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Impulsivity is associated with food intake, snacking and eating disorders in a general population

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Keywords: Impulsivity, Food Intake, Snacking, Eating Disorders, Psychology

Abbreviations: EDs, Eating Disorders; BIS-11, 11th version of the Barratt Impulsiveness Scale; SCOFF, Sick-Control-One-Fat-Food questionnaire; mPNNS-GS, modified Programme National Nutrition Santé - Guideline Score; IRB, Institute for Health and Medical Research; CNIL, Commission Nationale de l’Informatique et des Libertés ; BMI, Body Mass Index; DSM, The Diagnostic and Statistical Manual of Mental Disorders; CU, Consumption Unit; OECD, Organization for Economic Cooperation and Development; IPAQ, International Physical Activity Questionnaire; MET, Metabolic Equivalent of Task; CES-D, Center for Epidemiology Studies Depression scale;

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1 **ABSTRACT**

2 **Background:** Impulsivity is a psychological trait linked with health issues such as obesity.
3 However, few studies have explored the relationship between impulsivity, dietary intake and
4 eating disorders (EDs) in a general population.

5 **Objective:** The objective of this cross-sectional study was to assess whether impulsivity was
6 associated with energy intake, food group consumption, snacking, and risk of EDs.

7 **Design:** In 2014, 51,368 adult participants from the NutriNet-Santé study completed the Barratt
8 Impulsiveness Scale (BIS-11) which assesses impulsivity. Food group consumption and diet
9 quality were evaluated using at least three self-reported 24-h dietary records (N = 35,830), while
10 snacking behavior was evaluated by an ad-hoc question (N = 48,562). Risk of EDs was assessed
11 with the Sick-Control-One-Fat-Food (SCOFF) questionnaire and categories of ED (restrictive,
12 bulimic, hyperphagic, and other types of EDs) were determined with the Expali algorithm (N =
13 48,824). Logistic and linear regressions were used to analyze the associations between
14 impulsivity and energy intake, food group consumption, diet quality, snacking, and risk of EDs,
15 taking into account socio-demographic and lifestyle factors.

16 **Results:** Positive associations were found between impulsivity and consumption of alcoholic
17 beverages and appetizers; whereas negative associations were found for fruits and vegetables,
18 meat and poultry, processed meat, dairy products, milk-based desserts, and starchy foods.
19 Impulsivity was positively associated with energy intake and negatively associated with diet
20 quality. Impulsivity was also positively associated with snacking (OR = 3.32, 95% CI: 2.99, 3.68)
21 and risk of EDs (OR = 3.02, 95% CI: 2.74, 3.33). The strongest associations were found for
22 bulimic disorders (OR = 4.38, 95% CI: 3.66, 5.23) and hyperphagic disorders (OR = 2.91, 95%
23 CI: 2.56, 3.31).

24 **Conclusions:** Impulsivity was associated with food intakes, snacking and risk of EDs and could
25 be taken into account in the promotion of a healthy eating behavior.

26 INTRODUCTION

27 Psychological factors are important determinants of food choices and individual differences in
28 specific psychological traits could therefore lead to different eating behaviors (1–3). In particular,
29 trait impulsivity is an interesting construct to explore in this context. Impulsivity is a personality
30 trait that is defined as “a predisposition toward rapid unplanned reactions to internal or external
31 stimuli without regard to the negative consequences of these reactions to the impulsive
32 individuals or to others” (4). Trait impulsivity is linked to deficient inhibitory processes (5) and
33 impulsive individuals could therefore make rash decisions toward food or in extreme cases could
34 have an impaired dietary behavior leading to eating disorders (EDs).

35 Both trait impulsivity (measured by self-report questionnaires) and state impulsivity
36 (measured by behavioral tasks) have been linked to overeating and obesity (6). Higher state
37 impulsivity also led to higher caloric intake measured with a bogus taste test (7) and higher
38 caloric purchases (8), whereas trait impulsivity was found associated with overall unhealthy
39 eating based on self-perception (9,10) and self-reported intentions to consume saturated fats (11).
40 Trait and state impulsivity were also linked to higher alcohol consumption (12–16). However,
41 none of these studies has looked at the association with all food groups of the diet. Impulsivity
42 has also been associated with preferences for immediate rewards (17). Thus, we expect
43 individuals with a high level of impulsivity to be more sensitive to palatable foods, which are
44 generally sugary and fatty.

45 Snack consumption has been associated with lower nutrient density and higher energy
46 density compared to main meals (18), while it has also been associated with both healthy and
47 unhealthy food choices (19). Trait and state impulsivity have been positively associated with
48 snacking (20–24), and with a lower tendency to choose healthy snacks (9). However, these

49 studies were often performed on small or specific samples essentially composed of adolescents,
50 students or overweight participants.

51 Impulsivity could also be associated with EDs, which are disturbances of eating habits or
52 weight-control behavior that can result in a clinically significant impairment of physical health
53 and/or psychosocial functioning (25). EDs are particularly prevalent in western countries, more
54 specifically in women and in adolescents or young adults (26,27). Previous studies showed an
55 association between impulsivity and EDs (28–35). However, a systematic review (34) pointed out
56 the lack of research performed on general populations and taking into account potential
57 confounders such as socioeconomic status. Sociodemographic variables represent important
58 confounders since they are associated with dietary intake (36), EDs (26,27), and impulsivity
59 (37,38).

60 The main objectives of this study were to explore how impulsivity was associated with
61 dietary intake, snacking behavior, and risk of EDs in a large sample of the general population,
62 considering sociodemographic, lifestyle and anthropometric measures.

63 **METHODS**

64 *Population*

65 This study was conducted as part of the NutriNet-Santé study, which is a large ongoing web-
66 based prospective cohort launched in France in May 2009. The rationale, design and methods of
67 the study have been described elsewhere (39). Its overall aim is to explore the relationships
68 between nutrition and health, as well as the determinants of eating behavior and nutritional status.
69 Participants are adult volunteers (age \geq 18 years) of the general French population. At inclusion,
70 participants complete several self-report web-based questionnaires to assess their diet, physical

71 activity, anthropometric measures, lifestyle characteristics, socioeconomic conditions and health
72 status. Participants then complete this same set of questionnaires every year after inclusion.
73 Another set of optional questionnaires related to determinants of eating behaviors, nutritional
74 status, and specific health-related aspects are sent to every participant each month.

75 This study was conducted in accordance with the guidelines of the Declaration of
76 Helsinki, and all procedures were approved by the International Research Board of the French
77 Institute for Health and Medical Research (IRB Inserm n° 0000388FWA00005831) and the
78 Commission Nationale de l'Informatique et des Libertés (CNIL n° 908450 and n° 909216).
79 Electronic informed consent was obtained from all participants. The study was registered at
80 clinicaltrials.org (Clinical Trial no. NCT03335644).

81 ***Data collection***

82 *Impulsivity*

83 Impulsivity was assessed with the eleventh version of the Barratt Impulsiveness Scale (BIS-11)
84 (40) (derived from the French version of the BIS-10 questionnaire). The BIS-11 (41) is one of the
85 most often used self-report questionnaires to assess impulsivity (42). This questionnaire was
86 administered between June and December 2014. It is a 30-item self-report questionnaire with
87 each item scored on a 4-point Likert scale ranging from “rarely/never” to “almost
88 always/always”. Impulsivity is measured by summing all the item ratings and by dividing the
89 result by 30 for a final score ranging from 1 to 4, with higher scores indicating higher
90 impulsivity. In our population, the BIS-11 displayed good internal consistency (Cronbach's $\alpha =$
91 0.78), which was close to the results observed in another adult population (0.83 (42)).

92 *Assessment of food group consumption and diet quality*

93 For the present analysis, we selected participants who had completed at least three dietary records
94 between the 2 years preceding and the 2 years following the completion of the BIS-11
95 questionnaire. The dietary record is completed by using an interactive interface and is designed
96 for self-administration on the Internet (43). Participants report all foods and beverages consumed
97 at breakfast, lunch, dinner, and other eating occasions. They estimate the amounts eaten using
98 standard measurements or using validated photographs (44). These photographs represent > 250
99 foods (corresponding to 1,000 generic foods). Participants can choose among 7 portion sizes for
100 most food products: 3 main portion sizes plus 2 intermediate and 2 extreme sizes. The
101 participants cannot submit the record if no estimate for each food or beverage previously listed is
102 provided. Nutrient intakes are estimated by using the published NutriNet-Santé food composition
103 table including > 2,000 foods (45). Mean daily food intake (in grams per day) is weighted for the
104 type of day of the week (weekday or weekend). Participants with unlikely estimates of energy
105 intake were identified as under-reporters by using the method proposed by Black (46). Briefly,
106 basal metabolic rate was calculated according to age, gender, weight and height using Schofield's
107 equations (47). Energy requirement was based on basal metabolic rate and physical activity level.
108 The ratio between energy intake and estimated energy requirement was calculated and
109 individuals with ratios below Goldberg cut-off were excluded (48). This method has been
110 validated in the NutriNet-Santé cohort in a previous study (49). For the present study, we defined
111 17 food groups: fruit and vegetables; seafood (fish and shellfish); meat and poultry; dairy
112 products (e.g. milk, yogurts with less than 12% of added sugar); cheese; milk-based desserts (e.g.
113 sweetened yogurts, flan, cottage cheese, cream desserts); starchy foods; whole-grain foods; fats
114 (oil, butter, and margarine); sugary and fatty foods (e.g. cakes, chocolate, ice cream, pancakes);
115 confectionery (e.g. honey, jelly, sugar, candy); non-alcoholic beverages (excluding water);

116 alcoholic beverages; processed meat; eggs; fast food (e.g. pizzas, hamburgers, sandwiches, hot
117 dogs) ; and appetizers (e.g. crisps, salted biscuits).

118 The modified French National Nutrition and Health Program Guideline Score (mPNNS-
119 GS), which is an a priori nutritional diet quality score reflecting adherence to the French
120 nutritional recommendations was calculated. It is based on the PNNS-GS score (50), but accounts
121 for dietary component only, excluding the physical activity component (51). The score includes
122 12 components: eight refer to food serving recommendations (fruit and vegetables; starchy foods;
123 whole-grain products; dairy products; meat, eggs and fish; seafood; vegetable fat; water vs soda)
124 and four refer to moderation of intake (added fat; salt; sweets; and alcohol). Points are deducted
125 for overconsumptions of salt and added sugars from sweetened foods, and when energy intake
126 exceeds the energy requirement (as assessed by physical activity level and basal metabolic rate
127 calculated using Schofield equations (47) by more than 5%. The score has a maximum of 13.5
128 points, with a higher score indicating a better overall nutritional quality of the diet.

129 *Assessment of snacking*

130 A meal pattern questionnaire was administered in April 2014 where snacking (defined as eating
131 food between meals) was assessed. Participants were asked “How often do you usually snack in
132 the daytime?” Responses were rated on a 7-point scale from “never” to “6 times or more per
133 day, each day” and further classified into 4 categories: never, snacking < 1 time/week, \geq 1
134 time/week to < 1 time/day, and \geq 1 time/day. A binary variable was also computed with
135 participants who never snacked against the others.

136 *Assessment of Eating Disorders*

137 The French version of the SCOFF (Sick-Control-One-Fat-Food) (52) questionnaire was

138 administered in June 2014. It is a self-report questionnaire with five dichotomous questions
139 designed to screen for EDs (53). The total score varies from 0 to 5 and a score equal or greater
140 than 2 indicates risk of ED. This questionnaire has been validated, displaying good sensitivity
141 and specificity regarding the diagnostic of EDs (52–54). At least 2 positive answers indicate a
142 positive SCOFF with a sensitivity of 88.2% and a specificity of 92.5% (54). The National
143 Institute for Health and Care Excellence (NICE) guidelines suggest using the SCOFF test as a
144 screening tool for ED in primary care (55). The Expali algorithm was used in order to allow the
145 distinction between ED categories (56). It takes into account each SCOFF response and the
146 participant's body mass index (BMI), and thus differentiates participants with an ED into four
147 broad categories. These ED categories, similar to that previously reported for DSM-IV (The
148 Diagnostic and Statistical Manual of Mental Disorders), were created based on the DSM-V
149 categories of ED (Annex A): (1) Restrictive disorders category including anorexia nervosa,
150 restrictive food intake disorder, and atypical anorexia nervosa; (2) Bulimic disorders category
151 including Bulimia nervosa or Bulimia nervosa of low frequency or duration; (3) Hyperphagic
152 disorders category including Binge-Eating Disorder and Binge-Eating Disorder of low frequency
153 or duration; (4) Other eating disorders: category including Purging disorder, and Night Eating
154 Syndrome and any other ED.

155 *Covariates*

156 Potential confounders of the relationship between BIS-11, food group consumption, energy
157 intake, snacking and EDs were collected. These data are provided yearly by the participants after
158 their inclusion. We used the data closest to the date of completion of the BIS-11. Selected
159 confounders were the following: age (years), gender, education level (primary, secondary,
160 undergraduate, and postgraduate), occupational status (unemployed, student, self-employed and

161 farmer, employee and manual worker, intermediate profession, managerial staff and intellectual
162 profession, and retired), monthly income per household unit, smoking status (never smoker,
163 former smoker, and current smoker), level of physical activity, history of dieting (never dieter,
164 former dieter, and current dieter), BMI (kg/m²), and depressive symptomatology. More precisely,
165 monthly income per household unit was calculated with information about income and household
166 composition. The number of people in the household was converted into number of consumption
167 units (CU) according to the OECD (Organization for Economic Cooperation and Development)
168 equivalence scale: one CU is attributed for the first adult in the household, 0.5 for other persons
169 aged 14 or older, and 0.3 for children under 14 (57). Categories of monthly income were defined
170 as followed: < 1,200; 1,200-1,799; 1,800-2,299; 2,300-2,699; 2,700-3,699; and ≥ 3,700 euros per
171 household unit as well as “unwilling to answer”. Physical activity was assessed using the short
172 form of the French version of the International Physical Activity Questionnaire (IPAQ) (58).
173 Energy expenditure expressed in Metabolic Equivalent of Task (MET-minutes/week) was
174 estimated and three levels of physical activity were constituted (low (< 30min/day), moderate
175 (30-60min/day), and high (≥ 60min/day)). BMI (kg/m²) was calculated based on self-reported
176 weight and height. Depressive symptomatology was assessed with the French version of the
177 CES-D (Center for Epidemiology Studies Depression scale) (59,60). It is a 20-item questionnaire
178 rated on a 4-point scale with higher scores indicating higher depressive symptomatology. The
179 CES-D had a good internal consistency (Cronbach’s $\alpha = 0.91$) in our sample.

180 *Statistical analysis*

181 The relationships between impulsivity and participants’ characteristics were described with
182 Pearson correlations for continuous variables and linear regressions for categorical variables.
183 Linear regressions were used to study the association between impulsivity, diet quality, energy

184 and macronutrient intake, and food groups that displayed a normal distribution. Multinomial and
185 ordinal logistic regressions were performed between impulsivity and food groups that did not
186 display a normal distribution based on histograms (processed meat, eggs, fast food, and
187 appetizers). Three levels were defined for these food groups: no intake, < median of intake of the
188 food group (Low), > median of intake of the food group (High), with the no intake level as
189 reference. Medians were calculated based on positive values of the distributions. Binary,
190 multinomial and ordinal logistic regressions were also performed between impulsivity and
191 snacking (with the binary and the 4-category dependent variables), and between impulsivity and
192 risk of EDs (overall risk of EDs and risk of EDs by category). The strength of the association was
193 estimated by calculating odds ratios (ORs) and 95% confidence intervals (95% CI). Analyses
194 were not stratified by gender since the interactions with impulsivity were non-significant ($P >$
195 0.05 for most groups (except meat and poultry, whole-grain foods, confectionery, and alcoholic
196 beverages), $P = 0.88$ for snacking and $P = 0.88$ for EDs). All models had impulsivity as a
197 continuous independent variable. Analyses were performed with and without confounding
198 variables. Models were adjusted for age, gender, education level, occupational status, monthly
199 income per household unit, smoking status, physical activity, as well as history of dieting and
200 BMI (except when EDs were the outcomes), and energy intake (except when energy intake,
201 snacking, and EDs were the outcomes). In addition, two sensitivity analyses were performed. One
202 took into account individuals who completed at least three 24h records over a 2-year period (1
203 year preceding and 1 year following the BIS-11 completion) in order to assess the consistency of
204 the results. In the other sensitivity analysis, depressive symptomatology was added as a covariate.
205 This analysis was performed on a subsample of individuals (40% of the original sample) who
206 also completed the optional CES-D. Missing data regarding confounders were handled with
207 multiple imputation by fully conditional specification (20 imputed datasets). All tests of statistical

208 significance were 2-sided and significance was set at 5%. Holm-Bonferroni method was applied
209 to control the familywise error rate for multiple testing. Statistical analyses were performed using
210 SAS software (SAS Institute Inc., version 9.4).

211 **RESULTS**

212 *Individual characteristics of the participants*

213 A total of 51,394 participants of the NutriNet-Santé cohort study completed the BIS-11
214 questionnaire from the 125,377 subjects who received it. Among them, 26 participants were
215 excluded because they presented an acquiescence bias (agreeing to all questions without
216 consideration of reversed items). From the 51,368 remaining participants, 35,830 participants had
217 completed at least three dietary records (excluding under-reporters), 48,562 had completed the
218 snacking assessment, and 48,824 had completed the SCOFF questionnaire, **see Supplemental**
219 **Figure 1**. Therefore, each analysis was carried on a different subsample to make better use of
220 available data. Compared with excluded participants of the NutriNet-Santé cohort who did not
221 complete the BIS-11, included participants were older, had a higher proportion of men, had a
222 higher proportion of individuals with university education, and had a lower mean BMI (all *P*
223 values < 0.0001).

224 **Table 1** shows the relationships between individual characteristics of the overall sample
225 and impulsivity. Impulsivity was negatively correlated with age and positively correlated with
226 BMI. In average, impulsivity was higher in men, in participants with a low level of education, in
227 unemployed individuals or students, in participants with a low monthly income, in smokers, in
228 participants with a low level of physical activity, and in current dieters.

229 ***Diet quality, energy and macronutrient intake, food group consumption, snacking and eating***
230 ***disorders***

231 Descriptive characteristics of diet quality, energy and macronutrient intake, food group
232 consumption, and snacking are detailed in **Table 2**. Around four-fifth of the participants declared
233 to snack, and a majority snacked more than once a week (and less than once a day). A high
234 percentage of the participants had no risk of EDs. Among participants with risk of EDs,
235 hyperphagic disorders were the most prevalent whereas restrictive disorders were the least
236 prevalent.

237 ***Association between impulsivity, diet quality, intakes of energy and macronutrient and food***
238 ***group consumption***

239 **Tables 3 and 4** describe the associations between impulsivity and dietary intakes. After
240 adjustment, impulsivity was negatively associated with diet quality and positively associated with
241 energy intake (even when alcohol was excluded from energy intake calculation). Greater
242 impulsivity was associated with higher intake of lipids (% of energy), and lower intake of
243 proteins and carbohydrates. Considering food groups, greater impulsivity was associated as
244 expected with higher consumptions of alcoholic beverages and appetizers, and with a lower
245 consumption of fruits and vegetables, meat and poultry, processed meat, dairy products, and
246 milk-based desserts. Sensitivity analyses showed overall equivalent results compared with the
247 main observations (data not shown).

248 ***Association between impulsivity and snacking***

249 The results of the logistic regressions between impulsivity and snacking behavior are presented in
250 **Table 5**. Impulsive participants were more likely to snack no matter the snacking frequency

251 reported, and the association increased with snacking frequency. Sensitivity analyses showed
252 overall equivalent results compared with the main observations (data not shown).

253 *Association between impulsivity and eating disorder*

254 The results of the logistic regressions between impulsivity and risk of EDs are shown in **Table 6**.
255 Impulsivity was significantly associated with risk of EDs overall, and more specifically, with
256 every category of EDs. The strongest association was found for the bulimic disorders category
257 whereas the weakest association was found for the restrictive disorders category. Sensitivity
258 analyses showed similar results apart from an absence of association between impulsivity,
259 restrictive disorders and other type of EDs when depressive symptomatology was taken into
260 account (data not shown).

261 **DISCUSSION**

262 The present study is the first to investigate in a large adult general population the association
263 between trait impulsivity and all food groups using 24h records and taking sociodemographic and
264 lifestyle factors into account. Trait impulsivity was associated with a lower overall diet quality. In
265 particular, impulsivity was associated with a greater consumption of alcoholic beverages and
266 appetizers, and with a lower consumption of fruits and vegetables, meat and poultry, processed
267 meat, dairy products, and milk-based desserts and starchy foods. It was associated with greater
268 intake of energy and lipids (as percentage of energy), and lower intake of proteins and
269 carbohydrates. In addition, impulsivity was associated with snacking and snacking frequency.
270 Finally, impulsivity was associated with EDs, and more specifically with bulimic and
271 hyperphagic disorders.

272 *Impulsivity and diet quality, energy and macronutrient intake, and food group consumption*

273 The association between trait impulsivity and lower diet quality observed in our study support
274 previous data suggesting an overall unhealthy eating (9), and a Western-style diet (10) in
275 impulsive individuals. Participants with an impulsive personality could make food decisions
276 without forethought or planning regarding the negative consequences of their behavior. Previous
277 studies also indicated that impulsivity was linked to higher intentions to consume saturated fats
278 (11) and higher alcohol intake (12–16). Our data indicated that impulsive individuals had higher
279 energy intake. Mixed findings were found in the literature, with either positive association
280 between impulsivity and overall energy intake (6–8), or no association between emotion-driven
281 impulsivity and energy intake at snacking occasions (21). Accordingly, interventions aiming at
282 decreasing impulsive processes of eating behavior showed a reduction of self-selected portion
283 size (61). However, although a positive relationship between trait impulsivity and the
284 consumption of palatable and high caloric foods was expected (17), no difference in impulsivity
285 for food groups such as cheese, fats, sugary and fatty foods, confectionery, and fast food was
286 found. One possibility is that the consumption of these food groups rather depends on the
287 impulsive state of the individuals, which relies on the environment and contextual cues (5)
288 leading for example to only punctual increased consumptions of these food groups, and/or
289 depends on specific mechanisms not measured by self-report questionnaires.

290 *Impulsivity and snacking*

291 Our results showed that impulsive individuals were more likely to snack, in agreement with
292 previous observations (9,20,21,24,62). More precisely, impulsivity was positively associated with
293 snacking frequency. Impulsive individuals have been shown to have greater difficulties at
294 inhibiting urges to eat (17) and would be more likely to eat when having the opportunity (6).
295 Consequently, impulsive restrained eaters had been found more likely to overeat (7,63), and less

296 likely to report a high level of success in dieting (64). Moreover, hunger has been shown to
297 interact with impulsivity to predict higher purchases of snack food (8). Several strategies have
298 emerged to reduce impulsive behaviors toward snacking, such as targeting inhibitory control (65–
299 67), or use of temporally framed health messages regarding immediate health consequences of
300 food decisions (24). These strategies are expected to increase control over food-related decisions
301 and temptations in order to reduce snack consumption and improve overall diet quality overall.

302 *Impulsivity and eating disorders*

303 The observed percentage of individuals presenting risk of EDs in our study (15.9% for women,
304 and 8.1% in men) is similar to previous studies using the SCOFF questionnaires among
305 university students (68). Overall, women were more likely to have an ED compared with men
306 and hyperphagic disorders category was the most prevalent type of EDs, which is consistent with
307 previous findings (25–27).

308 In agreement with the literature (28,29,32–35), we found a positive association between
309 impulsivity and risk of EDs. In our study, gender did not moderate the association between
310 impulsivity and EDs, suggesting that the same mechanisms operate in both genders. The
311 strongest associations were found with bulimic and hyperphagic disorders, supporting previous
312 data showing main associations with bulimia nervosa and binge eating disorder (1,28,29,32,33).
313 Individuals with a binge eating trait typically show high reward sensitivity and deficit in
314 inhibitory control in response to food stimuli (32), and could therefore present recurrent episodes
315 of uncontrolled overeating. Our results showed a particularly strong association with bulimic
316 disorders. It is possible that the purging act is another characteristic of an impulsive personality
317 since it could be considered a rash behavior in response to loss of control. Finally, we found a
318 positive association between impulsivity, restrictive disorders, and other types of EDs, but these

319 associations were no longer significant once depressive symptomatology was accounted for.
320 Previous studies showed that individuals with restrictive anorexia nervosa had lower levels of
321 impulsivity compared to persons with binge-purging type (6,29).

322 *Strengths and limitations*

323 The relationship between impulsivity and overall dietary intakes has not been fully explored in
324 the literature. The main strength of this study was the use of at least three 24-h dietary records
325 provided over a 4-year period that allowed us to have a good representation of the participants'
326 usual diet. A sensitivity analysis over a 2-year period was performed and the results were overall
327 equivalent to the main observations. Other strengths include the large sample size with subjects
328 with various socio-demographic characteristics, adjustment for confounding factors, and use of
329 the Expali algorithm to discriminate among the main categories of EDs based on the DSM-V
330 using the SCOFF questionnaire. However, we cannot rule out the possibility that other important
331 confounders were not taken into account. One limitation of our study was its cross-sectional
332 design, which does not allow causality inference. Reverse causation could also explain the
333 observed results. In particular, several studies showed that alcohol lead to impairments in
334 impulsivity and inhibitory control (69–71). Nutritional quality of the snacks was not assessed in
335 the present study, although previous data of the NutriNet-Santé cohort suggested a lower nutrient
336 density and higher energy density of snacks compared to main meals (62). Our study could also
337 present a selection bias because of the method used to recruit participants, which was based on
338 volunteering. Consequently, our subjects are likely to have high health awareness and a higher
339 interest in nutrition compared to the French population. Impulsivity can be measured with various
340 methods (self-reported questionnaires and behavioral tasks), therefore caution is needed when
341 interpreting and extrapolating our results (72). Trait impulsivity generally correlates poorly with

342 state impulsivity measured by behavioral tasks (5,6). It is regarded as a stable personality
343 characteristic and depends less on the context of the measure compared with state impulsivity (5).
344 However, it relies on the subject's self-perception and comprehension of the questionnaire, and
345 limits the understanding of the underlying mechanisms of impulsivity. In addition, impulsivity
346 was measured as a general trait and was not specific of the food choice domain which could have
347 provided better explanation on the mechanisms of impulsivity. The average score of the BIS-11
348 in our study was consistent with previous studies (42,73). Finally, the SCOFF questionnaire is
349 considered as a robust screening tool for EDs (54), however the actual diagnosis of EDs, like
350 other psychiatric conditions, can only be ascertained in a clinical setting. We cannot rule out a
351 certain number of false positives or other misclassifications in our study.

352 **CONCLUSIONS**

353 This study provided detailed results on the relationships between trait impulsivity and dietary
354 intakes. More precisely, impulsivity was negatively associated with diet quality and positively
355 associated with energy intake. Impulsivity was also associated with a greater consumption of
356 several food groups such as fatty sweets and alcoholic beverages and a lower consumption of
357 some food groups such as dairy products and meat and poultry, and processed meat. An
358 impulsive personality was also associated with snacking frequency and risk of EDs (in particular
359 with bulimic and hyperphagic disorders). Reducing impulsive behaviors may therefore represent
360 a potential public health lever regarding the prevention of EDs and nutrition-related chronic
361 diseases. Longitudinal and experimental studies are needed to obtain a better understanding of
362 these relationships.

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Table 1. Individual characteristics of 51,368 participants (NutriNet-Santé study, 2014)

	Mean \pm SD and/or %	BIS-11	<i>P</i> ¹
All		1.96 \pm 0.27 ²	
Age, y	50.4 \pm 14.6	-0.017 (-0.026, -0.008) ³	0.0001
Gender (%)			<0.0001
Female	76.8	1.92 \pm 0.27	
Male	23.2	1.97 \pm 0.27	
Educational level (%)			<0.0001
Primary	2.4	2.05 \pm 0.30	
Secondary	29.0	2.00 \pm 0.28	
Undergraduate	31.1	1.96 \pm 0.26	
Postgraduate	37.4	1.92 \pm 0.26	
Missing data	0.1		
Occupational status (%)			<0.0001
Unemployed	9.6	2.03 \pm 0.29	
Student	1.9	2.02 \pm 0.29	
Self-employed, farmer	2.0	1.99 \pm 0.27	
Employee, manual worker	15.5	1.99 \pm 0.27	
Intermediate professions	15.5	1.95 \pm 0.25	
Managerial staff, intellectual profession	23.4	1.91 \pm 0.25	
Retired	32.1	1.96 \pm 0.27	
Monthly income ⁴ (%)			<0.0001
< 1,200€	11.2	2.03 \pm 0.29	
1,200-1,799€	21.1	1.98 \pm 0.27	
1,800-2,299€	15.1	1.96 \pm 0.26	
2,300-2,699€	10.0	1.95 \pm 0.26	
2,700-3,699€	17.0	1.92 \pm 0.25	
> 3,700€	12.5	1.91 \pm 0.25	
Unwilling to answer	12.6	1.95 \pm 0.27	
Missing data	0.4		
Smoking status (%)			<0.0001
Never smokers	50.2	1.93 \pm 0.26	
Former smokers	38.5	1.98 \pm 0.27	
Current smokers	11.4	2.03 \pm 0.28	
Physical activity (%)			<0.0001
Low	23.4	1.97 \pm 0.27	
Moderate	41.0	1.96 \pm 0.26	
High	35.5	1.95 \pm 0.27	
Missing data	0.1		
History of dieting (%)			<0.0001
Never dieter	67.3	1.95 \pm 0.26	
Former dieter	25.7	1.97 \pm 0.27	
Current dieter	7.0	2.00 \pm 0.28	
BMI, kg/m ²	24.0 \pm 4.5	0.047 (0.039, 0.056)	<0.0001

BIS-11, Barratt Impulsiveness Scale (11th version), score ranges from 1 to 4.

¹p-value based on linear regressions for categorical variables or Fisher's z transformation for continuous variables (corrected for multiple testing with the Holm-Bonferroni method)

²Mean \pm SD, all such values

³Pearson correlations (95% CI), all such values

⁴Monthly income represents the household income per month calculated by consumption unit (CU). The number of people of the household was converted into a number of CU according to a weighting system: one CU is attributed for the first adult in the household, 0.5 for other persons aged 14 or older and 0.3 for children under 14.

Table 2. Descriptive characteristics of diet quality, energy and macronutrient intake, food group consumption, and snacking (NutriNet-Santé study, 2014)

	Mean \pm SD and/or %
Diet quality (N=35,586)	
mPNNS-GS ¹	7.61 \pm 1.45
Energy and macronutrient intake (N=35,830)	
Energy intake, kcal/d	2282.55 \pm 439.81
Energy intake without alcohol, kcal/d	2176.79 \pm 429.36
Protein, % energy	16.02 \pm 2.57
Lipids, % energy	37.75 \pm 5.30
Carbohydrates, % energy	41.40 \pm 6.60
Food group consumption (N=35,830)	
Fruit and vegetables, g/d	412.10 \pm 218.73
Seafood, g/d	41.82 \pm 33.83
Meat and poultry, g/d	86.59 \pm 47.49
Dairy products, g/d	152.53 \pm 144.75
Cheese, g/d	43.75 \pm 29.56
Milk-based desserts, g/d	33.36 \pm 42.30
Starchy foods, g/d	280.65 \pm 99.64
Whole-grain foods, g/d	45.84 \pm 56.45
Fats, g/d	24.01 \pm 14.77
Sugary and fatty foods, g/d	80.67 \pm 56.63
Confectionery, g/d	35.12 \pm 29.19
Non-alcoholic beverages, g/d	411.38 \pm 286.84
Alcoholic beverages, g/d	180.77 \pm 190.39
Processed meat, g/d	13.75 [4.53; 25.67] ²
Eggs, g/d	8.93 [1.85; 18.66]
Fast food, g/d	23.57 [5.67; 47.36]
Appetizers, g/d	2.62 [0.00; 7.14]
Snacking behavior (N=48,562)	
Snacking (%)	
No	14.2
Yes	85.8
Snacking frequencies (%)	
Never	14.2
< once a week	23.3
\geq once a week (and < once a day)	43.4
\geq once a day	19.1
Eating disorders (N=48,824)	
Eating disorders (%)	
No	85.9
Yes	14.1
Categories of eating disorders (%)	
No eating disorders	85.9

Restrictive disorders	1.0
Bulimic disorders	3.6
Hyperphagic disorders	7.5
Other eating disorders	2.0

¹*mPNNS-GS, modified French National Nutrition and Health Program Guideline Score.*

²*Median [IQRs] (all such values)*

Table 3. Association between impulsivity and diet quality, energy and macronutrient intake and food group consumption in 35,830 participants (NutriNet-Santé study, 2014).

	Raw model		Adjusted model	
	BIS-11 Slope (95% CI)	<i>P</i> ¹	BIS-11 Slope (95% CI)	<i>P</i> ²
mPNNS-GS ³	-0.42 (-0.48, -0.37)	<0.0001	-0.25 (-0.30, -0.19)	<0.0001
Energy intake, kcal/d	-18.05 (-34.54, -1.56)	0.51	54.58 (40.03, 69.14)	<0.0001
Energy intake without alcohol, kcal/d	-30.84 (-46.64, -15.05)	0.004	41.21 (26.93, 55.48)	<0.0001
Protein, % energy	-0.54 (-0.65, -0.43)	<0.0001	-0.64 (-0.75, -0.54)	<0.0001
Lipids, % energy	1.18 (0.97, 1.39)	<0.0001	0.71 (0.50, 0.92)	<0.0001
Carbohydrates, % energy	-1.30 (-1.55, -1.06)	<0.0001	-0.63 (-0.87, -0.39)	<0.0001
Fruit and vegetables, g/d	-35.06 (-42.79, -27.34)	<0.0001	-17.49 (-24.93, -10.05)	0.0001
Seafood, g/d	-2.75 (-3.94, -1.55)	0.0002	-1.09 (-2.27, 0.08)	0.75
Meat and poultry, g/d	-3.62 (-5.28, -1.95)	0.0007	-5.85 (-7.44, -4.26)	<0.0001
Dairy products, g/d	-37.31 (-42.56, -32.06)	<0.0001	-35.33 (-40.66, -29.99)	<0.0001
Cheese, g/d	-0.58 (-1.54, 0.38)	1.00	-0.29 (-1.19, 0.61)	1.00
Milk-based desserts, g/d	-4.11 (-5.64, -2.58)	<0.0001	-4.33 (-5.88, -2.78)	<0.0001
Starchy foods, g/d	-6.43 (-9.81, -3.05)	0.005	-0.85 (-3.66, 1.97)	1.00
Whole-grain foods, g/d	-0.05 (-1.77, 1.67)	1.00	2.27 (0.53, 4.00)	0.22
Fats, g/d	1.59 (1.09, 2.10)	<0.0001	0.63 (0.15, 1.11)	0.22
Sugary and fatty foods, g/d	2.08 (0.07, 4.10)	0.56	2.66 (0.86, 4.46)	0.08
Confectionery, g/d	-2.51 (-3.51, -1.50)	<0.0001	-0.83 (-1.80, 0.15)	0.96
Non-alcoholic beverages, g/d	14.45 (1.20, 27.71)	0.51	7.29 (-5.89, 20.48)	1.00
Alcoholic beverages, g/d	24.00 (18.69, 29.30)	<0.0001	21.84 (16.95, 26.73)	<0.0001

¹*P* value based on linear regressions (corrected for multiple testing with the Holm-Bonferroni method), with impulsivity as a continuous independent variable.

²*P* value based on linear regressions (corrected for multiple testing with the Holm-Bonferroni method) adjusted for age, gender, education level, occupational status, monthly income per household unit, smoking status, physical activity, history of dieting, BMI, and energy intake (except for the model where energy intake was the outcome), with impulsivity as a continuous independent variable.

³mPNNS-GS, modified French National Nutrition and Health Program Guideline Score, results for 35,586 participants.

Table 4. Association between impulsivity and food group consumption in 35,830 participants (NutriNet-Santé study, 2014).

	Raw model			Adjusted model ¹		
	BIS-11 OR (95% CI)	<i>P</i> ²	<i>P</i> ³	BIS-11 OR (95% CI)	<i>P</i> ²	<i>P</i> ³
Processed meat			<0.0001			0.0009
No intake	Ref			Ref		
Low	0.63 (0.56, 0.70)	<0.0001		0.68 (0.61, 0.77)	<0.0001	
High	0.63 (0.56, 0.70)	<0.0001		0.64 (0.56, 0.72)	<0.0001	
Eggs			<0.0001			0.003
No intake	Ref			Ref		
Low	0.72 (0.64, 0.81)	<0.0001		0.83 (0.74, 0.93)	0.03	
High	0.92 (0.82, 1.03)	1.00		0.96 (0.86, 1.08)	1.00	
Fast food			0.0009			0.48
No intake	Ref			Ref		
Low	0.79 (0.71, 0.88)	0.0007		0.87 (0.78, 0.97)	0.26	
High	0.88 (0.79, 0.97)	0.26		0.89 (0.79, 0.99)	0.51	
Appetizers			0.002			0.96
No intake	Ref			Ref		
Low	0.83 (0.75, 0.91)	0.004		0.93 (0.84, 1.03)	1.00	
High	1.10 (1.00, 1.22)	0.56		1.21 (1.09, 1.34)	0.01	

(*P* values are adjusted for multiple testing with the Holm-Bonferroni method)

¹adjusted for age, gender, education level, occupational status, monthly income per household unit, smoking status, physical activity, history of dieting, BMI, and energy intake, with impulsivity as a continuous independent variable.

²*P* value based on multinomial logistic regressions, with impulsivity as a continuous independent variable.

³*P* value based on ordinal logistic regressions, with impulsivity as a continuous independent variable.

Table 5. Multiple logistic regression analyses showing the association between impulsivity and snacking in 48,562 participants (NutriNet-Santé study, 2014).

	Raw model			Adjusted model ¹		
	BIS-11 OR (95% CI)	<i>P</i> ²	<i>P</i> ³	BIS-11 OR (95% CI) ³	<i>P</i> ²	<i>P</i> ³
Overall Snacking						
No	Ref			Ref		
Yes	3.21 (2.90, 3.55)	<0.0001		3.32 (2.99, 3.68)	<0.0001	
Snacking frequencies			<0.0001			<0.0001
Never	Ref			Ref		
< once a week	2.02 (1.79, 2.27)	<0.0001		2.11 (1.87, 2.38)	<0.0001	
≥ once a week (and < once a day)	3.23 (2.90, 3.59)	<0.0001		3.50 (3.13, 3.91)	<0.0001	
≥ once a day	5.71 (5.06, 6.45)	<0.0001		5.64 (4.97, 6.40)	<0.0001	

(*P* values are adjusted for multiple testing with the Holm-Bonferroni method)

¹adjusted for age, gender, education level, occupational status, monthly income per household unit, smoking status, physical activity, history of dieting, and BMI, with impulsivity as a continuous independent variable.

²*P* value based on logistic regressions, with impulsivity as a continuous independent variable.

³*P* value based on ordinal logistic regressions, with impulsivity as a continuous independent variable.

Table 6. Multiple logistic regression analyses showing the association between impulsivity and eating disorders in 48,824 participants (NutriNet-Santé study, 2014).

	Raw model		Adjusted model ¹	
	BIS-11 OR (95% CI)	<i>P</i> ²	BIS-11 OR (95% CI)	<i>P</i> ²
Eating Disorders ³				
No	Ref		Ref	
Yes	3.70 (3.36, 4.06)	<0.0001	3.02 (2.74, 3.33)	<0.0001
Type of Eating Disorder				
No Eating Disorder	Ref		Ref	
Restrictive Disorders	2.23 (1.61, 3.09)	0.0001	1.72 (1.23, 2.42)	0.04
Bulimic Disorders	5.30 (4.47, 6.28)	<0.0001	4.38 (3.66, 5.23)	<0.0001
Hyperphagic Disorders	3.53 (3.12, 4.00)	<0.0001	2.91 (2.56, 3.31)	<0.0001
Other Eating Disorders	2.93 (2.32, 3.70)	<0.0001	2.27 (1.79, 2.88)	<0.0001

(*P* values are adjusted for multiple testing with the Holm-Bonferroni method)

¹adjusted for age, gender, education level, occupational status, monthly income per household unit, smoking status, and physical activity, with impulsivity as a continuous independent variable.

²*P* value based on logistic regressions, with impulsivity as a continuous independent variable.

³Eating disorders correspond to participants with 2 positive answers based on the SCOFF questionnaire