**Keep calm and manage impulsivity: Mood as a modulator of
impulsive behaviour**

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14 **Abstract**

15 This study investigated how different mood states affect distinct subtypes of impulsivity: motor
16 impulsivity [measured with the Stop Signal (SST) and the 5-Choice Serial Reaction Time Task
17 (5-CSRTT)], reflection impulsivity [assessed with the Information Sampling Task (IST)], and
18 temporal impulsivity (the Delay Discounting Questionnaire). Eighty healthy volunteers
19 completed two experimental sessions. During session 1, which served as a baseline measure,
20 participants underwent a neutral mood induction procedure. In Session 2, they were randomly
21 allocated to one of the mood-induction groups (Neutral, Positive, Sad, and Anxiety). Mood state
22 ratings included bipolar visual analogue scales on mood (positive/negative), tension/relaxation
23 and arousal (tired/active). No group effect was found on any of the impulsivity measures.
24 Correlational analyses between mood changes (following the mood manipulation procedures)
25 and behaviour in the tasks revealed that increased relaxation was related to increased information
26 sampling in the IST (decreased reflection impulsivity). In addition, the more active subjects
27 reported to be, the more likely they were to choose a delayed reward over the immediate one
28 (decreased temporal impulsivity). These results indicate that subjective changes in mood state are
29 associated with behavioural impulsivity levels. Importantly, distinct facets of impulsivity
30 (reflection, motor and temporal) are differently affected by changes in mood state.

Introduction

Impulsivity is often described as a tendency to act rapidly without taking into account consequences of one's actions [1]. It is generally considered to be maladaptive as impulsivity is associated with risky sexual activities [2], gambling [3–5], smoking [6] and binge drinking [7,8]. Furthermore, deficits in impulse control, both behavioural and trait characteristic, are related to several disorders such as attention deficit and hyperactivity disorder (ADHD), manic episodes of bipolar disorder, borderline personality disorder, Parkinson's disease, schizophrenia, eating disorders or substance abuse (American Psychiatric Association, 2013).

Given the importance of impulsivity both in everyday life and in clinical practice, it is vital to understand the modulators of impulsive behaviour. Numerous studies show that negative emotions exert a great impact not only on our actions but also on decision-making processes. Tice and colleagues [15] demonstrated that experiencing negative emotions leads to limited self-control, which in turn results in impulsive behaviours such as compulsive eating, reduced delayed gratification or procrastination. Experience of stress or anxiety has also been shown to lead to maladaptive behaviours including smoking, comfort-eating or drinking alcohol [16–19]. Such activities are believed to serve as a coping mechanism. Episodes of binge eating and vomiting in patients with bulimia nervosa are related to prior states of increased self-reported negative mood, stress or feelings of anger [20,21] and engagement in purging behaviours leads to decrease in negative emotions [21].

On the other hand, the beneficial impact of positive affect in everyday life has been reported in several studies. For instance, people in a good mood state perform better at creative problem-solving tasks [22] and show increased cognitive flexibility [23]. However, high levels

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of positive affect may also be associated with undertaking risky and impulsive behaviours such as heavy-drinking as part of celebrations [24,25] or gambling [26].

The evidence summarised above provides support for the link between emotional states and impulsivity, as well as an interaction between the two in forming our actions and motivations contributing to addictive behaviours. However, little is known about how exactly emotional states impact the different facets of behavioural impulsivity. Therefore, the current experiment aimed to examine, how incidental changes in mood state influence the distinct impulsivity subtypes using common laboratory tests.

The study examined, how modulation of affective state influences the distinct impulsivity subtypes using standard laboratory tests. Due to the multifaceted nature of impulsivity [27–30], several independent measures were used to capture a wider range of impulsivity dimensions: impulsive tendencies (personality traits), reflection, temporal, motor ‘stopping’ and ‘waiting’ impulsivity, and inattention. We hypothesised that negative emotional state might reduce inhibitory control, as worry and rumination are costly in terms of cognitive resources [31]. Since negative affect has been related to an increase in task-unrelated thoughts [32], we also hypothesised that sadness and anxiety might be related to increased impulsivity on the tasks which require attention. On the other hand, positive affect might decrease reflection impulsivity by improving efficiency [33,34]. Positive affect could also improve self-regulation [35] and, therefore, make individuals more likely to wait for their incentive (decrease temporal impulsivity).

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73 **Materials and methods**

74 **Participants**

75 Eighty-three volunteers (50 females) were recruited from the University of Sussex community,
76 providing consent to participate in the study. Sample size was motivated by previous studies
77 using similar methodologies [15,32,35,36]. Participants were informed that the study
78 investigated the effects of experience on cognitive tasks performance. The inclusion criteria were
79 following: age 18-35 years old, fluency in English, no current diagnosis of any mental or
80 neurological disorders, and no current pharmacological treatment (except birth control). During
81 the experiment participants' olfactory abilities were tested; therefore, additional exclusion criteria
82 was anosmia, hay fever or cold. Data from this part of the procedure will be reported elsewhere.
83 Participants were instructed not to consume any caffeine-containing products or any other
84 substances which may affect their heart rate on the days of testing. The study was approved by
85 the local Ethics Committee. All participants were compensated for their time.

86

87 **Materials**

88 Nuffield Hospitals Medical History Questionnaire assessed demographic details, past and present
89 health status (to confirm meeting study inclusion criteria), use of medications and recreational
90 drugs, and an estimate of a number of cigarettes smoked per day.

91

92 **Subjective ratings:**

93 *KUSTA Mood scale* [37] was used to assess mood state. To capture the crucial changes in affective
94 state, only Kusta bipolar scales of Mood (a measure of valence, positive vs negative), Activity (a

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self-report measure of arousal) and Tension/Relaxation (a measure of stress, Ilona Papousek et al., 2010; Ilona Papousek, Schulter, & Premsberger, 2002; Iona Papousek & Schulter, 2001) were employed.

Alcohol Use Questionnaire (AUQ) [38] gives a measure of total units of alcohol consumed per week, binge score and alcohol use score.

Barratt Impulsiveness Scale (BIS-11) [39] consists of 30 items which assess a tendency for impulsive actions in everyday life. BIS is organised into three subscales: attentional, motor and non-planning impulsivity.

UPPS Impulsivity Scale [29] consists of four subscales: Urgency (a tendency to act impulsively while experiencing strong negative emotions), Premeditation, Perseverance and Sensation Seeking.

Both scales are commonly used measures of trait impulsivity and were introduced to assess distinct aspects of impulsivity characteristics.

Tasks

The 5-Choice Serial Reaction Time Task (5-CSRTT) [7]: The 5-SSRT assesses motor impulsivity, particularly the ability to wait for a signal to respond (i.e. 'waiting' impulsivity). Participants were required to hold their index finger of the dominant hand on the "home button" at the bottom of the iPad (iOS 6 operating system; Apple Inc) screen until one of five blue circles moving on the screen in a "circular" fashion illuminated briefly (0.5s). Subjects respond to it by tapping the appropriate circle as fast as possible and return to the home button. Premature responses, occurring before stimulus onset, were considered a measure of poor inhibitory control and punished by a 5s time-out period. Following practice trials in which the stimuli were presented at fixed inter-trial intervals of 5s, in experimental trials targets were presented at variable inter-trial

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118 intervals (vITI) lasting for 2, 5, 10, or 15 seconds. The task lasted until 50 correct trials were
119 completed or 10 minutes has elapsed, whichever came first.

120 *The Monetary Choice Questionnaire (MCQ)* [40]: The MCQ is a measure of temporal
121 impulsivity. Volunteers are presented with 27 hypothetical choices between small, immediate
122 rewards (SIR) and larger delayed rewards (LDR), for example, “would you prefer £54 today or
123 £55 in 117 days?”. For each participant the discounting parameter (k) is calculated using the
124 formula: $k = ((LDR - SIR) - 1) / \text{delay}$.

125 *The Stop Signal Task (SST)* [41]: The SST assessed an ability to inhibit a pre-potent motor
126 response. Participants respond with button presses to the direction of a green arrow (Go signal)
127 displayed on a computer screen but are required to withhold this response whenever the arrow
128 changes colour to red (a Stop Signal, occurring on 25% of trials). The difficulty of inhibition of
129 pre-potent responses is reflected in heightened Stop Signal Reaction Time (SSRT).

130 *The Information Sampling Task (IST)* [42]: The IST is a measure of reflection impulsivity. On
131 each trial, a matrix of 5x5 grey squares is presented on a computer screen. Participants select a
132 square by clicking with the mouse over the square, to reveal one of two colours until they are
133 confident enough to decide which of the two colours is most frequent in the array. There are two
134 conditions of the task:

135 (i) Fixed win condition (FW): participants win 100 points if they make the right decision
136 (regardless of how many boxes they have opened); otherwise, they lose 100 points. Participants
137 complete ten experimental trials.

138 (ii) IST reward conflict (RC): for every box opened, participants lose 10 points from a bank of
139 250. If a participant chooses correctly they win the remaining points from the bank; otherwise,
140 they lose 100 points. Participants complete ten experimental trials.

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141 **Dependent variables for the tasks**

142 5-CSRTT: Number of premature responses made (No Premature) - high scores indicate high

143 impulsivity, Number of omissions (No Omissions) - high values indicate inattention;

144 SST: SSRT - high scores indicate high impulsivity;

145 MCQ: Mean k value- high values high impulsivity (values log transformed to improve

146 distribution;

147 IST, for each condition (FW and RC) No of boxes opened - high values indicate low impulsivity;

148 **Mood induction**

149 Details on mood induction procedures can be found in Appendix. Briefly, the neutral, positive

150 and sad mood was induced by presentation of emotional images (neutral, positive, or sad

151 respectively) together with congruent emotional music to strengthen the effect. Participants in the

152 anxiety group were simultaneously exposed to different types of stressors: emotional (pictures

153 depicting anxiety-provoking images, e.g. snakes), acoustic (white noise), and cognitive (mental

154 calculations under the pressure of time).

155 **Procedure**

156 Participants attended two experimental sessions 3-9 days apart ($M = 6.09$, $SD = 1.80$). Sessions

157 took place between 9 am and 6 pm.

158

159 **Session 1:**

160 Participants were informed about the procedures of the experiment and before signing the

161 consent to participate in the study, they were shown an example of a negatively valenced image

162 used in the study to ensure they would not find it too distressing.

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163 The aim of the first session was to ensure the mood-induction groups were well-matched and did
164 not differ on any of the trait, mood or behavioural measures. Therefore, all participants
165 completed the trait and AUQ questionnaires and underwent a neutral mood induction procedure
166 (viewing neutral images while listening to music), to assess performance on the task under
167 neutral conditions. Immediately before and after the mood induction, participants completed the
168 VAS scales.

169 Next, participants completed a battery of cognitive tasks (SST, MCQ, 5-CSRTT and IST). Tasks
170 were completed in a randomised order with short pauses in-between. During the breaks, a
171 shortened mood induction procedure (1 minute only) was introduced to maintain the stable mood
172 throughout the session.

173

174 **Session 2:**

175 Participants were semi-randomly (to ensure equal numbers of males and females in each group)
176 assigned to one of the four conditions: neutral (control), positive, sad, or anxious mood. Their
177 mood was assessed with VAS before and immediately after the procedure. As in the first session,
178 participants completed the five cognitive tasks in a randomised order with 1 minute-mood
179 induction periods in-between.

180 At the end, participants were debriefed and signed a form confirming their willingness for the
181 data being used in the analyses.

182

183 **Statistical analyses**

184 To test whether the four groups were well-matched baseline group demographics (age, smoking
185 habit, alcohol use, and trait impulsivity measurements) as well as performance on the tasks

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during session 1 were compared using one-way ANOVA in SPSS, v22. Furthermore to assess that groups did not differ in the way their mood ratings changed following the neutral mood manipulation at Session 1 a mixed ANOVA with time (pre- and post-manipulation) applied as a within-subject factor, and experimental condition (Control, Anxiety, Sad, Positive) as a between-subject factor was performed. Same mixed ANOVA was performed for session 2 to assess whether mood induction was successful. To examine the influence of mood state on impulsive behaviour during session 2 a series of ANOVAs were performed. As the perception of mood induction may differ across individual, in addition, correlational analyses were performed between changes in mood state ratings (post-induction score – pre-induction score) and performance indices in the tasks, at session 2.

Results

Exclusions

Two participants (one male) did not return for the second session. Moreover, one male volunteer was very inattentive throughout the first session of the study and failed to comply with the experimenter's instructions on three of the tasks; therefore, he was compensated for attending the first session and not invited to return for the second session and were excluded from the analyses completely. Thus, the final number of participants who completed both sessions of the study is 80 (49 females).

Nine participants (3 from the Control group, 3 Sad, 3 Anxiety) were excluded from the SST analyses for the first session and 9 (4 Control, 2 Positive, 2 Sad, 1 Anxiety) for the second session as they failed to follow task instructions (i.e. they were slowing down responses waiting

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for the stop signal to occur, which resulted in go accuracy below 90% and stop correct rate above 60%).

One participant (Anxiety group) was excluded from the analyses from the IST FW analyses and another two individuals (Anxiety group) from the Reward Conflict condition for session 1 only, as they misunderstood the instructions (guessing rather than sampling information before making a choice or ignored changed instructions for the reward conflict condition). One participant was excluded from the IST FW condition and further three participants (Positive group) were excluded from the analyses of session 2, Reward conflict condition, due to continuous guessing on the task, rather than sampling information.

Two participants (1 Anxiety, 1 Control) were excluded from the MCQ analyses for the first session and 1 (Control) for the second session, because of highly inconsistent responses given (less than 75% consistency).

Due to technical problems, the 5-CSRTT was completed only by 56 participants during session 1 and 57 during session 2.

Session 1 (Control session)

Groups were well matched for their demographics, personality trait measurements and performance on the tasks (see Table 1 for details).

Repeated measures ANOVA with time (baseline vs post-mood induction 1) as a within-subject factor and group (Control, Anxiety, Sad, Positive) as a between-subject factor showed a main effect of time, $F(1, 76) = 4.77, p = .032, \eta_p^2 = 0.059$, on activity self-rating score, indicating a decrease in activity following the induction. No other main effects were observed (time effect: $F(3, 76) \leq 2.63, p > .05, \eta_p^2 \leq .10$, group effect : $F(3, 76) \leq 0.81, p > .05, \eta_p^2 \leq .03$). Data related

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to mood state ratings are presented in Table 2. There were also no group differences regarding performance on any of the task measurements (p 's > 0.5; see Table 3).

Table 1 Sample demographics and trait measurements for each of the mood manipulation groups.

Variable	All		Control		Anxiety		Sad		Positive		One-way ANOVA	
N (Female)	80(49)		20(12)		20(13)		21(13)		19(11)			
No of Smokers	13		2		3		4		4		1.04 ¹	.79
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	<i>F</i>	<i>p</i>
Age	22.15	3.69	22.05	3.75	22.75	4.32	22.57	4.09	21.16	2.52	0.71	.55
Alcohol Units per week	12.52	12.08	14.41	16.72	9.75	9.06	10.50	11.03	15.66	10.15	1.13	.34
No of Cigarettes a day	0.60	1.68	0.45	1.61	0.45	1.28	0.86	2.35	0.63	1.42	0.35	.79
BIS Total	64.07	9.00	63.75	8.61	63.75	11.22	65.00	9.29	63.58	7.35	0.10	.96
Premeditation	21.34	4.63	21.30	4.26	20.30	4.45	21.91	4.21	21.53	5.78	0.43	.73
Negative Urgency	28.73	5.61	27.45	4.82	28.15	6.04	30.38	6.23	28.68	5.39	1.01	.39
Sensation Seeking	36.23	6.79	36.35	7.69	37.50	6.08	34.71	5.54	36.47	8.20	0.57	.64
Perseverance	19.96	4.91	19.25	4.52	19.95	5.17	21.10	5.71	19.00	4.00	0.74	.53

¹X² test

Table 2 Mood state ratings for each group for Session 1 and 2 for each of the mood manipulation groups. * a main time effect; &a group by time interaction indicating differential manipulation changes (relevant means in **bold**).

Ratings		Control		Anxiety		Sad		Positive	
Session 1		Mean	SE	Mean	SE	Mean	SE	Mean	SE
Mood	Baseline	73.19	5.09	62.73	5.36	66.94	4.25	62.31	8.42
	Post 1	67.13	5.09	59.67	5.30	64.72	4.68	61.00	7.27
Activity*	Baseline	60.88	6.74	51.67	6.49	62.28	4.97	53.92	6.07
	Post 1	54.56	6.08	46.80	5.94	58.22	5.29	52.08	6.83
Relaxation	Baseline	75.81	5.30	66.40	5.75	70.33	4.10	65.23	7.53
	Post 1	69.38	5.20	60.00	6.50	73.39	3.71	67.38	7.16
Session 2									
Mood&	Baseline	74.85	3.84	73.60	4.17	69.29	3.34	69.21	5.12
	Post 1	70.95	3.75	46.00	5.51	43.81	3.19	77.58	3.02
Activity	Baseline	76.30	4.4	67.33	5.07	62.14	4.78	64.37	4.53
	Post 1	71.90	4.5	40.35	5.55	49.71	3.66	72.37	2.78
Relaxation&	Baseline	74.70	4.03	71.23	3.73	65.24	3.51	70.16	2.58
	Post 1	70.55	4.05	49.70	5.48	41.29	3.08	73.05	3.15

Session 2 (Mood Manipulation)

Mood

Repeated-measures ANOVA with time (baseline vs post 1) as a within-subject factor and mood induction group as a between-subject factor was conducted to assess the successfulness of mood manipulation (see Table 2 for descriptive statistics). The Anxiety and Sad groups showed significant decrease in mood ratings (increase in negative mood) following the induction, the Positive group showed an increase in mood ratings (increase in positive mood), while the Control group presented no significant change (time vs group interaction: $F(3, 76) = 15.26, p < .001, \eta_p^2 = .38$). Regarding the tension-relaxation scale, Anxiety and Sad groups showed a decrease in relaxation, Positive group showed an increase in relaxation, while the Control group did not change (interaction: $F(3, 76) = 9.09, p < .001, \eta_p^2 = .26$). There was also a marginal interaction effect in

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activity ratings ($F(3, 76) = 2.71, p = .051, \eta^2 = .097$): the Positive group showed an increase in activity, while the remaining groups did not present any significant changes.

Task performance

The assumption of homogeneity of variances (Levene's test p 's $< .05$) was violated for several measures: SSRT, NoOmiss and IST FW; therefore, Welsh test was computed to compare the performance between groups on these measures. A main group effect was found only for the number of omissions in the 5-CSRTT, Welsh ($F(3, 28,51) = 2.96, p = .049$), reflecting a higher number of omissions in the Sad group (see Table 3). However, Games-Howell post-hoc test showed no significant differences between any of the groups' pairs (p 's $> .05$). No other group effects were found.

Correlations

Subsequent correlational analyses were performed to explore the relationship between mood changes and performance on the tasks (see Table 4).

There was a negative correlation between the tension-relaxation score change and SSRT, indicating that the more tensed participants were, the more impulsively they behaved in the task.

There were positive correlations between the tension-relaxation score change and the performance on the IST in both conditions, indicating that the more relaxed participants were, the more information they sampled (decreased reflection impulsivity).

The change in the activity score was negatively correlated with the discounting rate ($\log k$), suggesting that an increase in activity was related to a decrease in temporal impulsivity. Change in the activity score was also negatively correlated with the number of premature responses, indicating that increased activity was related to lower level of premature responses; therefore, decreased 'waiting' impulsivity.

273 **Table 3 Tasks performance during session 1 and session 2 for each of the mood manipulation group.** ¹Welsh statistics

Variables	Control			Anxiety			Sad			Positive			One-way ANOVA		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	F	p	effect size
Session 1															
SSRT	17	246.01	34.17	17	244.6	30.79	18	249.68	33.86	19	262.89	21.17	1.4	0.252	0.06
5-CSRRT No Omissions	15	1.60	1.92	10	0.60	0.84	17	1.00	1.54	14	0.79	1.42	1.07	0.369	0.06
5-CSRRT No Premature	15	3.40	2.90	10	2.50	2.42	17	3.00	2.6	14	1.71	0.91	1.37	0.261	0.07
IST FW No boxes opened	20	15.21	6.22	19	14.32	5.44	21	14.89	6.91	19	14.89	6.91	0.37	0.775	0.02
IST RC No boxes opened	20	9.54	3.24	18	9.73	4.19	21	9.72	4.84	19	9.72	4.84	0.17	0.915	0.01
Mean k-value (log transformed)	19	-4.83	1.55	19	-5.33	1.63	21	-5.00	1.53	19	-4.98	1.16	0.38	0.767	0.02
Session 2															
SSRT	16	246.25	29.19	19	248.78	39.28	19	242.76	26.93	17	240.15	46.71	0.16	¹ 0.920	0.01
5-CSRRT No Omissions	16	1.69	2.41	14	0.50	0.76	17	2.18	2.72	10	0.50	0.71	2.96	¹ 0.049	0.12
5-CSRRT No Premature	16	2.06	2.64	14	1.64	2.65	17	2.29	2.59	10	1.30	1.95	0.40	0.756	0.02
IST FW No boxes opened	20	12.70	6.40	20	10.70	3.35	21	13.42	6.47	18	12.46	5.97	1.33	¹ 0.279	0.03
IST RC No boxes opened	20	8.36	3.34	20	8.01	2.45	21	8.77	4.13	16	10.09	3.39	1.24	0.300	0.03
Mean k-value (log transformed)	19	-4.62	1.04	20	-4.92	1.29	21	-4.81	1.61	19	-5.11	1.64	0.40	0.754	0.02

Table 4 Correlation matrix between performance on the tasks during session 2 and changes in mood state ratings (Post-induction - Pre-induction). Correlations which survived the correction for multiple comparison ($p \leq .004$) are depicted in **bold**.

Variable		Mood	Activity	Relaxation
SSRT	Pearson's r	-0.05	-0.14	-0.27
	p-value	0.664	0.233	0.023
No Omissions	Spearman's rho	0.149	0.031	-0.05
	p-value	0.27	0.822	0.711
No Premature Responses	Spearman's rho	-0.25	-0.265	-0.06
	p-value	0.061	0.047	0.685
FW No boxes	Pearson's r	0.017	-0.056	0.259
	p-value	0.882	0.626	0.021
RC No boxes	Pearson's r	0.115	-0.124	0.434
	p-value	0.321	0.281	< .001
log k	Pearson's r	-0.06	-0.33	-0.09
	p-value	0.574	0.003	0.452

With correction for multiple comparisons set at $p < .004$ only the relationships between activity score change and discounting rate, and the relationship between tension-relaxation score change and the performance in RC on the IST survived (see Fig 1).

Fig 1. Plots showing significant association between post-induction changes in mood state and performance in the tasks during session 2. The top panel presents the relationship between the change in activity score (Post Activity – Pre Activity) and the discounting parameter (k value). The bottom panel presents the relationship between the change in Tension/Relaxation score (Post Relaxation – Pre Relaxation) and the performance on the information sampling task (IST), reward conflict condition (RC)

Discussion

The current study investigated the role of the emotional state as a modulator of impulsive behaviour. Although no group differences in performance on the tasks were found, based on correlational analyses, we report relationships between behavioural impulsivity and subjective changes in mood state, irrespective of the group allocation. Specifically, increased relaxation (vs tension) was related to increased information gathering on the IST (decreased reflection impulsivity), while increased activity (vs tiredness) was associated with lower levels of delay discounting (decreased temporal impulsivity). Together, our results suggest that distinct facets of impulsive behaviours are differentially affected by individual changes in mood state.

We predicted that increased positive affect might be related to decreased reflection impulsivity via enhanced task efficiency [33,34]. We found no relationship between neither mood state (valence) nor arousal (activity) measures, instead, increased relaxation state following the mood manipulation procedure was related to higher information sampling before deciding in the IST. This relationship was stronger for the reward conflict condition, in which participants sample information at a certain cost – the more boxes they open, the smaller the potential reward. This may indicate that changes across the tension-relaxation domain may be related to motivational changes. The “tension-relaxation” scale had proved to be a sensitive measure of subjectively experienced stress state in previous investigations [43–45]. Therefore, our results might be interpreted as the more stressed participants felt, the more impulsively they behaved on the IST RC.

We suspected that increased positive affective state might be associated with improved self-regulation, and therefore, decreased temporal impulsivity. We found no associations between temporal impulsivity and measures of either mood or tension/relaxation scales. The lack of

findings linking mood scale (valence) contradicts previous research. For example, a study with preschool children also showed that pupils in whom a happy mood state was induced chose the larger delayed rewards significantly more often than those in a sad mood state [46]. In contrast, participants who report high levels of negative affective state, show higher discounting rates (higher temporal impulsivity) than those low in a negative affective state [47]. Instead, our results indicate a specific relationship between temporal impulsivity and self-reported activity: Increased activity following the mood induction procedure was associated with low temporal impulsivity. Mental fatigue following completion of a cognitive task was associated with a diminished emotion regulation [48]. Possibly the same mechanism applies to self-control on inter-temporal decisions in fatigued (decreased in activity) individuals resulting in short-sighted choices as shown in the present study.

Regarding motor impulsivity, there were significant group differences in the number of omissions on the 5-CSRTT. Post-hoc tests were insignificant, but judging by the mean values only, it appears that the Sad group was the most inattentive. This lends some support to our hypotheses that negative affective state might be related to attentional lapses. This conclusion also agrees with reports by Smallwood and colleagues [32]: Relative to positive, negative mood state was associated with more attentional lapses, increased frequency of reports of task-irrelevant thoughts, and more difficulty to adjust behaviour following a lapse.

Moreover, there was a negative association between change in activity ratings and the number of premature responses, suggesting that individuals who felt more active following the mood induction, showed lower 'waiting' impulsivity. However, this correlation did not survive the correction for multiple comparisons; therefore, providing only tentative evidence for the relationship between mood state and 'waiting' impulsivity.

Similarly, our results lend some tentative evidence for the relationship between increased reports of tension (stress state) and impaired response inhibition. Noteworthy, past research on the role of emotional states on response inhibition yielded inconsistent results, with some studies reporting no effects [49,50], some increased prepotent response inhibition following stress induction [51], yet another study found diminished inhibitory control following distress induction [52]. Possibly, some of these differences may be accounted by different measures of ‘stopping’ impulsivity employed. Our findings agree with results by Patterson et al. [52], who used a standard version of the SST, suggesting that acute stress state is associated with diminished motor response inhibition. Overall, the role of current emotional states on aspects of motor impulsivity remains unclear, and further research is necessary to resolve this issue.

Considering all findings together, we suggest that individual differences in perceived mood state or susceptibility to mood changes may play an essential role in situational impulsivity. In other words, individuals who are more prone to mood swings may also experience more mood-dependent changes in impulsive behaviour. Indeed, deficits in emotion regulation, which can lead to mood swings, have been linked to many impulse-related behaviours such as excessive food intake or substance and non-substance-related addictive behaviours (including alcohol, drug abuse, gambling disorder, video game addiction, and problematic Internet use) [53–56]. Moreover, in a study by Tice and colleagues, distress induction led to impulsive behaviours. However, ‘mood-freezing’ manipulation (i.e. leading people to believe that their mood state will not be affected) diminished the effect of distress on behaviour [15], suggesting that being in control (or a sense of control) over emotional reactions, simultaneously aids impulse control. Together, these findings imply that improved emotional regulation strategies may help reduce impulsive behaviours.

357 Additionally, current results also pose some implications for research: a current mood state should
358 be considered when assessing behavioural impulsivity.

359 There were some limitations to the current study that should be considered. Our sample consisted
360 of a narrow age range of individuals, the typical undergraduate sample of students, which
361 restrictions the generalisation of the findings. Mood inductions were successful, but as in previous
362 studies [e.g. 57], it was easier to modulate negative emotions (Sad and Anxiety groups) than
363 positive emotions (Positive group). In fact, the Control and Positive groups showed similar mood
364 ratings.

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