Pressure, Performance, and Sense of Agency: An Investigation of Sense of Agency and Task Accuracy Under High Stakes

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Abstract

In this novel study we characterize factors that modulate sense of agency (SoA), defined as the feeling of control over one's voluntary actions and their outcomes. We assessed individuals' trait locus of control and state anxiety and manipulated task difficulty to evaluate whether internal traits are stronger modulators of SoA versus external performance pressure. We employed a novel task where participants press a button to stop a moving dot on a target. We manipulated the dot speed, time pressure to complete the task, and incentivized performance. We found that manipulating difficulty (faster dot speed) produced more failures and was predictive of lower explicit SoA ratings. Furthermore, SoA scores were boosted by receiving a high reward on success trials. This suggests a postdictive evaluation – increasing post-hoc feelings of control (not performance) when incentivized for success. Increasing anxiety was negatively correlated with SoA rating for failure in all manipulations.

Keywords: Sense of Agency; Explicit Measures; Performance Pressure.

Introduction

Choking under pressure is a phenomenon that occurs when the performance of highly skilled individuals collapses during high-stakes situations. This failure to perform has been argued to be the result of two leading theories. The explicit monitoring theory argues that pressure causes individuals to consciously monitor motor processes that should be automatic, disrupting the fluid execution and causing error (Wine, 1971). The attentional control theory suggests that pressure distracts from a given task by overwhelming working memory with worry, disrupting the ability to process task-relevant information (Masters, 1992). As such, the two theories are complementary in that they focus on both the physical motor action and the mental processes affected by stressors. These theories, however, focus on the objective accuracy resulting from pressure. Nevertheless, there is also a subjective experience of a decreasing sense of control over the outcome of one's actions (sense of agency, SoA) when under pressure. For example, acute psychosocial stress has been shown to decrease SoA (Chu et al., 2023). Here, we bring together the literature on choking under pressure and anxiety to investigate the role of both internal factors (trait locus of control and state anxiety) and external factors (performance pressure) on modulating SoA. This study introduces SoA, defined as the subjective experience of controlling one's own actions and their external consequences, as a critical mediator (Haggard, 2002). We propose that high pressure environments are not just the cause of errors, but they fundamentally disrupt the agent's feeling of control.

The relationship between choking under pressure and SoA is well illustrated by professional sports. For example, a professional basketball player shooting a potentially game-winning free throw. In the case of highly trained athletes in a practice setting, this would be an automatic motor process with high SoA. Transitioning into a high-stakes environment with spectators and winning on the line, the player may choke and become overly aware of their mechanics (explicit monitoring). Explicit monitoring in turn might disrupt the automatic processes involved in the execution of the predicted outcome (sinking the basket) and create a mismatch to the consequences of the action (missing the shot). Though the player committed the action, they might feel a diminished sense of agency as they were unsuccessful in implementing their intention (Synofzik, Vosgerau, & Newen, 2008). In contrast, a player might try for a hail mary buzzer-beating shot and make the basket, resulting in an after-the-fact increase in SoA.

These predictive and postdictive (after-the-fact) accounts have been fundamental in theories for how people experience SoA (Moore & Haggard, 2008). The predictive account (Blakemore et al., 2002; Haggard, 2005) explains SoA as arising when the predicted and actual sensory consequences of an action match. As the reliability of this match increases due to repeated successful trials, the agent's subjective experience of control is strengthened. The postdictive account posits that SoA is established after the action is completed by assessing whether priority, consistency, and exclusivity criteria are met. This aligns with the 'Two-Level Account' proposed by Mylopoulos (2017), which distinguishes between a "low-level", agentive experience (the immediate feeling of acting) and a "high-level" agentive judgment (the reflective conclusion that one is the cause of an outcome). Distinguishing between these levels is necessary for evaluating whether external performance pressure disrupts the immediate feeling of control or the subsequent evaluation of it.

In G. Boleda, I. Dautriche, M. Maldonado, C. Saldana and T. Torrent (Eds.), *Proceedings of the 48th Annual Conference of the Cognitive Science Society*

In addition, choking does not occur the same way for everyone. People experience individual differences in anxiety (Spitzer et al., 2006) that may heighten performance pressure outcomes. For example, consistent with attentional control theory, those who have higher anxiety have less room in their working memory (Lukasik et al., 2019) to handle the added pressure of high stakes and fast speeds. Locus of control, defined as an individual's belief about the extent to which their behavior influences the life outcomes they experience (Rotter, 1954) has also been posited as an essential part of human agency (Bandura, 1997). Internal locus of control is rooted in a belief that reinforcement (whether as failure of reward) is the result of their own effort. As such, people with an external locus of control may be expected to experience lower SoA.

In the study presented here, we jointly assess individuals' pre-experimental state anxiety and trait locus of control, and then manipulate performance pressure via task difficulty, to evaluate whether traits are stronger modulates of SoA versus performance pressure. We employed a simple task where a dot was continuously moving back and forth across the computer screen. The goal was to press a button (to stop the movement) when the dot touched a vertical line in the middle of the screen. We manipulated difficulty via the speed of the moving dot (slow or fast), and performance pressure via time pressure (4 or 8 seconds) to complete the task, and incentivized performance with a reward structure (50 or 100 points). By measuring subjective SoA ratings we aimed to evaluate how stressors and individual dispositions interact to produce the choking effect.

Hypotheses

H1: We hypothesized that increased situational pressure (highspeed, high stakes, restricted time) would significantly decrease task accuracy (fewer successes).
H2: We hypothesized that high pressure conditions will result in lower subjective SoA ratings compared to low pressure conditions.
H3: We hypothesized that baseline anxiety would moderate performance, such that individuals with higher anxiety scores would report a greater decline in SoA ratings under pressure.
H4: We hypothesized that locus of control would moderate performance, such that participants with an internally oriented locus of control would report lower SoA following failure than externally oriented participants.

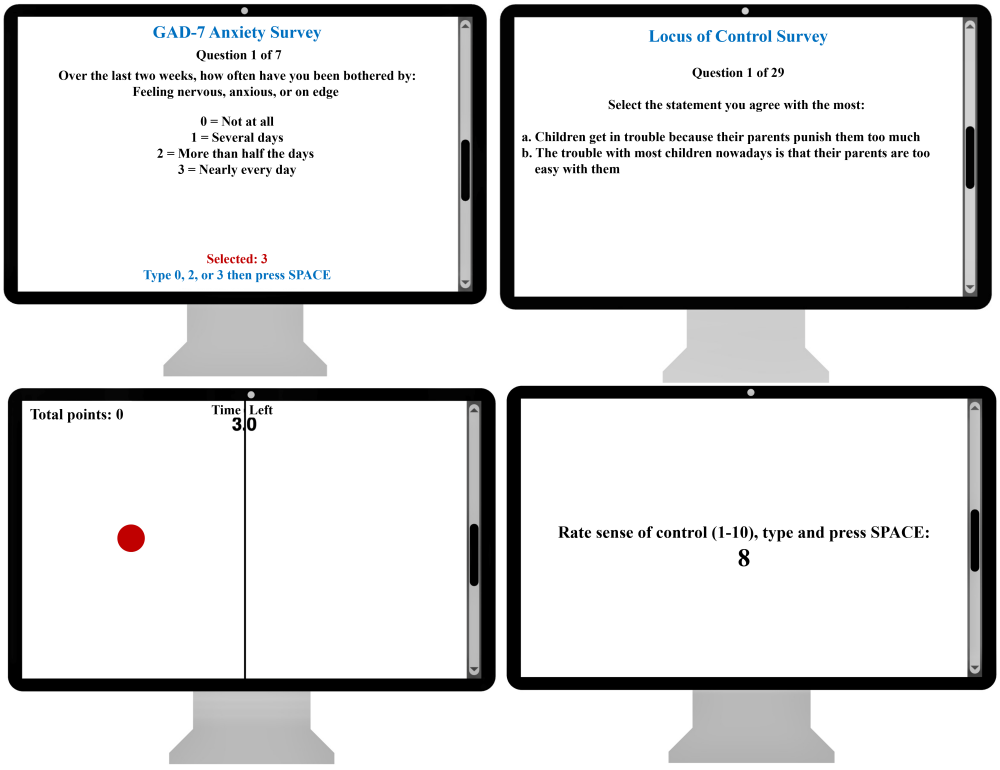

Figure 1. (Top panels) Sample questions from the GAD-7 scale and Rotter Locus of Control scale. (Bottom left panel) The task consisted of a red dot moving back and forth across the screen and the task was to press the space bar to stop the dot on the vertical black bar (the target). (Bottom right panel) Explicit sense of agency ratings were collected after every trial.

Experiment

Methods

Participants

Twenty participants over the age of 18 recruited from the local community participated in exchange for a monetary compensation of a $15 Amazon gift card. A power analysis was conducted using G*Power 3.1 to determine the required sample size for a repeated measures, within factors ANOVA. Based on an expected medium effect size (f = 0.25), and alpha of .05, and a power of .80 (with 8 repeated measurements), it was determined that a minimum of 16 participants was required.

Design

The study employed a 2x2x2 within subjects design. The independent variables were; difficulty easy(slow dot speed) and hard (fast dot speed), Stakes low (50 points) and high (100 points), time pressure low (8 second limit) and high (4 second limit). The dependent variables were success/failure and subjective SoA rating.

Materials and Procedure

The experiment was conducted on a computer in an environment with minimal distractions. See Figure 1 for an illustration of the two scales, the task, and the explicit ratings.

Generalized Anxiety Disorder (GAD-7): Prior to the task, participants completed a GAD-7 Survey to measure their anxiety levels. The GAD-7 consists of 7 questions scored on a 4 point likert scale (0-3). The final score is calculated by summing the responses with the total score ranging from 0 to 21. Scores range 0-4 (minimal), 5-9 (mild), 10-14 (moderate), and 15-21 (severe) (Spitzer et al., 2006). A score of 10 or above indicates a preliminary diagnosis of GAD.

Rotter's Locus of Control (LOC): Participants also completed the Rotter's locus of control scale, a 29 question survey measuring internal or external reinforcement beliefs. Participants chose between two statements (label a or b). The scale consists of 6 filler questions that are not counted toward the final score. Participants receive 1 point for every external statement chosen. Scores ranging 0-11 (internal) and 12-23 (external) (Rotter, 1966).

Participants gave consent to participate. Prior to starting the task participants filled out two digital surveys (GAD-7 and Rotter's locus of control). Once the surveys were complete participants were presented with an instruction screen informing them that their goal was to press the space bar when the dot moving horizontally aligned with the black vertical marker in the center of the screen. Participants were informed that the factors of the experiment were dot speed (2/4), Reward (50/100), and time (4/8s). They were instructed that upon missing (defined as failing to stop the dot with a minimum distance of X of the black bar) they would lose the reward value for that trial. A screen then appeared informing participants they were about to complete 8 practice trials that did not count toward their final score. After every trial participants were asked to rate their sense of control on a scale of 1-10. Response were given by typing the number into a box of the screen using the computer keyboard. Following the practice trials, participants completed 20 blocks of 8 experimental trials with breaks in between each block. The experiment took approximately 30 minutes to complete.

Results

GAD-7 score: We calculated the GAD-7 score for each participant following the procedure outlined in the Materials and Procedure section above. Of the 20 participants 8 received a 'minimal' score, 10 received a 'mild' score, 2 received a 'moderate' score and 0 participants received a severe score.

LOCUS score: We calculated the locus of control score for each participant following the procedure outlined above. We found that 15 participants received an 'internal' score, and 5 participants received an 'external' score. Note that there were not any effects of locus of control scores in any manipulations, and will not report any other results for locus of control.

Below are the results organized by experimental manipulation.

Dot Speed Pressure

Success and failure.

We first calculated the success rate as a function of dot speed (slow = 2, fast = 4). We found that the success rate was significantly lower ($t(19) = 9.585$, $p < 0.001$, 95% CI = [1.329, 2.941]) for fast dot speed (M= 0.482, SE = 0.049) than slow dot speed (M = 0.753, SE = 0.065).

Explicit ratings of SoA

We analyzed explicit agency ratings as a function of success and failure for the two dot speeds (slow = 2, fast = 4) by running a repeated-measures ANOVA. We found a large main effect of success/failure ($F(1,19) = 68.449$, $p < .001$, $\eta^2 = 0.618$), such that SoA ratings were significantly lower for failures (M = 5.642, SE = 0.443) than for successes (M = 7.870, SE = 0.327). There was also a main effect of dot speed ($F(1,19) = 8.487$, $p = .009$, $\eta^2 = 0.054$), such that SoA ratings were lower for a fast (M = 6.427, SE = 0.390) than for a slow (M = 7.086, SE = 0.375) moving dot. The interaction was not significant. See Figure 2.

GAD-7 score

We analyzed explicit agency ratings as a function of success and failure for the two dot speeds (slow = 2, fast = 4) by running a repeated-measures ANOVA with GAD-7 score as a covariate. We found a small interaction between GAD-7 and dot speed ($F(1,18) = 6.909$, $p = 0.017$, $\eta^2 = 0.021$), and a marginal interaction between GAD-7 and success ($F(1,18) = 3.833$, $p = 0.066$, $\eta^2 = 0.019$).

We correlated GAD-7 scores with SoA ratings for each of the four condition combinations (see Figure 3). We found a significant negative correlation between both fast success and GAD-7 ($R = -0.504$, $p = 0.024$) and fast failure and GAD-7 ($R = -0.584$, $p = 0.007$). There was a marginal negative

correlation between slow failure and GAD-7 (R = -0.379, p = 0.099). High dot speed (harder trials) appears to have a greater impact on SoA in participants with higher (moderate) state anxiety.

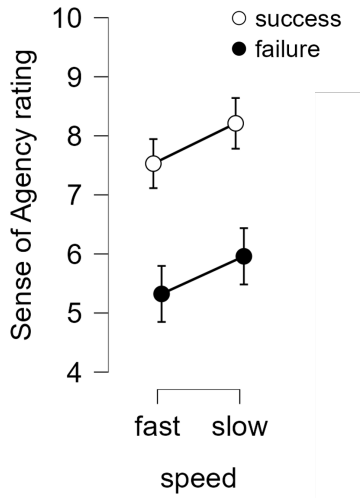

Figure 2. Explicit SoA ratings as a function of dot speed. The separate lines indicate success (white marker) and failure (black markers).

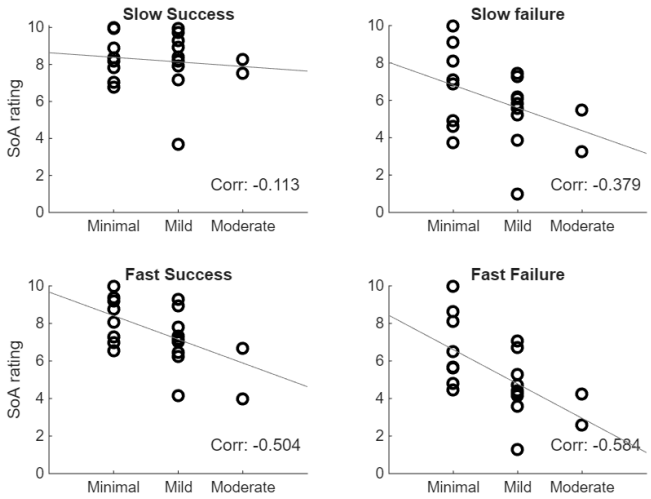

Figure 3. Correlations between anxiety (GAD-7 score) and explicit SoA rating for the four dot speed conditions.

Reward Pressure

Success and failure.

We first calculated the success rate as a function of reward (low = 50 points, high = 100 points). There was no effect of reward on success (50 points: M= 0.610, SE = 0.040; 100 points: M = 0.624, SE = 0.041).

Explicit ratings of SoA

We analyzed explicit agency ratings as a function of success and failure for the two rewards (low = 50 points, high = 100 points) by running a repeated-measures ANOVA. We found a large main effect of success/failure (F(1,19) = 73.873, p < .001, η^2 = 0.774), such that SoA ratings were significantly higher for successes (M = 7.923, SE = 0.326) than for failures (M = 5.537, SE = 0.443). There was no main effect of reward, but there was a small significant interaction (F(1,19) = 7.040, p = 0.016, η^2 = 0.004), such that SoA ratings were significantly higher for successes with high rewards. This appears to be a postdictive evaluation where it is not the performance itself, but the reward that results in greater feeling of control. See Figure 4.

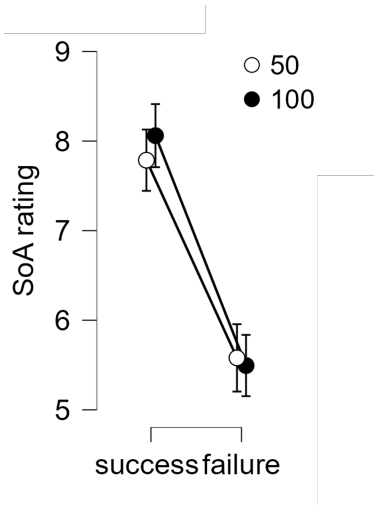

Figure 4. Explicit SoA ratings as a function of success and failure. The separate lines indicate reward. Low reward = 50 points (white marker) and high reward = 100 points (black markers).

GAD-7 score

We analyzed explicit agency ratings as a function of success and failure for the two rewards (low = 50 points, high = 100 points) by running a repeated-measures ANOVA with GAD-7 score as a covariate. We found an interaction between GAD-7 and success (F(1,18) = 6.680, p = 0.019, η^2 = 0.034), and a marginal interaction between GAD-7 and reward (F(1,18) = 4.006, p = 0.061, η^2 = 0.001).

We correlated GAD-7 scores with SoA ratings for each of the four condition combinations (see Figure 5). We found a significant negative correlation between both low reward failure and GAD-7 (R = -0.482, p = 0.032) and high reward failure and GAD-7 (R = -0.591, p = 0.006). Failure (both for the loss of high and low rewards) appears to have a greater impact on SoA in participants with higher (moderate) state anxiety.

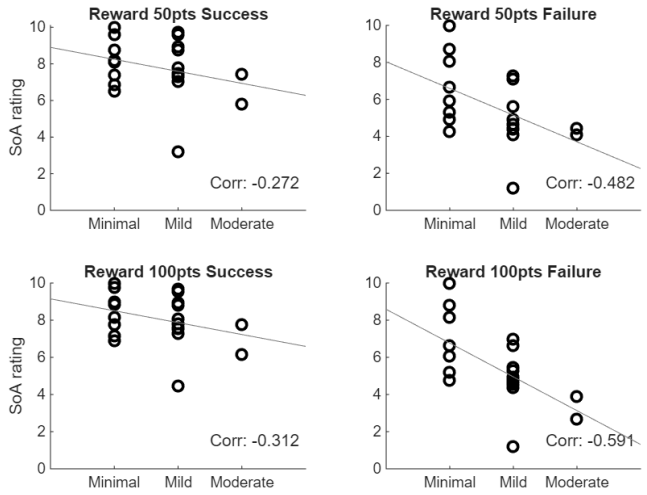

Figure 5. Correlations between anxiety (GAD-7 score) and explicit SoA ratings for the four reward conditions.

Time Pressure

Success and failure.

We first calculated the success rate as a function of time pressure (low = 8 sec, high = 4 sec). There was no effect of time pressure on success (4 seconds: M= 0.618, SE = 0.043; 8 seconds: M = 0.616, SE = 0.039).

Explicit ratings of SoA

We analyzed explicit agency ratings as a function of success and failure for the two time limits (low time pressure = 8 sec, high time pressure= 4 sec) by running a repeated-measures ANOVA. We found a large main effect of success/failure ($F(1,19) = 73.846, p < .001, \eta^2 = 0.775$), such that SoA ratings were significantly higher for successes (M = 7.929, SE = 0.326) than for failures (M = 5.543, SE = 0.440). No other effect was significant. See Figure 6.

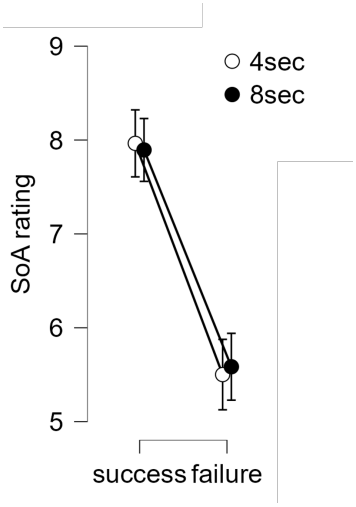

Figure 6. Explicit SoA ratings as a function of success and failure. The separate lines indicate time pressure. High pressure = 4 seconds (white marker) and low pressure = 8 seconds (black markers).

Given that the time manipulation did not appear to be successful, we also evaluated Response Times and found that participants were well within the high pressure time limit of 4 seconds for both the 4 sec condition (mean RT = 1.143, SD = 0.75) and the 8 sec condition (mean RT = 1.165, SD = 0.839)

GAD-7 score

We analyzed explicit agency ratings as a function of success and failure for the two time limits (low time pressure = 8 sec, high time pressure= 4 sec) by running a repeated-measures ANOVA with GAD-7 score as a covariate. We found an interaction between GAD-7 and success ($F(1,18) = 6.004$, $p = 0.025$, $\eta^2 = 0.031$), and an interaction between GAD-7 and time pressure ($F(1,18) = 5.372$, $p = 0.032$, $\eta^2 = 0.002$).

We correlated GAD-7 scores with SoA ratings for each of the four condition combinations (see Figure 7). We found a significant negative correlation between both high time pressure (4 sec) failure and GAD-7 ($R = -0.604$, $p = 0.005$) and low time pressure (8 sec) failure and GAD-7 ($R = -0.448$, $p = 0.048$). Failure (under both time pressures) appears to have a greater impact on SoA in participants with higher (moderate) state anxiety.

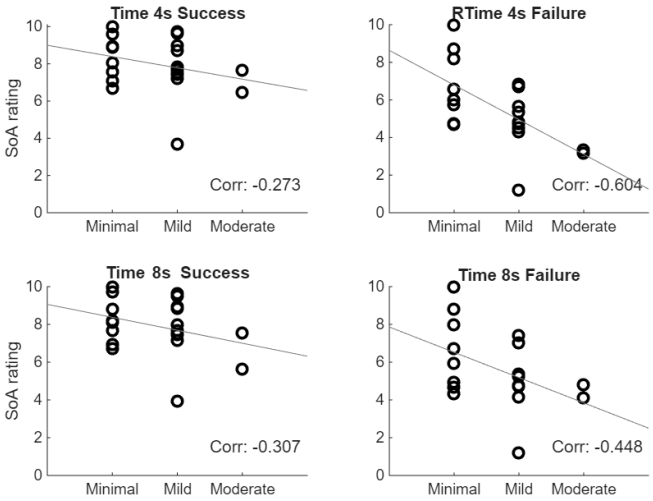

Figure 7. Correlations between anxiety (GAD-7 score) and explicit SoA ratings for the four time pressure conditions.

Discussion

This novel study aimed to investigate how individual psychological factors, task difficulty, and task pressure interact to modulate SoA. We tested four hypotheses: 1) that increased situational pressure would decrease accuracy 2) that increased situational pressure would decrease SoA, 3) baseline anxiety would moderate performance, such that individuals with higher GAD-7 scores would report in a greater decline in SoA ratings under pressure, and 4) that locus of control would moderate performance.

Consistent with Hypothesis 1 and Hypothesis 2, increasing task difficulty via dot speed pressure significantly decreased

both objective accuracy and subjective SoA. We found that the manipulation of difficulty and the measure of success/failure were predictive of explicit SoA ratings – indicating that people were sensitive to the manipulation intended to decrease task control (i.e., SoA). This aligns with the predictive account of agency (Blakemore et al., 2002); as task difficulty increases, the internal forward model's prediction of the success becomes less reliable. The mismatch between the intended goal (stopping the dot) and the outcome leads to a diminished feeling of being "in the driver's seat".

Furthermore, while high reward pressure did not improve objective performance, it did significantly boost SoA ratings following successful trials. This supports a postdictive evaluation of agency: when the stakes are high and we succeed, we credit ourselves with more control to align with the positive value of the outcome. This is important in that in the postdictive evaluation it is not the performance itself, but the post hoc feeling of control when being incentivized for a success, that increases SoA ratings.

Notably, our time pressure manipulations (4s vs 8s) failed to affect accuracy or SoA. The response time data showed that participants responded on average in 1.1 seconds regardless of the time limit. The nature of the task was fast paced so even the 4s pressure was not restrictive enough to induce a "choke". Additionally, the salience of the time pressure manipulation might not have been strong enough. Figure 1, bottom left panel illustrates the task appearance. The count-down timer was at the top of the screen in relatively unobstructive font. In future iterations we will seek to make the time pressure manipulation more similar to a 'shot clock' in a basketball game – where the numbers are large, pulsing, and salient. It is also worth noting that a similar issue was present within the reward trials. Here the reward verification came after the trial and might not have been salient enough to increase task pressure.

Consistent with Hypothesis 3, state anxiety (GAD-7) negatively correlated with SoA ratings, particularly following failure trials. Interestingly participants with higher anxiety felt significantly less control when facing fast dot speeds. This supports the attentional control theory that suggests that anxious individuals may suffer from a double hit, meaning that their working memory is taxed by worry, and when they fail, their subjective sense of agency is impacted more than their less anxious peers. We also found a negative correlation between failure and reward and failure and time pressure. Failure (both for the loss of high and low rewards and under high and low time pressure) appears to have a greater impact on SoA in participants with higher (moderate) state anxiety.

There was no evidence to provide support for Hypothesis 4, as locus of control did not correlate with SoA or success/failure. This may be due to desirability bias in the locus of control (LOC) responses or due to LOC being a trait like construct causing it to not be reflected in a trial by trial measure of SoA.

Conclusion

The current study makes a novel contribution to our understanding of SoA under pressure. Of the three performance manipulations dot speed was the most successful. The success rate was significantly higher for slow dot speed, and consistent with a predictive processing account that when the match between the motor action and the outcome is disrupted, there were lower SoA rating for increased dot speed. This also concords with the explicit monitoring theory that pressure disrupts fluid execution and causes errors. This is important confirmation of the effect external factors have on being able to enact our actions in the world and thus on our experience of control – i.e., SoA.

In addition, reward appears to affect SoA more than punishment – especially high reward. While this was not an explicit prediction for our study, we found that the penalty of losing points when failing does not impact SoA, but bigger rewards feel even better.

Anxiety was also a significant modulator of SoA. We found that higher GAD-7 scores (moderate anxiety) were correlated with decreased SoA scores for failures. For fast (but not slow) dot speed this was also the case for success. However, for reward and time pressure there was no correlation for success trials. In other words, failure negatively impacts SoA for people with moderate anxiety, but success does not positively impact SoA. This is interesting relative to our finding that high reward success boosted postdictive SoA. Perhaps anxiety makes failure more salient or reduces postdiction. These results provide a critical foundation for future research into the relationship between sense of agency and performance under pressure.

Acknowledgments

This work was supported by the National Science Foundation (NSF) under grant NSF NRT-FW-HTF: Socially Cognizant Robotics for a Technology Enhanced Society (SOCRATES) No. 2021628 and grant nos. CNS-2055520, CNS-1901355, CNS-1901133.

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