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1 **Interoceptive accuracy mediates the longitudinal relationship between attention deficit**
2 **hyperactivity disorder (ADHD) inattentive symptoms and disordered eating in a**
3 **community sample**

4
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14 Interoception, Disordered eating, Longitudinal study, Negative mood

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19 **Abstract**

20 Attention deficit hyperactivity disorder (ADHD) symptoms are associated with disordered
21 eating and interoceptive deficits (as assessed by reliance on hunger/satiety cues) have been
22 suggested as a potential mediating influence. The aim of this longitudinal study was to
23 examine whether the association between ADHD symptoms and disordered eating is
24 explained by deficits in specific facets of interoception. We also aimed to provide further
25 evidence on the previously reported association between ADHD symptoms, negative mood
26 and disordered eating. A community-based sample of 345 adult men and women (M age =
27 33.9, 72.5% women) completed questionnaires assessing disordered eating (restrictive and
28 binge-type), ADHD symptoms, reliance on hunger/ satiety cues, specific facets of
29 interoception (interoceptive accuracy and interoceptive sensibility) and negative mood at two
30 timepoints over a 6-month period. We tested the mediating influence of reliance on
31 hunger/satiety cues, facets of interoception and negative mood on the relationship between
32 ADHD symptoms and disordered eating. Reliance on hunger/satiety cues mediated the
33 relationship between inattentive symptoms of ADHD and both restrictive and binge-type
34 eating. Interoceptive accuracy, but not sensibility mediated the relationship between
35 inattentive ADHD symptoms and binge-type eating. Negative mood mediated the
36 relationship between both ADHD symptom types and restrictive and binge-type eating. The
37 results from this longitudinal study confirm that deficits in interoception and negative mood
38 contribute to the relationship between ADHD symptoms and disordered eating and extend
39 knowledge by highlighting interoceptive accuracy specifically as the most important facet of
40 interoception in the relationship between inattentive symptoms and binge-type eating.

41 1. Introduction

42 Symptoms of Attention Deficit Hyperactivity Disorder (ADHD) are consistently
43 associated with an increased risk of disordered eating, particularly binge and disinhibited
44 eating (Kaisari et al., 2017). This relationship may suggest that the cognitive symptoms
45 which are central to ADHD (e.g. inattention and impulsivity) foster disordered eating
46 behaviour. To date, it is unclear how exactly ADHD symptoms may contribute towards
47 disordered eating, as few studies have investigated the contribution of specific symptoms of
48 ADHD to disordered eating, or explored potential mediators of this relationship.

49 One potential mediator is negative mood/emotional dysregulation. Symptoms of
50 depression and anxiety are elevated in both ADHD (Kessler et al., 2006) and disordered
51 eating (Santos, Richards & Bleckley, 2007; Puccio et al., 2017), and disordered eating may
52 be used as a coping strategy to deal with negative affect (El Archi et al. 2020). In support of
53 this suggestion, Kaisari and colleagues (2018) analysed self-report data on ADHD symptoms,
54 disordered eating and several related variables from two large non-clinical independent
55 samples and found that negative mood mediated the relationship between both inattentive and
56 impulsive symptoms of ADHD and disordered eating (both binge-type and restrictive eating).
57 Similarly in another cross-sectional study of bariatric surgery patients, probable ADHD
58 diagnosis was associated with significant binge eating and this relationship was mediated by
59 problems with emotional regulation (El Archi et al. 2021). Negative mood has also been
60 found to mediate the relationship between ADHD symptoms and disordered eating
61 longitudinally in a large cohort of young adults (Martin et al., 2020).

62 Another potential mediator is interoceptive ability. Kaisari et al. (2018) found that a
63 reduced reliance on hunger and satiety cues to guide eating (as measured by the intuitive
64 eating scale) specifically mediated the relationship between inattentive symptoms of ADHD
65 and disordered eating. Reliance on hunger and satiety cues may reflect the interpretation and

66 use of gastric interoceptive information to guide eating, which is altered in individuals with
67 eating disorders and with disordered eating (e.g. Van Dyck et al., 2016; Nyman-Carlsson et
68 al., 2015; Pollatos et al., 2008, Martin et al., 2019). The results of Kaisari et al. (2018)
69 suggest that trait inattention may negatively impact interoceptive processing, which in turn
70 could contribute towards disordered eating. However, longitudinal evidence is lacking. In
71 addition, recent research has identified different facets of interoception: interoceptive
72 attention (herein referred to as interoceptive sensibility: the trait tendency to attend to
73 interoceptive signals) and interoceptive accuracy (how accurately one detects internal state)
74 (Murphy et al. 2019; Garfinkel et al., 2015). Using measures to specifically target different
75 facets of interoception may enable determination of whether any interoceptive deficits
76 associated with ADHD occur specifically in one facet (e.g. sensibility *or* accuracy), or in both
77 facets. Initial evidence for dissociable effects of different facets of interoception on eating
78 behaviours is mixed. For example, Young et al. (2017) found that external eating (eating in
79 response to the sight and smell of food) was associated with lower interoceptive accuracy,
80 and emotional eating tendencies were associated with higher interoceptive accuracy. In
81 contrast, it has been suggested that emotional eating is associated with poorer interoceptive
82 accuracy, but is unrelated to interoceptive sensibility (Robinson et al., 2021). It is therefore
83 unclear how specific facets of interoception may contribute to disordered eating. Similarly,
84 the potential influence of inattention on different facets of interoception and how this may
85 contribute towards disordered eating has yet to be assessed.

86 The current study aimed to address the gaps in the literature regarding the potential
87 mediating mechanisms between inattention and impulsivity/hyperactivity symptoms of
88 ADHD and disordered eating (binge-type and restrictive eating). The longitudinal
89 relationship between self-reported ADHD symptoms and disordered eating over six months
90 was assessed using mediation models testing the mediating influence of negative mood,

91 reliance on hunger and satiety cues, interoceptive accuracy and interoceptive sensibility. We
92 hypothesised that ADHD symptoms would predict binge-type and restrictive eating at 6-
93 month follow-up. Further, we hypothesised that the data would confirm previous evidence of
94 a mediating influence of negative mood on the relationship between ADHD symptoms and
95 both types of disordered eating and a mediating influence of reliance on cues of hunger and
96 satiety between ADHD inattentive symptoms and binge-type and restrictive eating. We also
97 predicted that the mediating influence of cues of hunger and satiety could be explained by
98 one or more facet of interoception: self-reported interoceptive accuracy as measured by the
99 Interoceptive Accuracy Scale, Murphy et al., 2020) and/or interoceptive sensibility, as
100 measured by the Body Perception Questionnaire (Porges, 1993).

101 **2. Methods**

102 **2.1 Participants**

103 504 participants were recruited at baseline using Prolific (<https://prolific.co/>). To
104 detect a mediated effect (power = 0.8), a sample size of between 398 and 412 was required,
105 assuming a small effect on the predictor-to-mediator pathway (Fritz & MacKinnon, 2007), as
106 was apparent in previous similar research (Kaisari et al., 2018). To account for potential data
107 loss due to incomplete responding, poor quality data, and participant attrition, we aimed to
108 recruit 500 participants at baseline. Inclusion criteria were: a minimum age of 18 years and a
109 maximum age of 60 years, and English as a first language.

110 **2.2 Procedure**

111 Two data collection rounds took place in November 2020 and May 2021. In the study
112 consent form completed at baseline, participants agreed to be re-contacted through Prolific 6
113 months after initial participation. The study was advertised under the title ‘Cognitive Factors
114 Influencing Eating Behaviours’ to conceal details of the study aims. Questionnaires were
115 presented in the order in which they are described below and took around 30 minutes to

116 complete. Three attention check questions were inserted between true questionnaire items to
117 assess if participants were reading questions, to ensure data quality. Attention check
118 questions asked participants to select a specific response, for example ‘Please Select ‘Never’
119 for this question’. Ethical approval was granted by the University of Birmingham Ethical
120 Review Committee (reference number ERN_19-1237).

121 **2.3 Measures**

122 Demographic information including age, sex and ethnicity were recorded to characterise the
123 sample. Height and weight were self-reported by participants to calculate body mass index
124 (BMI, kg/m²).

125 **2.4 Measurement of interoception**

126 2.4.1 The Intuitive eating scale (IES)

127 The IES (Tylka, 2006) comprises 23 items measuring trait tendency to use cues of hunger and
128 satiety to guide eating, scored on a 5-point scale ranging from Strongly disagree to Strongly
129 agree. There are four subscales: Unconditional permission to eat; Eating for physical rather
130 than emotional reasons; Reliance on hunger and satiety cues; body-food choice congruence
131 scale. The ‘reliance on internal cues of hunger/satiety’ subscale of the IES has good
132 reliability and validity (e.g. Tylka and Kroon Van Diest, 2013; Duarte, Gouveia & Mendes,
133 2016) and previously been found to mediate the relationship between ADHD and disordered
134 eating behaviour (Kaisari et al., 2018).

135 2.4.2 The interoceptive accuracy scale (IAS)

136 The IAS (Murphy et al., 2020) is a 21-item questionnaire measuring self-reported
137 interoceptive accuracy across a range of interoceptive domains including hunger, thirst,
138 heartbeat and itch. Items consist of the stem questions ‘I can always accurately perceive
139 when’, followed by a bodily sensation e.g. hunger, breathing rate. Items are scored on a 5-

140 point scale ranging from 1 = Disagree Strongly to 5 = Strongly Agree. The IAS shows good
141 reliability and validity (Murphy et al., 2020). Self-reported interoceptive accuracy as
142 measured by the IAS has been shown to correlate with objective measurement (heartbeat
143 counting) of interoceptive accuracy (Murphy et al., 2020).

144 2.4.3 Body Perception Questionnaire – Very Short Form (BPQ-VSF)

145 The BPQ-VSF (Porges, 1993) is a 12-item questionnaire used to measure body awareness,
146 thought to reflect interoceptive sensibility as opposed to interoceptive accuracy. Respondents
147 are asked ‘During most situations I am aware of:’ followed by 12 bodily sensations e.g.
148 bloating and heartbeat. Items are scored on a 5-point scale ranging from 1 = Never to 5 =
149 Always. It has been shown to have good validity and reliability (Cabrera, et al. 2018).

150 **2.5 Measurement of ADHD symptoms**

151 The Conners’ Adult ADHD Rating Scale: Short Version (CAARS:SV) (Conners, Erdhart &
152 Sparrow, 1999) was used to measure ADHD symptoms. The CAARS:SV comprises 30
153 items, which can be used to score participants on a continuous measurement of ADHD
154 symptoms (inattention, impulsive/hyperactive, and combined). It can also be used to
155 determine a possible diagnosis of ADHD, based on age and sex of the respondent.
156 Standardised scores (T-scores) > 60 indicate elevated levels of any symptom subscale and
157 indicate an at-risk ADHD index score. Responses are scored on a 4-point scale ranging from
158 Not at all/Never to Very much/Very frequently. The CAARS-S:SV shows good validity and
159 reliability (Sadeghi-Bazargani, Amiri, Hamraz, Malek, Abdi & Shahrokhi, 2014).

160 **2.6 Measurement of Disordered Eating**

161 2.6.1 The Eating Attitudes Test (EAT-26)

162 The EAT-26 (Garner et al., 1982) is a 26-item questionnaire consisting of three subscales:
163 dieting, bulimia and oral control. Items are scored on a 6-point scale ranging from Always to

164 Never. Acceptable to good reliability has been reported for the EAT-26 (Ocker, Lam, Jensen
165 & Zhang, 2007; Siervo, Boschi, Papa, Bellini & Falconi, 2005).

166 2.6.2 The Binge Eating Scale (BES)

167 The BES (Gormally et al., 1982) consists of 16 questions relating to frequency and severity
168 of binge eating behaviours. Each question includes 3 - 4 statements on behaviours and
169 thoughts associated with binge eating, increasing in severity. Participants are asked to select
170 the statement that best describes themselves. Each response is assigned a numerical value
171 from 0 (least severe) to 4 (most severe). Good reliability and validity have been reported for
172 the BES (Duarte, Pinto-Gouveia & Ferreira, 2015).

173 2.6.3 The SCOFF questionnaire

174 The SCOFF (Morgan, Reid & Lacey, 1999) is a screening tool for detecting eating disorders.
175 It comprises 5 yes/no questions asking whether in the past year the participant 1) has lost
176 more than one stone in 3 months (1 stone = 6.3 kg) (weight loss); 2) had made him/herself be
177 sick because he/she felt uncomfortably full (self-sick for feeling full); 3) worried that he/she
178 had lost control over how much he/she eats (uncontrolled eating); 4) believed him/herself to
179 be fat when others said that he/she was too thin (self-perceived fatness); and 5) thought that
180 food dominated his/her life (food dominance). Endorsement of ≥ 2 items suggests a possible
181 eating disorder. Good reliability and validity have been reported for the SCOFF (Garcia,
182 Grigioni, Allais, Houy-Durand, Thubaut, Déchelotte, 2011; Kutz, Marsh, Gunderson,
183 Maguen & Masheb, 2020).

184 2.6.4 The Dutch Eating Behaviour Questionnaire (DEBQ)

185 The DEBQ (Van Strien, Frijters, Bergers, & Defares, 1986) consists of 33-items which relate
186 to three dimensions of eating behaviour: restrained, emotional and external eating. Items are

187 scored on a 5-point scale ranging from Never to Very Often. The DEBQ has been reported to
188 have good reliability and validity (e.g. Ohara et al., 2020; Malesza & Kaczmarek, 2021).

189 **2.7 Measurement of Negative Mood**

190 2.7.1 The Hospital Anxiety and Depression Scale (HADS)

191 The HADS (Zigmond & Snaith, 1983) consists of 14 questions relating to anxiety and
192 depression symptoms (7 depression, 7 anxiety). Responses are scored from 0 (least
193 severe/frequent symptoms) - 3 (most severe/frequent symptoms) to give a total score for
194 anxiety and depression ranging from 0 – 21. The HADS has good reliability and validity
195 (Bjelland, Dahl, Haug & Neckelmann, 2002).

196 2.7.2 The Perceived Stress Scale (PSS)

197 The PSS (Cohen et al., 1983) is a 10-item questionnaire to measure how frequently the
198 respondent has experienced feelings of stress in the last month. Items are scored on a 5-point
199 scale ranging from Never to Very Often. The PSS is a reliable and valid measurement of
200 perceived stress (Roberti, Harrington & Storch, 2006).

201 **2.8 Covariate Measures**

202 The Fast Alcohol Screening Test (FAST) (Hodgson, Alwyn, John, Thom, and Smith, 2002)
203 and The Drug Abuse Screening Test (DAST) (Skinner, 1982) were used to measure drug and
204 alcohol use.

205 **2.9 Data processing and Analysis**

206 **2.9.1 Composite Scores**

207 Using scores from the EAT-26, DEBQ and BES, composite scores were calculated for
208 binge/disinhibited eating and restrictive eating, based on factor loadings from Kaisari et al.
209 (2018).

210 **2.9.2 Mediation models**

211 Mediation was analysed using PROCESS for SPSS (Hayes, 2017). Age, sex, BMI,
212 alcohol and drug use were covariates in the mediation models. Three models for both
213 disordered eating type (binge/disinhibited and restrictive) were defined. The first included
214 IES-RHSC as the mediating variable, to test the relationship reported in Kaisari et al. (2018).
215 The second model included both BPQ and IAS scores as mediators to assess specific
216 contributions of interoceptive sensibility and self-reported interoceptive accuracy. The final
217 model included negative mood as the mediating variable. Predictor and mediator variables
218 were from baseline measurement. Two outcome variables for each disordered eating type
219 were tested: change in disordered eating score between baseline and follow-up, and
220 disordered eating score at follow-up only.

221 **2.10. Sensitivity Analysis**

222 Sensitivity analyses were conducted to address the potential impact of participant
223 attrition on results. Mediation models were replicated on datasets in which follow-up data
224 missing due to participant attrition was replaced using multiple imputation ($n_{\text{Imp}} = 5$).
225 Analyses were completed in R version 4.2.1. using the lavaan (Rosseel, 2012) and mitml
226 (Grund et al., 2016) packages.

227

228 **3. Results**

229 **3.1 Baseline Participant Characteristics**

230 At baseline, 493 participants were included after removing participants with
231 incomplete datasets, and participants who did not pass the attention checks ($n = 11$). At
232 follow-up 70% of participants completed the second data round, resulting in a final sample
233 size of 345 participants (M age = 33.9 ± 10.9), M BMI = 26.3, 72.5% women). See Table 1

234 for baseline characteristics of the sample. Forty-two participants (12% of total sample) scored
235 ≥ 2 on the SCOFF screening tool, suggesting possible risk of eating disorder in those
236 participants. Eight participants (2%) reported having previously been treated for an eating
237 disorder. Seventy-eight participants reported inattentive ADHD symptoms within a clinically
238 significant range (26% of total sample). Thirty-three participants reported hyperactive
239 symptoms of ADHD within a clinically significant range (10% of total sample). Fifty-two
240 participants reported combined symptoms of ADHD within a clinically significant range
241 (15% of total sample). Fifty-seven participants reported symptoms indicating an ‘at-risk’
242 ADHD index (17% of total sample). One participant reported currently taking ADHD
243 medication. No participants were excluded due to the above measures.

244 **3.2 Differences between completers and non-completers**

245 T-tests revealed that completers were significantly older ($M = 33.9$) ($M = 29.9$) $t(491)$
246 $= 4.0, p < 0.001$ and had significantly lower combined ADHD symptoms ($M = 17.2$) than
247 non-completers ($M = 20.1$), $t(491) = 3.7, p < 0.001$. Fewer men completed both timepoints
248 than expected, whereas more women completed than expected, $\chi^2(1) = 4.1, p = 0.04$.

249 **3.3 Change in Disordered Eating**

250 There was a significant increase in restrictive eating between baseline ($M = 11.0$) and
251 follow-up ($M = 12.3$), $t(344) = 3.7, p < 0.001$. The increase in mean binge/disinhibited eating
252 between baseline ($M = 20.5$) and follow-up ($M = 21.1$) was not significant $t(342) = 1.3, p =$
253 0.078 .

254 **3.4 Associations between interoception measures**

255 Bivariate correlations revealed that IES-RHSC was associated with interoceptive
256 accuracy as measured by the IAS ($r = 0.19, p < 0.001$), but not interoceptive sensibility as

257 measured by the BPQ ($r = -0.12, p = 0.83$). Interoceptive accuracy and sensibility were
258 significantly positively associated ($r = 0.33, p < 0.001$).

259 **3.5 Mediation Analysis: Follow-up disordered eating**

260 3.5.1 Mediation through Reliance on Hunger and Satiety Cues

261 Inattentive symptoms predicted binge eating and restrictive eating both directly
262 (Effect = 0.64, S.E. = 0.12, $T = 7.3, p < 0.001$, CI = 0.42 - 0.86; Effect = 0.35, S.E. = 0.10, T
263 = 3.4, $p < 0.001$, CI = 0.15 - 0.55) and indirectly through IES-RHSC (Effect = 0.27,
264 Bootstrapped S.E. = 0.07, Bootstrapped CI = 0.15 - 0.41; Effect = 0.09, Bootstrapped S.E. =
265 0.04, Bootstrapped CI = 0.03 - 0.17).

266 Hyperactive/Impulsive symptoms predicted binge eating and restrictive eating directly
267 (Effect = 0.30, S.E. = 0.13, $T = 2.3, p = 0.025$, CI = 0.04 - 0.57; Effect = 0.33, S.E. = 0.12, T
268 = 2.7, $p = 0.006$, CI = 0.09 - 0.56) but not indirectly through IES-RHSC (Effect = 0.10,
269 Bootstrapped S.E. = 0.09, Bootstrapped CI = -0.08 - 0.27; Effect = 0.003, Bootstrapped S.E.
270 = 0.003, Bootstrapped CI = -0.03 - 0.10).

271 3.5.2 Mediation through Interoceptive Accuracy and Interoceptive Sensibility

272 Inattentive symptoms predicted binge eating and restrictive eating directly (Effect =
273 0.85, S.E. = 0.13, $T = 6.7, p < 0.001$, CI = 0.60 - 1.09; Effect = 0.30, S.E. = 0.10, $T = 2.9, p =$
274 0.006, CI = 0.15 - 0.55) and predicted binge eating but not restrictive eating indirectly
275 through IAS (Effect = 0.57, Bootstrapped S.E. = 0.29, Bootstrapped CI = 0.06 - 1.09; Effect
276 = 0.30, S.E. = 0.10, $T = 2.9, p = 0.006$, CI = 0.15 - 0.55). BPQ did not mediate the
277 relationship between inattentive symptoms and binge or restrictive eating (Effect = 0.007,
278 Bootstrapped S.E. = 0.01, Bootstrapped CI = -0.016 - 0.03; Effect = 0.008, Bootstrapped S.E.
279 = 0.02, Bootstrapped CI = -0.03 - 0.05) (See Figure 1).

280 Hyperactive/Impulsive symptoms predicted binge eating and restrictive eating directly
281 (Effect = 0.33, S.E. = 0.16, $T = 2.1$, $p = 0.04$, CI = 0.015 - 0.64; Effect = 0.29, S.E. = 0.12, T
282 = 2.4, $p = 0.017$, CI = 0.052 - 0.53), but did not predict either indirectly through either IAS
283 (Effect = 0.04, Bootstrapped S.E. = 0.032, Bootstrapped CI = -0.01 - 0.12; Effect = 0.025,
284 Bootstrapped S.E. = 0.021, Bootstrapped CI = -0.006 - 0.076) or BPQ (Effect = 0.03,
285 Bootstrapped S.E. = 0.023, Bootstrapped CI = -0.07 - 0.08; Effect = 0.04, Bootstrapped S.E.
286 = 0.024, Bootstrapped CI = -0.0003 - 0.092). (see Figure 1).

287 3.5.3 Mediation through Negative Mood

288 Inattentive symptoms predicted binge eating scores, but not restrictive eating scores
289 directly (Effect = 0.49, S.E. = 0.14, $T = 3.5$, $p = 0.0004$, CI = 0.22 - 0.76; Effect = 0.12, S.E.
290 = 0.12, $T = 1.1$, $p = 0.29$, CI = -0.104 - 0.35) and predicted both indirectly through negative
291 mood (Effect = 0.42, Bootstrapped S.E. = 0.090, Bootstrapped CI = 0.26 - 0.60; Effect =
292 0.22, Bootstrapped S.E. = 0.07, Bootstrapped CI = 0.089 - 0.37).

293 Hyperactive/Impulsive ADHD symptoms did not predict binge eating or restrictive
294 eating scores directly (Effect = 0.096, S.E. = 0.15, $T = 0.65$, $p = 0.52$, CI = -0.19 - 0.39; Effect
295 = 0.22, S.E. = 0.12, $T = 1.8$, $p = 0.069$, CI = 0.017 - 0.24) but did predict binge and restrictive
296 eating indirectly through negative mood (Effect = 0.303, Bootstrapped S.E. = 0.08,
297 Bootstrapped CI = 0.16 - 0.47; Effect = 0.13, Bootstrapped S.E. = 0.047, Bootstrapped CI =
298 0.55 - 0.24).

299 3.6 Mediation Analysis: Change in disordered eating

300 Neither the direct nor indirect pathways in any of the assessed mediation models
301 predicted change in disordered eating scores.

302 **3.7 Moderation by sex**

303 The moderating influence of sex on all model pathways was assessed. Sex did not
304 moderate the direct or indirect pathways of any model.

305 **3.8 Sensitivity Analysis**

306 Overall, results for the mediation models followed a similar pattern. Briefly, RHSC
307 maintained a mediating influence between inattentive symptoms and both binge and
308 restrictive eating ($p < 0.001$, $p = 0.01$ respectively), while hyperactive/impulsive symptoms
309 were no longer directly related to binge ($p = 0.8$) or restrictive eating ($p = 0.17$).

310 The overall effects in the models assessing mediation through the IAS and the BPQ
311 followed the same pattern as in the main analysis, with the exception of the overall indirect
312 effect of inattentive symptoms through IAS, which became only marginally significant ($p =$
313 0.059). Full mediation model results based on pooled estimates can be found in the
314 supplemental materials.

315 **4 Discussion**

316 This is the first study to examine the potential mediating influence of specific
317 interoceptive facets on the relationship between ADHD symptoms and disordered eating over
318 a 6-month period. We found that hyperactive/impulsive and inattentive symptoms of ADHD
319 at baseline predicted both binge and restrictive eating behaviours 6 months later. Mediation
320 models showed that self-reported interoceptive accuracy, but not interoceptive sensibility
321 mediated the relationship between inattention and binge eating symptoms, but not restrictive
322 eating symptoms. Hyperactive/impulsive symptoms of ADHD predicted restrictive and
323 binge/disinhibited eating only through negative mood, not through interoceptive measures.

324 To date, it has been unclear how inattentive symptoms of ADHD relate to disordered
325 eating. Previous evidence suggested that disturbed interoception, as reflected in reduced

326 reliance on hunger and satiety signals to guide eating, may be one underlying mechanism
327 (Kaisari et al., 2018). Here, we replicate and extend this previous finding by providing
328 evidence that inattention specifically contributes towards disordered eating via reduced
329 interoceptive accuracy, rather than interoceptive sensibility. Taken together, these results
330 suggest that trait attention enables accurate interpretation of interoceptive signals, and that
331 this accurate interpretation may specifically protect against binge eating. On the other hand,
332 attention does not appear to influence the trait tendency to notice interoceptive signals.

333 Trait inattention could lead to inaccuracy in the processing of interoceptive signals
334 relating to fullness/overeating, contributing towards excessive eating associated with binge
335 eating episodes. In addition, inaccuracy in interoceptive signals may encourage
336 binge/disinhibited eating through contributing towards an overreliance on salient external
337 cues to guide behaviour, rather than interoceptive cues which are perceived as inaccurate
338 (Young et al., 2017). In the context of the modern food environment, this tendency could
339 contribute towards overconsumption of highly palatable foods. The specific association
340 between interoceptive accuracy and binge eating rather than interoceptive sensibility may be
341 explained by the predictive coding framework of interoception, which suggests that
342 interoceptive accuracy reflects the ability to use attention to prioritise interoceptive signals
343 (Ainley, Apps, Fotopoulou & Tsakiris, 2016), leading to increased precision in processing but
344 not necessarily an enhancement in the saliency of signals (Ainley, Apps, Fotopoulou &
345 Tsakiris, 2016). It should be noted however that the robustness of this relationship across
346 populations is unclear, given that the mediating effect of interoceptive accuracy became
347 marginally significant when the model was run using multiple imputation to account for
348 missing data. Future research should replicate the models presented here, to assess the
349 robustness of the mediating effect of interoceptive accuracy.

350 We also identified a relationship between symptoms of ADHD and restrictive eating.
351 Research into ADHD symptoms and restrictive eating has been limited to date and the results
352 inconsistent (see Kaisari et al., 2017 for a review). The relationship between inattention and
353 restrictive eating was mediated by reliance on hunger and satiety cues as has been reported
354 previously (Kaisari et al., 2018), but not through specific interoception measures. It is
355 plausible that for individuals who engage in restrictive eating, attention to, and accuracy of
356 interoceptive signals, as measured by the BPQ and IAS respectively are intact. However,
357 there may be mistrust in bodily signals that gives rise to a trait tendency to ignore these
358 signals (Martini et al., 2021). Brown et al. (2020) found that mistrust in body sensations was
359 the most relevant facet of interoception to disordered eating and was particularly associated
360 with weight concerns. These results highlight that for individuals who are more prone to
361 restrictive eating, trust in interoceptive signals may be more influential to symptomatology
362 than sensibility or accuracy.

363 Negative mood mediated the relationship between both symptom subtypes of ADHD
364 and both disordered eating behaviour types. However, unlike inattentive symptoms,
365 hyperactive/impulsive symptoms of ADHD predicted restrictive and binge/disinhibited eating
366 only through negative mood, and not through any interoceptive measures. The relationship
367 between negative mood and eating has been well documented (e.g. Rosenbaum & White,
368 2015; Haynos, Watts, Loth, Pearson, Neumark-Stzainer, 2016; Schulz & Laessle, 2010), as
369 has the relationship between ADHD symptoms and negative mood (El Archi, et al. 2020;
370 Katzman, Bilkey, Chokka, Fallu, & Klassen, 2017). Thus, the experience of ADHD
371 symptoms may contribute towards negative mood, and disordered eating behaviours may
372 reflect a coping mechanism for this negative mood, for example through emotional eating.

373 We observed a significant increase in restrictive eating reported over the 6-month
374 period, but no statistically significant change in binge eating. No variables included in the

375 current study were associated with a change in restrictive eating. This may be because the
376 absolute change was relatively small and the 6-month period was insufficient in duration to
377 capture sufficient variability in responding for us to identify significant predictors of change.
378 Alternatively, it is possible that other variables which were not assessed in this study might
379 have predicted change. For example, changes in restrictive eating over a similar time period
380 in young adults have been associated with variables such as body dissatisfaction and weight-
381 related teasing (Wertheim, Koerner & Paxton, 2001; Haynos et al., 2016). Additionally, the
382 differences in season during which responses were collected may interact with these factors.
383 It is possible that a 'seasonal body image' variation exists (e.g. Griffiths, Austen & Blake,
384 2021), such that body dissatisfaction increases in warmer months, potentially as a result of
385 factors such as the tendency to wear less clothing during warmer months, and media
386 pressures to alter appearance in preparation for this seasonal change. It is unclear whether this
387 may at least partially explain the increase in reported restrictive eating in our sample.
388 Influences such as body dissatisfaction and weight-related teasing may have contributed to
389 the significant increase in restrictive eating in the current sample but were not variables of
390 interest and were therefore not recorded in this study. Either way, the present data do not shed
391 light on the directionality of the relationship between ADHD symptoms and disordered
392 eating. Although there are plausible pathways through which ADHD could contribute
393 towards disordered eating, the reverse relationship may also be possible. Further research
394 over a longer time period with multiple follow up assessments will be required to determine
395 the direction of any causal relationship between ADHD symptoms and disordered eating.

396 The findings reported here should be interpreted in the context of the strengths and
397 limitations of our study. Interoceptive accuracy and disordered eating were assessed via self-
398 report and so future research could test whether the same relationships hold using objective
399 measures of interoceptive accuracy (Legrand et al. 2022) as well as lab-based measures of

400 uncontrolled eating (Hartmann, Rief, & Hilbert, 2012). Results from our sensitivity analysis
401 showed a non-significant mediating effect of interoceptive accuracy on the relationship
402 between inattention and binge eating, while this effect was significant in the main analysis.
403 This result may have implications for the robustness of the mediation model. We estimated
404 that a sample size of between 398 and 412 was required and the sample at follow up was
405 under this number at 346, which meant the study was slightly underpowered for mediation
406 analysis. An advantage of using an online survey is access to a large sample size of
407 volunteers with ADHD and disordered eating scores across a spectrum (Insel et al., 2010).
408 However, future research should also confirm the findings in a clinically diagnosed sample.

409 The results of this study have implications for the assessment of risk of disordered
410 eating. Given that symptoms of ADHD, deficits in self-reported interoceptive accuracy, and
411 negative mood appear to be associated with disordered eating, screening for negative mood
412 and interoceptive accuracy may be useful in identifying individuals (e.g. those who present
413 with symptoms of ADHD), who are at risk of developing disordered eating.

414 In summary, we provide the first evidence that self-reported interoceptive accuracy,
415 rather than sensibility, mediates the relationship between inattentive ADHD symptoms and
416 binge-type eating. We also confirm the importance of negative mood as a mediator in the
417 relationship between both ADHD symptom types and restrictive and binge-type eating
418 behaviours. These results have implications for the development of screening tools with a
419 focus on negative mood and interoceptive accuracy for individuals with ADHD and
420 individuals at-risk of eating disorders.

421

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426

427 **Conflicts of interest**

428 Author Colin T Dourish is a Director and shareholder of P1vital Limited and a Director and
429 shareholder of P1vital Products Limited.

430

431 **Ethical statement**

432 The authors assert that all procedures contributing to this work comply with the ethical
433 standards of the relevant national and institutional committees on human experimentation and
434 with the Helsinki Declaration of 1975, as revised in 2008. Ethical approval was granted by
435 University of Birmingham Research Ethics Committee.

436

437 **Data availability**

438 Data for this study will be made available in a public archive following publication of
439 this study. In the interim, data are available upon request.

440

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- 598

600 Table 1. Baseline participant characteristics.

| | Mean (\pmSD) | Range | 601 |
|--|----------------------------------|--------------|-----|
| Age | 33.9 (\pm 10.9) | 18 - 60 | 602 |
| BMI | 26.3 (\pm 6.6) | 15.8 - 56.3 | 603 |
| BES (0-46) | 12.7 (\pm 9.2) | 0 - 42 | 604 |
| DEBQ (1-5) | | | 605 |
| <i>Restrained Eating</i> | 2.7 (\pm 0.9) | 0.8 - 5.0 | 606 |
| <i>External Eating</i> | 3.2 (\pm 0.6) | 1.5 - 4.8 | 607 |
| <i>Emotional Eating</i> | 2.4 (\pm 1.0) | 0.2 - 5.0 | 608 |
| EAT-26 | | | 609 |
| <i>Dieting (0-39)</i> | 5.7 (\pm 6.3) | 0 - 34 | 610 |
| <i>Bulimia and Food Preoccupation (0-18)</i> | 1.6 (\pm 2.6) | 0 - 12 | 611 |
| <i>Oral Control (0-21)</i> | 2.1 (\pm 2.8) | 0 - 21 | 612 |
| SCOFF (0-5) | 0.9 (\pm 1.1) | 0 - 5 | 613 |
| CAARS | | | 614 |
| <i>Impulsive/Hyperactive (0-27)</i> | 8.0 (\pm 4.2) | 0 - 25 | 615 |
| <i>Inattentive (0-27)</i> | 9.2 (\pm 5.0) | 0 - 25 | 616 |
| <i>Combined (0-54)</i> | 17.2 (\pm 7.8) | 0 - 49 | 617 |
| IES RHSC (1-5) | 3.3 (\pm 0.9) | 1 - 5 | |
| IAS (21-105) | 76.5 (\pm 10.5) | 34 - 100 | |
| BPQ-VSF (12-60) | 40.8 (\pm 9.6) | 14 - 60 | |

618 BES = Binge Eating Scale; DEBQ = Dutch Eating Behaviour Questionnaire; EAT-26 =
619 Eating Attitudes Test; CAARS = Conners' Adult ADHD Rating Scale (short screening
620 version; IES RHSC = Intuitive Eating Scale; Reliance on Hunger and Satiety Cues subscale;
621 IAS = Interoceptive Accuracy Scale; BPQ-VSF = Body Perception Questionnaire-Very Short
622 Form.

623

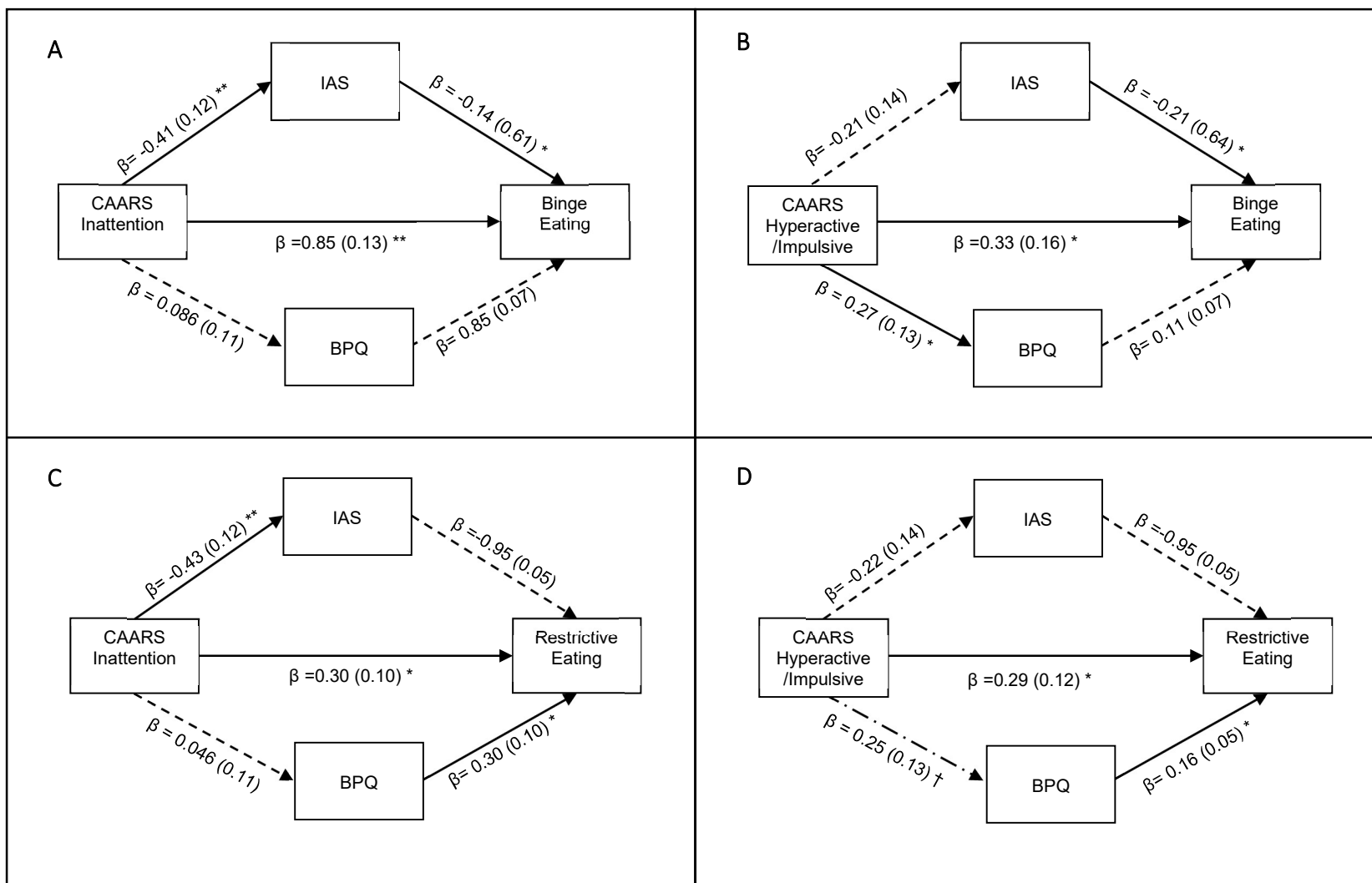


Figure 1. Mediation model showing the mediated relationship between inattentive symptoms and **A:** binge/disinhibited eating, **B:** restrictive eating. Solid lines reflect significant pathways. IAS = Interoceptive Accuracy Scale. BPQ = Body Perception Questionnaire

Estimates (β) are unstandardized regression coefficients, numbers in parentheses show error (direct effects) and bootstrapped error (indirect effects). All analyses controlled for sex, age, BMI, alcohol use and illicit drug use. * = $p < 0.05$, ** = $p < 0.001$, † = $p = 0.05$