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Article (Accepted Version)

Herman, Aleksandra M, Critchley, Hugo D and Duka, Theodora (2018) Risk-taking and impulsivity; the role of mood states and interoception. *Frontiers in Psychology*, 9 (1625). pp. 1-11. ISSN 1664-1078

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# Risk-taking and impulsivity; the role of mood states and interoception

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10 **Keywords: UPPS-P, sensation seeking, delay discounting, probability discounting, reflection**  
11 **impulsivity, interoceptive sensibility, emotional state.**

12

## 13 Abstract

14 Objectives: The consequences of impulsive decisions and actions represent a major source of concern  
15 to the health and well-being of individuals and society. It is, therefore, crucial to understand the  
16 factors which contribute to impulsive behaviors. Here, we examined how personality traits of  
17 behavioral tendencies, interoceptive sensibility as well as transient mood states predict behavioral  
18 performance on impulsivity and risk-taking tasks.

19 Method: 574 (121 males; age 18-45) individuals completed self-report personality measures of  
20 impulsivity, reward sensitivity, punishment avoidance as well as interoceptive sensibility, undertook  
21 a mood assessment and performed a set of cognitive tasks: delay discounting (temporal impulsivity),  
22 probability discounting (risk-taking), and reflection impulsivity task. Data were interrogated using  
23 principal component analysis, correlations and regression analyses to test mutual relationships  
24 between personality traits, interoceptive sensibility, mood state and impulsive behaviors.

25 Results: We observed a clear separation of measures used, both trait and behavioral. Namely,  
26 sensation-seeking, reward sensitivity and probability discounting reflected risk-taking. These were  
27 separate from measures associated with impulsivity, both trait (negative and positive urgency,  
28 premeditation, perseverance) and behavioral (delayed discounting and reflection impulsivity). This  
29 separation was further highlighted by their relationship with the current emotional state: positive  
30 affect was associated with increased risk-taking tendencies and risky decision-making, while  
31 negative emotions were related to heightened impulsivity measures. Interoceptive sensibility was  
32 only associated with negative emotions component.

33 Conclusions: Our findings support the proposal that risk-taking and impulsivity represent distinct  
34 constructs that are differentially affected by current mood states. This novel insight enhances our  
35 understanding of impulsive behaviors.

36

37 **1 Introduction**

38 Impulsivity describes a set of behaviors characterized by relative dominance of spontaneity over  
39 consideration. Examples include a preference towards obtaining immediate gratification over a  
40 delayed (yet ultimately more profitable) outcome, making ‘snap decisions’ before evaluating  
41 available information, or having difficulty waiting one’s turn, withholding a reaction, or aborting an  
42 initiated motor response (Daruna & Barnes, 1993; Moeller *et al.*, 2001). Although, spontaneous  
43 actions may be adaptive, for example when the matter is of little importance or when there is little  
44 time to make a decision (Dickman, 1990), high levels of impulsivity often result in negative  
45 consequences. Correspondingly, impulsivity is associated with poor academic achievement and  
46 impaired psychometric performance on reasoning tasks (Schweizer, 2002; Lozano *et al.*, 2014). A  
47 high degree of impulsivity is also related to risky driving (Pearson *et al.*, 2013), violent behavior  
48 when under the influence of alcohol (Klimkiewicz *et al.*, 2014), diminished self-control and an  
49 increased food intake (Guerrieri, Nederkoorn, & Jansen, 2007; Guerrieri, Nederkoorn, Stankiewicz,  
50 *et al.*, 2007; Meule & Kübler, 2014), especially while experiencing negative emotions (Van  
51 Blyderveen *et al.*, 2016). The importance of impulsivity is increasingly recognized in a clinical  
52 setting: Many neuropsychiatric conditions, including addiction, bipolar disorder, and Attention-  
53 Deficit Hyperactivity Disorder are characterized by elevated impulsivity (American Psychiatric  
54 Association, 2013). Risk-taking is also closely related to impulsivity and predicts the initiation of  
55 drug and alcohol use and the pursuit of other hazardous behaviors (e.g. unprotected sex) (Donohew *et*  
56 *al.*, 2000; Ríos-Bedoya *et al.*, 2008).

57 Impulsivity may determine the integrity of our health and how everyday life flows or falters. It is,  
58 therefore, crucial to understand the factors that underlie impulsive behavior and its expression.  
59 Moreover, impulsivity is a multidimensional construct (Whiteside & Lynam, 2001; Caswell *et al.*,  
60 2015; Herman *et al.*, 2018), so it is also vital to investigate what factors might differentially influence  
61 distinct impulsivity subtypes. Ultimately, improved understanding of modulators of impulsive  
62 behavior can enable us to develop better-coping strategies to help impulsive individuals and promote  
63 more advantageous decision-making in everyday life. Finally, impulsivity research to date focuses  
64 either on university students or certain target populations, e.g. substance abusers or binge drinkers.  
65 Hence broad information about the general population is lacking, yet much needed.

66 One likely modulator of impulsive behavior is affective state (for discussion see Herman *et al.*,  
67 2018). Indeed, people show diminished impulse control (i.e. behave more impulsively) when  
68 experiencing negative affect (Tice *et al.*, 2001). However, it is unknown if subtypes of impulsivity  
69 are equally affected by emotional states or whether impulsive behavior is particularly sensitive to  
70 specific emotions. Moreover, the role of characterological features contributing to ‘behavioral style’,  
71 for example, personality traits or sensitivity to internal bodily signals (interoception), is not to be  
72 underestimated, as these may shape how impulsively individuals respond while experiencing various  
73 mood states.

74 Implicitly one would assume that a measure of trait impulsivity would reflect the degree to which an  
75 individual behaves impulsively. However, typically very weak relationships are observed between  
76 various trait impulsivity (questionnaire) measures and objective performance on impulsivity tasks  
77 (Caswell *et al.*, 2015; Cyders & Coskunpinar, 2011; Franken, van Strien, Nijs, & Muris, 2008; Shen,  
78 Lee, & Chen, 2014). Possibly, interoceptive ability, enabling more accurate detection of internal  
79 bodily sensations, e.g. heart rate (Craig, 2009), may determine why and when we behave  
80 impulsively. Physiological cues may guide behavior particularly when a potential risk is involved  
81 (Damasio, 1996; Bechara *et al.*, 1997; Katkin *et al.*, 2001). For example, in a classic study by

82 Bechara *et al.*, (1997), healthy individuals playing a gambling task generated anticipatory skin  
83 conductance responses whenever they considered a choice that turned out to be risky, before they  
84 developed an explicit knowledge that the choice was risky. In addition, more recently, good  
85 interoceptive ability was found to be associated with more advantageous choices in the Iowa  
86 Gambling Task (Werner *et al.*, 2009) and predicted profitable decisions in London financial traders  
87 (Kandasamy *et al.*, 2016). Since disadvantageous decision-making is considered a part of impulsivity  
88 construct (Winstanley, 2011; Herman *et al.*, 2018), this evidence could suggest that more impulsive  
89 individuals may lack interoceptive sensitivity. Alternatively, since highly impulsive individuals  
90 appear also to have lower resting levels of arousal compared to peers (Fowles, 2000; Mathias &  
91 Stanford, 2003; Puttonen *et al.*, 2008; Schmidt *et al.*, 2013), and engagement in impulsive or risky  
92 actions may be a maladaptive way of reaching an ‘optimal’ level of arousal (Zuckerman, 1969;  
93 Barratt, 1985; Eysenck & Eysenck, 1985), impulsive individuals may have normal interoceptive  
94 sensitivity to changes in their internal state, yet engage in impulsive actions as a means of regulating  
95 their arousal level.

96 Within the current study, we sought to examine the relationship between personality traits of  
97 impulsive tendencies, reward sensitivity and punishment avoidance, subjective interoceptive traits  
98 (interoceptive sensibility; Garfinkel *et al.*, 2015), current emotional states with behavioral  
99 impulsivity. In particular, we were interested which of these variables would be the best predictor of  
100 task performance. The UPPS-P impulsive behavior scale (Cyders & Smith, 2007; Whiteside &  
101 Lynam, 2001) was used to assess aspects of impulsive tendencies. This scale was selected as it  
102 incorporates several dimensions of impulsivity based on personality measures with addition of  
103 tendencies for impulsive behaviours while experiencing strong emotions (urgency subscales).  
104 Additionally, the Behavioral Inhibition System/Behavioral Activation System Questionnaire (Carver  
105 & White, 1994) was employed as a measure of reward sensitivity and punishment avoidance. The  
106 Body Perception Questionnaire (Porges, 1993) was used to score general subjective sensitivity to  
107 bodily processes (interoceptive sensibility; Garfinkel *et al.*, 2015). The Positive Affect/Negative  
108 Affect Scale (Watson *et al.*, 1988) and the Depression, Anxiety, Stress Scale (Henry & Crawford,  
109 2005) were used to assess self-reported emotional state. Risk-taking behavior was assessed from  
110 performance on a probability discounting task (Madden *et al.*, 2009). Distinct facets of impulsive  
111 behavior were measured with the Monetary Choice Questionnaire (Kirby *et al.*, 1999), which  
112 assesses the ability to delay gratification (temporal impulsivity), and performance of the Matching  
113 Familiar Figures Task (Cairns & Cammock, 1978), which measures the degree of information  
114 seeking before making a decision (reflection impulsivity).

115 Since impulsivity is a term which encompasses a wide range of behaviors (Herman *et al.*, 2018), we  
116 hypothesized that distinct behavioral dimensions would be predicted by distinct factors. First, as  
117 interoception is linked to risk-taking and advantageous decision-making (Werner *et al.*, 2009;  
118 Kandasamy *et al.*, 2016), we predicted that individual differences in interoceptive sensibility would  
119 predict risk-taking. Second, extending earlier observations (Tice *et al.*, 2001), we predicted that  
120 negative emotional states compromise self-control, and thus increase behavioral impulsivity. Third,  
121 we predicted that components of the UPPS-P scale, which include emotion-based impulsivity  
122 components, would predict objective aspects of behavioral impulsivity.

123 To test our hypotheses, we conducted an online survey study of participants extending into the  
124 general population, providing a more demographically representative sample of the UK population  
125 than earlier studies. Participants completed self-report personality questionnaires, state-mood  
126 assessment and interoceptive sensibility questionnaires, and performed specific behavioral tasks to  
127 obtain an objective measure of impulsivity and risk-taking.

## 128 2 Material and methods

129 The study was approved by the University of Sussex Ethical board. Volunteers had to be at least 18  
 130 years old to participate. The study was conducted online via Qualtrics platform  
 131 (<https://www.qualtrics.com/>) between May and October 2016. To make the results generalizable to a  
 132 broad population, we wanted to obtain information from people with different backgrounds,  
 133 educational levels, age, and not just university students. Therefore, participants were recruited via  
 134 social media, websites ([www.reddit.com](http://www.reddit.com), [www.craigslist.org](http://www.craigslist.org), [www.callforparticipants.com](http://www.callforparticipants.com)), mailing  
 135 lists, as well as posters advertising the study on Campus, cafes and community centers around  
 136 Brighton. Inclusion in a £25 prize draw or a possibility to earn two study credits for Psychology  
 137 undergraduate students were offered as an incentive for participation.

### 138 2.1 Procedures

139 After reading study information, volunteers confirmed that they understood all information and then  
 140 consented to their willingness to take part in the study. After completing the survey, participants were  
 141 debriefed. The completion of the study took approximately 20 minutes (based on a pilot study during  
 142 which participants completed the study uninterrupted).

### 143 2.2 Questionnaires

144 Basic demographics questionnaire was used to determine age, sex, education, smoking habits and  
 145 recreational drug use.

146 Alcohol Use Questionnaire (Townshend & Duka, 2002) provided an estimate of a number of alcohol  
 147 units consumed a week.

148 UPPS-P Impulsive Behavior Scale (Whiteside & Lynam, 2001; Cyders & Smith, 2007) is a 59-item  
 149 self-report measure of five dimensions of impulsivity: negative urgency (NU) – a tendency to act on  
 150 impulse while experiencing strong negative emotions, (lack of) premeditation (LPrem)– a tendency  
 151 to act without taking into account the consequences, (lack of) perseverance (LPe) – difficulty  
 152 completing tasks which may be tedious or difficult, sensation seeking (SS) – a pursue of excitement  
 153 and novelty, and positive urgency (PU) – a tendency to act on impulse while experiencing strong  
 154 positive emotions.

155 Behavioral Inhibition System/Behavioral Activation System (BIS/BAS) Questionnaire (Carver &  
 156 White, 1994) consists of 20 items organized into two main scales: BIS, which evaluates punishment  
 157 sensitivity, and BAS which assesses reward sensitivity. BAS is further divided into three subscales:  
 158 BAS Reward (anticipation or the occurrence of the reward), BAS Drive (the pursuit of desired goals),  
 159 and BAS Fun Seeking (desire for new rewards and willingness to approach them).

160 Body Perception Questionnaire (BPQ) Very Short Form (Porges, 1993) consists of 12 items rated on  
 161 a five-point scale and provides a measure of general awareness of bodily processes (high values  
 162 indicate high awareness of bodily sensations).

163 Depression, Anxiety, Stress Scale (DASS) (Henry & Crawford, 2005) consists of three 7-item self-  
 164 report scales that measure the extent of depression, anxiety, and stress experienced over the last  
 165 week.

166 Positive Affect/Negative Affect Scale (PANAS) (Watson *et al.*, 1988) is a 20-item measure of self-  
 167 reported positive (PA), and negative affect (NA) experienced at the present moment.

### 168 2.3 Tasks

169 Matching Familiar Figures Task (MFFT) (Kagan *et al.*, 1964; Cairns & Cammock, 1978) is a  
 170 measure of reflection impulsivity. Participants need to identify an image identical to a target one, out  
 171 of six possible options. The dependent variable is an Impulsivity Score (IS), which reflects quick  
 172 responses and a high number of errors (high values indicate high reflection impulsivity).

173 Monetary Choice Questionnaire (MCQ) (Kirby *et al.*, 1999) is a measure of temporal impulsivity. It  
 174 consists of a list of 27 choices between pairs of smaller immediate rewards (SIR) and larger but  
 175 delayed rewards (LDR). The dependent variable is the discounting parameter (k) calculated for each  
 176 participant using the formula:  $k = ((LDR - SIR) - 1) / \text{delay}$  (log-transformed to reduce skewness). Large  
 177 k values indicate high temporal impulsivity.

178 Probability Discounting task (PD) (Madden *et al.*, 2009) is a measure of risk-taking. It consists of a  
 179 list of 30 choices between smaller certain rewards and uncertain larger gains. The dependent variable  
 180 is h parameter, which reflects a degree of probability discounting at the indifference between two  
 181 outcomes (a point at which the certain and probabilistic rewards are of equivalent subjective value).  
 182 The h-parameter was calculated for each participant using the formula:  $h =$   
 183  $(\text{ProbabilisticReward} / \text{CertainReward} - 1) / \text{OddsAgainstWinning}$  (ln-transformed to reduce skewness).  
 184 Large h values indicate discounting of probabilistic rewards (risk aversion).

## 185 2.4 Data analysis

186 Data analysis was conducted using Statistical Package for Social Sciences (SPSS) version 22. First,  
 187 principal component analysis (PCA) with pairwise deletion was conducted to reduce the number of  
 188 variables for further analysis. PCA was carried out with Varimax rotation with Kaiser Normalization.  
 189 Next, exploratory correlations between identified components were computed to better characterize  
 190 their mutual relationship. Finally, multiple regression models were constructed to investigate which  
 191 components best predict each subtype of impulsive behavior.

## 192 3 Results

### 193 3.1 Participants

194 603 individuals completed the online questionnaire (132 males; age 18-74  $24.39 \pm 9.26$ ), of whom  
 195 183 were 1st or 2nd-year psychology students who took part in the study in exchange for course  
 196 credits. Due to such variability in age and a small fraction of older volunteers, we decided to focus on  
 197 a subset of younger participants ( $\leq 45$  years old). Therefore, the final sample size was constrained to  
 198 574 (121 males; age 18-45,  $22.83 \pm 6.06$ ). 474 participants were non-smokers.

### 199 3.2 Exclusions

200 The following exclusion criteria were employed: for the MCQ and PD, participants with low  
 201 response consistency ( $<75\%$ ) were excluded from the analysis (23 and 6 excluded, respectively), as  
 202 low consistency makes it difficult to establish the discounting parameters reliably. Due to the specific  
 203 character of the study and limited control over circumstances participants were completing the tasks,  
 204 for the MFFT, for which response time is important for calculating the dependent variable IS, we  
 205 excluded participants whose reaction times were outside the range observed in the previous study  
 206 performed in our lab with a large sample size ( $N = 160$ ) (Caswell *et al.*, 2015) (46 excluded).

### 207 3.3 Principle Component Analysis

208 Eighteen variables were included in the PCA: mean k value (log10-transformed to correct issue of  
 209 non-normality), mean h value (ln-transformed), MFFT IS, NU, PU, LPrem, LPe, SS, BIS, BAS Fun,  
 210 BAS Reward, BAS Drive, BPQ, Depression, Anxiety, Stress, PA, NA.

211 The total sample size of 574 participants for the 18 items exceeds the suggested minimum ration of 5  
 212 participants per item (Gorsuch, 1983). Chi-square was used to evaluate the fit between the model and  
 213 the data. Components with eigenvalues >1 were retained, yielding six components, with the total of  
 214 67% of variance explained, which seemed to fit the data well. The Kaiser-Meyer-Olkin measure of  
 215 sampling adequacy was .757, above the commonly recommended value of .6, and Bartlett's Test of  
 216 Sphericity was significant ( $\chi^2(153) = 3107.60, p < .001$ ), indicating that the null hypothesis that the  
 217 correlation matrix is an identity matrix can be rejected. Finally, the communalities were all above .4,  
 218 further confirming that each item shared some common variance with other items. Three items (PA  
 219 BAS reward, and BPQ) cross-loaded on two factors above .4. Overall, PCA was deemed to be  
 220 suitable for all 18 items. For details see Table 1.

221 The first component represented items related to the negative emotional state including Depression,  
 222 Anxiety, Stress and NA. Component 2 included items related to how behaviors are motivated by the  
 223 pursuit of rewards and excitement as well as positive feelings (namely all three BAS subscales, SS  
 224 and PA). Component 3 contained items related to trait impulsivity (PU, NU, LPe, LPrem; all  
 225 subscales of UPPS-P impulsivity scale but SS), and PA. Component 4 included punishment  
 226 avoidance trait (BIS) and BAS reward, and factor 5 contained discounting parameters (k and h) and  
 227 BPQ. Finally, factor 6 contained BPQ and MFFT IS.

228 Removal of PA and SS from component 2, resulted in more reliable BAS factor ( $\alpha = .721$ ), therefore,  
 229 for the further analysis, we chose to use BAS separately from SS and PA. Likewise, deletion of PA  
 230 from component 3 resulted in higher reliability score ( $\alpha = .751$ ); therefore, the new Impulsive  
 231 Personality Trait (IPT) component was computed. The components 4, 5 and 6, had low-reliability  
 232 scores; thus, these items were kept separately.

233 The complete list of variables used in subsequent analyses together with descriptive statistics is  
 234 presented in Table 2.

### 235 **3.4 Correlations**

236 The correlational analysis was conducted to explore further and better characterize the relationship  
 237 between items identified via PCA. Since impulsivity-related traits decrease with age (Steinberg *et al.*,  
 238 2008) and our sample had a large age-range (18-45), correlations between all the variables and age  
 239 were computed. PD h parameter was positively correlated with age, indicating increased discounting  
 240 of probabilistic rewards with age (risk-avoidance),  $r(566) = .118, p = .005$ . Similarly, SS was  
 241 negatively correlated with age,  $r(572) = -.142, p = .001$ , indicate a decrease in SS with age. MFFT IS  
 242 score slightly decreased with age, also indicating a decrease in reflection impulsivity with age,  $r(531)$   
 243  $= -.09, p = .032$ . IPT was also negatively correlated with age,  $r(572) = -.113, p = .007$ , suggesting a  
 244 decrease in trait impulsivity with age. Lastly, positive affect was positively correlated with age,  
 245  $r(572) = .119, p = .004$ .

246 We also wanted to account for possible sex differences in the identified components. Significant  
 247 differences were found in SS, BIS scores, and temporal impulsivity (table 2); namely, females  
 248 reported higher punishment avoidance (higher BIS score), but lower SS, than males. Females also  
 249 discounted delayed rewards less steeply than males (i.e. showed lower temporal impulsivity).

250 Therefore, partial correlations were computed between all variables used in the further analysis  
 251 controlling for age and gender (see Table 3 for details). Bonferroni correction for multiple  
 252 comparisons was set at  $p \leq .001$ .

### 253 3.4.1 Mood and impulsivity

254 IPT, as well as BIS, were significantly correlated with PA and the Negative Emotional state  
 255 indicating that individuals higher on self-reported impulsivity and punishment aversion also reported  
 256 lower levels of positive affect and higher levels of negative mood state. The reverse was true for SS –  
 257 increased sensation seeking, which was related to higher positive affect and lower negative emotions.  
 258 Similarly, BAS was positively correlated with PA, suggesting that individuals high in reward  
 259 sensitivity experience more positive affect. Temporal discounting and MFFT IS were correlated with  
 260 the Negative Emotional state indicating that increased negative state was related to an increased  
 261 temporal and reflection impulsivity. However, these correlations did not survive Bonferroni  
 262 correction for multiple comparisons.

### 263 3.4.2 The relationship between behavioral and trait measures:

264 MCQ and MFFT only correlated with IPT, indicating increased temporal and reflection impulsivity  
 265 in high-trait impulsivity individuals. PD, on the other hand, correlated with SS and BAS, suggesting  
 266 that high SS (did not survive the Bonferroni correction) and BAS was related with impulsive  
 267 decisions in the PD task (choosing the riskier option).

### 268 3.4.3 The relationship between personality traits:

269 SS was negatively associated with BIS, indicating that individuals who were high in sensation  
 270 seeking report low punishment avoidance. Instead, SS, BAS and impulsive personality were all  
 271 positively inter-correlated.

### 272 3.4.4 Interoceptive sensibility and impulsivity:

273 BPQ was positively correlated with Negative Emotions component indicating that self-reported  
 274 bodily awareness is related to increased negative mood. Moreover, BPQ was also weakly positively  
 275 correlated with MCQ, meaning that individuals high on impulsive personality also reported high self-  
 276 perceived bodily awareness, however, this correlation did not survive Bonferroni correction.

## 277 3.5 Regressions

278 Multiple linear regressions were conducted with performance on the three behavioral tasks as  
 279 dependent variables. Sex, mean centered age and items identified with the factor analysis served as  
 280 independent variables.

281 ANOVA indicated that all three regression models provided a good fit for the data (MCQ log k:  $F(9,$   
 282  $541) = 5.10, p < .001$ ; PD ln h:  $F(9, 558) = 2.91, p = .002$ ; MFFT IS:  $F(9, 523) = 2.41, p = .011$ ).  
 283 Tests to see if the data met the assumption of collinearity indicated that multicollinearity was not a  
 284 concern (for all the dependent variables: Tolerance  $> .06, 1 < VIF < 1.7$ ).

285 It was found that trait impulsivity and sex were both significant predictors of the MCQ k parameter.  
 286 Increased delay discounting (higher temporal impulsivity) was predicted by male sex and higher  
 287 impulsive personality trait. None of the measures of mood were predictors; however, BPQ  
 288 approached significance. Age and BAS were significant predictors of h parameter, indicating that  
 289 younger age and higher reward sensitivity were predictive of more risky behavior on the probability



290 discounting task. Trait impulsivity turned out to be the only significant predictor of the MFFT IS,  
 291 suggesting that high trait of impulsive personality is predictive of reflection impulsivity. Details are  
 292 presented in Table 4.

#### 293 4 Discussion

294 The current study investigated the role of personality traits (impulsive tendencies, reward sensitivity,  
 295 punishment avoidance, and interoceptive sensibility) and emotional states as potential modulators of  
 296 distinct subtypes of impulsive and risky behaviours. In accordance with our hypotheses, we first  
 297 confirmed that trait impulsivity (IPT; positive and negative urgency and lack of premeditation and  
 298 perseverance components of the UPPS-P scale) predicted temporal and reflection impulsivity.  
 299 Moreover, reward sensitivity (BAS) best predicted risk-taking in a probability discounting task.  
 300 However, contrary to our initial predictions, affective state did not predict any behavioural  
 301 dimensions and no link was found between subjective interoception (interoceptive sensibility) and  
 302 risk-taking.  
 303

304 We hypothesised that negative emotional state would relate to decreased self-control and therefore  
 305 more impulsive behaviour. Although mood state was not a predictor of any of the behavioural tasks,  
 306 we found correlational evidence providing tentative support for our hypothesis. Specifically, negative  
 307 emotional state was related to both more short-sighted monetary decisions (increased temporal  
 308 impulsivity) and more rushed decisions in the MFFT (increased reflection impulsivity). Although  
 309 these relationships were weak, they nevertheless added to evidence from earlier studies which have  
 310 suggested that the experience of emotional distress, drives people to treat themselves to immediate  
 311 pleasures, such as indulgent foods over healthy options, as a means of regulating one's mood (Moore  
 312 *et al.*, 1976; Tice *et al.*, 2001; Lerner *et al.*, 2013; Gardner *et al.*, 2014). Experience of emotional  
 313 distress is also considered a major trigger in substance use relapse. For example, stressful events  
 314 increase the urge to drink alcohol and chances of relapse in treated alcoholics (Sinha *et al.*, 2009;  
 315 Sinha, 2012). Increasingly, research also suggests that people drink alcohol to enhance positive or  
 316 manage negative emotional state, and reduce tension (Conger, 1956; Cooper *et al.*, 1995; Zack *et al.*,  
 317 2002). Together, these findings support the importance of emotional state in impulsive choice and  
 318 suggest that negative emotions bias behaviour toward rushed and more near-sighted decisions, which  
 319 can further lead to detrimental consequences both regarding finance (e.g. self-indulgence to improve  
 320 one's mood instead of saving) and health (obesity, the risk of cardiovascular disorders, substance  
 321 misuse).  
 322

323 A relationship was also observed between emotional state and trait measures: High levels of positive  
 324 affect were associated with high levels of sensation seeking and reward impulsivity (SS and BAS)  
 325 and low levels of both BIS and impulsive traits (IPT). The reverse was true for high levels of  
 326 negative emotions. The fact that self-reported trait measures were related to state mood-measures  
 327 merits comment since they are usually considered to be stable personality traits, unaffected by  
 328 changes in mood (Weafer *et al.*, 2013). The positive association between self-reported impulsivity  
 329 and negative emotions corroborates with findings from clinical populations indicating increased  
 330 impulsive tendencies in depressed individuals (Peluso *et al.*, 2007; Tomko *et al.*, 2015). Moreover,  
 331 similarly to previous research (Sperry *et al.*, 2016), higher sensation seeking (SS) ratings were  
 332 associated with higher positive affect.

333 However, since these are correlational measures, causality cannot be assumed. Nevertheless, it is  
 334 plausible that while experiencing negative emotions, individuals may recall events when they  
 335 behaved impulsively (memory bias) and be primed to behave the same way. Alternatively, engaging

336 in impulsive actions may serve as a way of regulating one's mood (Tice *et al.*, 2001). Thus it seems  
337 that emotional state is a consideration when assessing trait impulsivity.  
338

339 It is noteworthy that the impulsive personality trait (IPT; as identified here) was related to negative  
340 emotions, whereas levels of sensation seeking (SS) were associated with positive affect. This  
341 dissociation between impulsive and risk-taking traits was further supported by component loadings  
342 within the principal component analysis, which separated SS from the remaining UPPS-P subscales.  
343 Indeed, although sensation seeking is encompassed within some constructs of impulsivity  
344 (Zuckerman, 1984; Whiteside & Lynam, 2001), other research suggests a differentiation between  
345 these two concepts (Magid *et al.*, 2007). Our findings also show that sensation seeking is distinct  
346 from trait impulsivity.

347  
348 Delay discounting and reflection impulsivity were both predicted by the self-reported impulsivity  
349 (IPT), while risk-taking (probability discounting) was explained solely by BAS. Indeed, although  
350 early research suggests that delay and probability discounting are both facets of impulsive choice,  
351 sharing underlying processes (e.g. Mazur, 1993; Rachlin, 1990; Richards *et al.*, 1999), more recent  
352 work argues that these two concepts are distinct from each other (Holt *et al.*, 2003; Madden *et al.*,  
353 2009; Shead & Hodgins, 2009). Our findings agree with the latter, suggesting that delay and  
354 probability discounting reflect distinct aspects of decision-making, indexing delayed gratification and  
355 risk-taking/reward sensitivity respectively.

356  
357 In agreement with an earlier report (Silverman, 2003), we observed that males showed significantly  
358 more delay discounting than females. The reason why gender may play such a role, what the  
359 mechanisms and potential consequences are, should be a subject of the future research.

360  
361 Impulsive personality traits, which include facets of emotional impulsivity, predicted performance on  
362 the delay discounting task, supporting our hypothesis. It is worth noting that in both delay and  
363 probability discounting, our models explained only a small fraction of the variance, which suggests  
364 that other factors are contributing to discounting which are yet to be identified.

365  
366 The MFFT task has been widely used to study reflection impulsivity in children and other target  
367 populations (Kagan, 1965; Verdejo-García *et al.*, 2008; Carretero-Dios *et al.*, 2009). However, it has  
368 been heavily criticised as a measure of behavioural impulsivity (e.g. Block *et al.*, 1974) and  
369 suggested to be more related to cognitive performance more generally rather than behavioural  
370 impulsivity (Block *et al.*, 1986; Perales *et al.*, 2009). Our results indicate that impulsive personality  
371 trait is the best predictor of performance on the MFFT task, also supporting the classification of  
372 MFFT performance as a measure of reflection impulsivity (Caswell *et al.*, 2015).

373  
374 In contrast to our expectations, no relationship was found between subjective interoceptive sensibility  
375 (BPQ) and probability discounting. This is distinct from previous research which reported the  
376 relationship between risk-taking or disadvantageous decision-making and individual differences in  
377 interoception (Werner *et al.*, 2009; Kandasamy *et al.*, 2016). These discrepancies may be due to  
378 methodological aspects of the measures employed. In the current study, we used a probability  
379 discounting task, which is an explicit measure of risk-taking. Using a more implicit measure of risk-  
380 taking, e.g. a gambling task, alongside a dimensional approach to quantifying (subjective objective  
381 and metacognitive) interoceptive abilities (Garfinkel *et al.*, 2015) could provide much finer grained  
382 insight into how interoception relates to impulsivity, extending previous findings. Instead, we found a  
383 trend for bodily awareness to predict temporal discounting, indicating that heightened subjective  
384 sensitivity to bodily sensations (i.e. higher interoceptive sensibility, often characteristic of more

385 anxious individuals) may result in increased temporal impulsivity. Similarly, the observed  
386 relationship between BPQ and negative emotions is also consistent with the association between  
387 interoception and anxiety (e.g. Pollatos *et al.*, 2009; Dunn *et al.*, 2010; Stevens *et al.*, 2011; Garfinkel  
388 *et al.*, 2015).

#### 389 **4.1 Limitations**

390 Some study limitations merit comment. Firstly, this study relied on survey data obtained via an  
391 online questionnaire. There was consequently little experimental control over the circumstances in  
392 which participants completed the study, which should be taken into account. Future research may  
393 benefit from more controlled environments, e.g. as a typical lab-based study, to validate these  
394 findings. Secondly, despite recruiting participants online, our sample consisted mainly of female  
395 participants and a very small proportion of older adults. In the future, a more gender-balanced sample  
396 also including elderly should be studied to confirm these findings.

#### 397 **4.2 Conclusions**

398 Our results indicate that impulsive personality traits predict temporal and reflection impulsivity,  
399 while reward sensitivity predicts risk-taking behaviour (probability discounting). This separation  
400 between measures of impulsivity and risk-taking suggests that the two concepts are distinct. The  
401 dissociation between measures of impulsivity and risk-taking was further highlighted by their  
402 relationship to the current emotional state: While increased negative emotions were predictably  
403 associated with increased impulsivity, increased positive affect was associated with increased  
404 measures of risk-taking. This interesting finding has important consequences for research since it  
405 suggests that the same person may show different levels of trait impulsivity in a positive (less  
406 impulsive) than a negative (more impulsive) mood state. Thus, future research into trait impulsivity  
407 should attend to concurrent mood states of participants. Marginal findings of the present study also  
408 motivate areas of further research: The fact that negative emotions were related to increased temporal  
409 impulsivity may indicate at least partly why people in a positive mood are likely to make  
410 commitments, such as keeping to a diet or exercising regularly – that is when they can oversee long-  
411 term goals over immediate ones. Consequently, in a negative emotional state, perception shifts  
412 towards immediate gratification (e.g. comfort food, watching television series instead of going to the  
413 gym). Moreover, our findings with the BPQ link subjective body awareness to temporal impulsivity  
414 suggesting the need for in-depth understanding of the relationship between interoceptive ability and  
415 decision-making.

#### 416 **5 Conflict of Interests**

417 The authors declare that the research was conducted in the absence of any commercial or financial  
418 relationships that could be construed as a potential conflict of interest.

#### 419 **6 Author Contributions**

420 AH collected and analyzed data and wrote the initial manuscript. AH and TD interpreted the results.  
421 TD provided a guidance throughout. All authors contributed to the experimental design and the final  
422 version of the manuscript.

#### 423 **7 Funding**

424 The study was funded Sussex Neuroscience (PhD scholarship awarded to AH).

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603

604 **9 Data Availability Statement**

605 The data that support the findings of this study are available from the corresponding author upon  
606 reasonable request.

607

608 **10 Tables**609 **Table 1 Component loadings and reliability scores for components identified with the PCA.**

	RC 1	RC 2	RC 3	RC 4	RC 5	RC 6
Anxiety	<b>.850</b>	-.033	.065	.057	.119	-.069
BAS Drive	.095	<b>.766</b>	-.044	-.037	-.057	.079
BAS Fun	-.039	<b>.810</b>	.294	-.009	.029	-.002
BAS Reward	-.067	<b>.671</b>	-.240	<b>.486</b>	.031	.008
BIS	.165	-.128	-.051	<b>.868</b>	-.027	.006
BPQ	.201	.099	-.122	.137	<b>.569</b>	<b>-.495</b>
Depression	<b>.804</b>	-.095	.198	.082	-.086	.034
MCQ log k	.056	.094	.170	-.055	<b>.614</b>	.049
MFFT IS	.085	.069	.053	.050	.173	<b>.859</b>
NA	<b>.804</b>	.069	.020	-.084	.034	.054
Negative Urgency	.362	.324	<b>.589</b>	.321	.110	.072
Positive Affect	.092	<b>.449</b>	<b>-.499</b>	-.357	.173	.064
LPer	.139	-.219	<b>.776</b>	-.028	.028	.010
Positive Urgency	.282	.397	<b>.624</b>	-.085	.109	.033
LPrem	.016	.184	<b>.773</b>	-.187	.037	.080
PD In h	-.084	-.249	-.046	-.007	<b>.566</b>	.177
SS	-.126	<b>.672</b>	.136	-.355	-.091	-.086
Stress	<b>.864</b>	.037	.103	.173	.015	.011
Cronbach's Alpha	.864	.545	.665	.337	.142	.096
Variance Explained [%]	17.30	15.60	13.65	8.13	6.35	5.87

610 **Table 2 Final variables identified based on PCA, descriptive statistics and gender scores**  
 611 **comparisons.**

	All			Female			Male			Levene's Test		t-test		
	N	M	SD	N	M	SD	N	M	SD	F	p	t	df	p
BPQ	574	2.91	0.93	453	2.92	0.91	121	2.89	1.00	3.90	.049	0.30	177.44	.761
SS	574	31.99	7.42	453	31.44	7.46	121	34.07	6.94	1.44	.231	3.50	572	< .001
BIS	574	22.27	3.75	453	22.83	3.55	121	20.20	3.75	0.31	.578	7.14	572	< .001
BAS	574	38.58	5.66	453	38.56	5.78	121	38.68	5.19	4.03	.045	0.22	206.60	.827
PA	574	26.67	9.00	453	26.30	8.87	121	28.06	9.36	0.68	.409	1.91	572	.056
Negative Emotions	574	17.36	7.59	453	17.36	7.59	121	17.36	7.59	0.65	.420	1.09	572	.278
MCQ log k	551	-2.05	0.76	432	-2.11	0.74	119	-1.80	0.77	0.79	.374	4.00	549	< .001
PD ln h	568	0.69	0.99	448	0.71	0.98	120	0.60	1.01	0.00	.966	1.13	566	.260
MFFT IS	533	-0.02	1.36	419	0.01	1.34	114	-0.15	1.43	0.15	.697	1.15	531	.251
IPT	574	99.72	20.53	453	99.23	20.91	121	101.59	19.04	0.78	.377	1.12	572	.262

612

613

614 **Table 3 Pearson partial correlations, controlling for age and gender, between identified**  
615 **variables.**

		SS	BIS	BAS	Positive Affect	Neg Emotions	IPT	MCQ log k	PD ln h	MFFT IS
BPQ	<i>r</i>	-0.007	0.055	0.07	0.058	<b>0.179</b> ***	0.013	0.094 *	0.047	-0.05
	<i>p</i>	.877	.193	.094	.168	< .001	.75	.027	.26	.251
	<i>df</i>	570	570	570	570	570	570	547	564	529
SS	<i>r</i>		<b>-0.302</b> ***	<b>0.494</b> ***	<b>0.252</b> ***	-0.119 **	<b>0.167</b> ***	-0.007	-0.109 **	-0.012
	<i>p</i>		< .001	< .001	< .001	.004	< .001	.865	.009	.781
	<i>df</i>		570	570	570	570	570	547	564	529
BIS	<i>r</i>			-0.028	<b>-0.191</b> ***	<b>0.209</b> ***	-0.003	0.022	0.008	-0.02
	<i>p</i>			.506	< .001	< .001	.952	.614	.856	.638
	<i>df</i>			570	570	570	570	547	564	529
BAS	<i>r</i>				<b>0.303</b> ***	0.018	<b>0.23</b> ***	0.079	<b>-0.136</b> ***	0.06
	<i>p</i>				< .001	.669	< .001	.064	.001	.169
	<i>df</i>				570	570	570	547	564	529
Positive Affect	<i>r</i>					-0.03	<b>-0.166</b> ***	0.035	-0.018	0.009
	<i>p</i>					.479	< .001	.411	.663	.84
	<i>df</i>					570	570	547	564	529
Neg Emotions	<i>r</i>						<b>0.359</b> ***	0.104 *	-0.027	0.086 *
	<i>p</i>						< .001	.015	.525	.047
	<i>df</i>						570	547	564	529
IPT	<i>r</i>							<b>0.183</b> ***	-0.035	0.134 **
	<i>p</i>							< .001	.401	.002
	<i>df</i>							547	564	529
MCQ log k	<i>r</i>								0.005	0.091 *
	<i>p</i>								.916	.041
	<i>df</i>								545	508
PD ln h	<i>r</i>									0.045
	<i>p</i>									.307
	<i>df</i>									524

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p \leq .001$ , **in bold** are presented correlations that survived the correction for multiple comparison ( $p \leq .001$ ). BPQ – Body perception questionnaire score, SS – Sensation Seeking, BIS – Behavioral Inhibition Scale score, BAS – Behavioral Approach Scale score, Neg Emotions – Negative Emotional State (DASS and NA), IPT – Impulsive Personality Trait, MCQ log k – Monetary Choice Questionnaire log transformed k parameter, PD ln h – Probability Discounting ln transformed parameter h, MFFT IS – Matching Familiar Figures Task Impulsivity Score.

617 **Table 4 Results of the multiple regression.**

Dependent variable	Predictors	B	SE	Beta	t	Sig.	R	R Square
MCQ log k	(Constant)	-2.11	.04		-58.96	< .001	0.279	.078
	IPT	0.01	.00	.19	3.92	< .001		
	Gender	0.30	.08	.17	3.76	< .001		
	BPQ	0.06	.03	.08	1.85	.065		
	Positive Affect	0.01	.00	.07	1.46	.144		
	BAS	0.01	.01	.04	0.84	.402		
	Age	0.00	.01	.03	0.69	.492		
	Neg Emotions	0.00	.00	.01	0.27	.784		
	BIS	0.00	.01	.01	0.17	.869		
SS	-0.01	.01	-.07	-1.38	.167			
PD ln h	(Constant)	0.31	.02		15.37	< .001	0.212	.045
	BAS	-0.01	.00	-.12	-2.39	.017		
	Age	0.01	.00	.10	2.37	.018		
	BPQ	0.03	.02	.06	1.46	.144		
	Gender	-0.06	.05	-.06	-1.35	.179		
	SS	0.00	.00	-.07	-1.31	.190		
	Neg Emotions	0.00	.00	-.05	-1.07	.284		
	Positive Affect	0.00	.00	.03	0.75	.454		
	IPT	0.00	.00	.03	0.58	.565		
	BIS	0.00	.01	.00	-0.07	.944		
MFFT IS	(Constant)	0.01	.07		0.15	.880	0.198	.039
	IPT	0.01	.00	.12	2.37	.018		
	Age	-0.02	.01	-.08	-1.79	.074		
	BPQ	-0.10	.06	-.07	-1.53	.127		
	SS	-0.01	.01	-.08	-1.49	.138		
	BAS	0.02	.01	.06	1.21	.228		
	Neg Emotions	0.00	.00	.05	1.08	.281		
	BIS	-0.02	.02	-.05	-0.94	.348		
	Gender	-0.13	.15	-.04	-0.86	.391		
	Positive Affect	0.00	.01	.03	0.53	.594		

618 BPQ – Body perception questionnaire score, SS – Sensation Seeking, BIS – Behavioral Inhibition Scale score, BAS – Behavioral  
 619 Approach Scale score, Neg Emotions – Negative Emotional State (DASS and NA), IPT – Impulsive Personality Trait, MCQ log k –  
 620 Monetary Choice Questionnaire log transformed k parameter, PD ln h – Probability Discounting ln transformed parameter h, MFFT IS  
 621 – Matching Familiar Figures Task Impulsivity Score.