B* = .058; *CI* = -1.214 to 1.100). Hence, the individuals reported increase in stress, due to the subjective interpretation of a stressor was not able to account for any effects on individual's decision-making ability.

Next, an interaction model was used to investigate whether there is a significant interaction between the effect of the Stress-condition, and Age. Specifically, characteristics like age were hypothesized to confound and moderate the relation between the individuals stress condition and its IGT performance. Therefore, the individuals' stress-level, in combination with its age should account (to some extent) for its decision-making performance. A non-linear relationship between stress and cognitive performance such as decision-making was expected (inverted u-shape), which further supported the utilization of a Poisson distribution to assess the count data.