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Individual differences in bitter taste preferences are associated with antisocial personality traits

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32 **Abstract**

33 In two studies, we investigated how bitter taste preferences might be associated with antisocial
34 personality traits. Two US American community samples (total N = 953; mean age = 35.65
35 years; 48% females) self-reported their taste preferences using two complementary preference
36 measures and answered a number of personality questionnaires assessing Machiavellianism,
37 psychopathy, narcissism, everyday sadism, trait aggression, and the Big Five factors of
38 personality. The results of both studies confirmed the hypothesis that bitter taste preferences are
39 positively associated with malevolent personality traits, with the most robust relation to everyday
40 sadism and psychopathy. Regression analyses confirmed that this association holds when
41 controlling for sweet, sour, and salty taste preferences and that bitter taste preferences are the
42 overall strongest predictor compared to the other taste preferences. The data thereby provide novel
43 insights into the relationship between personality and the ubiquitous behaviors of eating and
44 drinking by consistently demonstrating a robust relation between increased enjoyment of bitter
45 foods and heightened sadistic proclivities.

46
47 **Keywords:** Bitter taste preferences, everyday sadism, DarkTriad, aggression, agreeableness

48

Introduction

49 Eating and drinking are universal social phenomena. Although they satisfy the most
50 fundamental human needs, they also relate to a number of more complex psychological
51 phenomena such as morality (Rozin, Haidt, & Fincher, 2009) and emotional distress (Heatherston,
52 Herman, & Polivy, 1991; Ulrich-Lai et al., 2010). Recently, Meier and his colleagues (Meier,
53 Moeller, Riemer-Peltz, & Robinson, 2012) reported that taste preferences are associated
54 with personality processes in that sweet taste preferences were positively linked to prosocial
55 personality characteristics. In this study, we aimed at further investigating the association
56 between the sense of taste and personality traits. Specifically, we set out to investigate to what
57 extent bitter taste preferences are associated with traits related to the darker side of personality.

58 The sense of taste is innately hedonic and biased. A preference for sweet tastes and an
59 aversion to bitter and sour tastes have been demonstrated in human newborns and primate infants
60 and adults (e.g., Cowart, 1981; Rosenstein & Oster, 1988; Steiner, Glaser, Hawilo, & Berridge,
61 2001). Indeed, even oysters (Parker, 1910) and protozoans (Schaeffer, 1905) reject bitter tasting
62 food. These preferences are grounded in omnivore phylogenesis. Survival depends on the
63 consumption of sweet and the rejection of bitter substances, because sweet foods typically feature
64 high caloric density whereas bitterness is often a marker for toxins. Despite these innate reactions
65 to oral intake, however, there are a number of non-biological circumstances that have the
66 potential to diversify our taste preferences throughout the life span. Among them are cultural,
67 social, economic, and health determinants (Birch, Zimmerman, & Hind, 1980; Drewnowski,
68 1997; Higgs, 2015; Rozin & Vollmecke, 1986). Moreover, taste preferences are by far not the
69 only guide to what is actually consumed. One can easily imagine people passing on a preferred
70 food because it is too expensive or because they fear a gain in weight, just as they may consume a
71 non-preferred food in order to eat more healthily or to be social. In fact, some of the most popular

72 foodstuffs such as coffee, wine, beer, and chili pepper are initially aversive to us. Yet,
73 humans acquire liking for originally unpalatable food due to simple mere exposure (Stein, Nagai,
74 Nakagawa, & Beauchamps, 2003), which may be enforced by the abovementioned extrinsic
75 reasons. In these cases the food is not consumed for its actual taste but for its physiological
76 (Goldstein & Kaizer, 1969; Mattes, 1996) or social consequences (Birch et al., 1980; Lesschaeve
77 & Nobel, 2005; Rozin & Zellner, 1985), which may themselves be adaptive behaviors (e.g.,
78 Higgs, 2015).

79 **Personality and Taste**

80 Could it be that the extent to which people learn to relish bitter substances is related to
81 their personality? While there are a variety of studies that suggest a close link between individual
82 differences in taste sensitivity, food consumption, and personality traits, the number of studies
83 investigating taste preferences in relation to personality is quite limited (cf. Elfhag & Erlanson-
84 Albertsson, 2006; Saliba, Wragg, & Richardson, 2009). Supertasting, that is, having a high
85 sensitivity to bitter compounds, has been consistently linked to increased emotionality in humans
86 and rats (e.g., Dess & Chapman, 1990; Dess & Edelhait, 1998; Macht & Mueller, 2006;
87 Whittemore, 1986). Nontasters, in contrast, report being more relaxed and placid than tasters
88 (Mascie-Taylor, McManus, MacLarnon, & Lanigan, 1983). Increased taste sensitivity to bitter
89 compounds has also been linked to food consumption. For example, children who are tasters of
90 the bitter compound PROP (6-*n*-propylthiouracil) are more likely to pick sweet foods from a
91 varied buffet than are nontasters (K. L. Keller et al., 2014). Recently, C. Keller and Siegrist
92 (2015) reported complex relationships between personality and food consumption. Direct
93 influences included openness to experience promoting the consumption of fruits and vegetables,
94 while the relation between neuroticism and unhealthy food consumption was mediated by
95 overeating behavior. Moreover, rats selectively bred for low saccharin intake have a lower social

96 status in a dyadic interaction with a high saccharin rat (Eaton, Dess, & Chapman, 2012), as well
97 as increased impulsivity and stress vulnerability (Carroll, Morgan, Anke, Parry, & Dess, 2008).
98 However, how sensitive people are to bitter compounds is only weakly related to how much
99 people like and consume bitter foods (e.g., Rozin & Vollmecke, 1986).

100 What do we know about the specifics of the interrelationship between preferences for the
101 different taste categories and personality traits? Sensation seeking is one of the personality
102 characteristics that has often been associated with individual differences in taste preferences. For
103 example, people high in sensation seeking tend to have an increased preference for spicy food
104 (e.g., Byrnes & Hayes, 2013; Logue & Smith, 1986; Ludy & Mattes, 2012; Terasaki & Imada,
105 1988) and for caffeine (Mattes, 1994). Additionally, caffeine consumption is positively correlated
106 with other facets of sensation seeking behavior, such as experience seeking and disinhibition
107 (Mattes, 1994). Increased preferences for sweet foods appear to co-occur with higher levels of
108 agreeableness (Meier et al., 2011) and trait neuroticism (K. L. Keller et al., 2014; Kikuchi &
109 Watanabe, 2000). Similarly, a preference for sweet white wine over dry white wine is associated
110 with more trait neuroticism and lower levels of openness (Saliba et al., 2009). Overall, some
111 connection between taste preferences and personality has been established, yet the evidence is
112 still scarce.

113 **Rationale of the Present Research**

114 The present research further investigates the relationship between general taste
115 preferences and personality. There is growing evidence that food preferences are genetically
116 influenced (Breen, Plomin, & Wardle, 2006; Falciglia & Norton, 1994). Moreover, abundant
117 findings show that earliest taste experiences in utero influence the development of food
118 preferences (see Ventura & Worobey, 2013, for a review). In particular, studies by Mennella and
119 her colleagues (e.g., Mennella & Castor, 2012; Mennella, Griffin, & Beauchamps, 2004;

120 Mennella, Jagnow, & Beauchamp, 2001) demonstrated that prenatal and early taste experiences
121 are critical in shaping taste preferences, possibly throughout the life span. Thus, taste preferences
122 feature a substantial genetic and ontogenetically old basis.

123 Although the experience of taste is conceptually different from the preference for tastes,
124 the psychological effects of taste experience may provide information about the co-development
125 of taste preferences and personality. Ventura and Worobey (2013) reviewed a host of findings
126 showing that prenatal and early childhood taste experiences are a crucial determinant of taste
127 preferences. Due to this empirical relationship between taste experience and preference, it seems
128 important to consider research that addresses the psychological consequences of taste
129 experiences. Specifically, taste experiences as induced in laboratory studies yield a first hint as to
130 the immediate causal effects of oral intake.

131 Most notably, sweet taste experiences increased self-reported agreeableness and the
132 intention to help (Meier et al., 2011, Studies 4 and 5) and decreased death anxiety (Hirschberger
133 & Ein-Dor, 2005), whereas bitter taste experiences were shown to elicit harsher moral judgments
134 (Eskine, Kacinik, & Prinz, 2011) and interpersonal hostility (Sagioglou & Greitemeyer, 2014). If
135 a one-time, minor taste experience—even of a palatable, good-tasting stimulus (see Sagioglou &
136 Greitemeyer, 2014, Study 2)—increases hostility, it is readily conceivable that this association
137 becomes chronic in people with more pronounced preferences for bitter substances. Moreover,
138 hostile and aggressive behaviors are manifestations of various malevolent personality traits, such
139 as the Dark Triad (e.g., Furnham, Richards, & Paulhus, 2013; Reidy, Zeichner, & Seibert, 2011).
140 The Dark Triad is a personality construct that comprises subclinical levels of Machiavellianism,
141 psychoticism, and narcissism (Paulhus & Williams, 2002). Importantly, a recent meta-analysis
142 (O’Boyle, Forsyth, Banks, Story, & White, 2014) confirmed that hostility is an important factor
143 underlying the Dark Triad traits. Thus, if increased liking of bitter substances is indeed linked to a

144 more hostile personality, this is likely to be expressed in a variety of “*interpersonally toxic*
145 *behaviors*” (Furnham et al., 2013, p. 210). Originally, this included the three traits of
146 Machiavellianism, psychopathy and narcissism, but studies by Chabrol and colleagues provided
147 first evidence that sadism constitutes a fourth unique component of noxious personality traits
148 (Chabrol, Van Leeuwen, Rodgers, & Séjourné, 2009). Borrowing the term from Paulhus and
149 Williams (2002), they called this extension of the Dark Triad “the Dark Tetrad” (Chabrol et al.,
150 2009, p. 738). Recently, studies by Buckels et al. confirmed the unique power of everyday
151 sadistic tendencies to predict specific forms of aggressive behavior (Buckels, Jones, & Paulhus,
152 2013), which further supports the usefulness of the Dark Tetrad concept.

153 Taken together, general taste preferences—unlike preferences for specific food items—
154 develop very early in life (e.g., Mennella & Castor, 2012). Moreover, these early taste
155 experiences are likely to influence taste preferences throughout the life span (Mennella et al.,
156 2004). Experiencing bitter tastes thus simultaneously contributes to the development of a
157 preference for bitter substances and evokes hostile reactions towards the stimulus, even when
158 perceived as palatable. Based on this reasoning, an increased preference for bitter taste should be
159 related to a more hostile personality. The present studies were conducted to test this notion—that
160 a liking of bitter tastes is associated with an increased presence of antisocial personality traits.

161 Study 1

162 Study 1 examined the relation between bitter taste preferences and antisocial psychological
163 propensities in a cross-sectional design. In the literature, taste and food preferences are often
164 measured differently and thus refer to different phenomena (Drewnowski, 1997). Sometimes it is
165 specific food items that are tasted by participants and subsequently rated, while at other times it is
166 simple solutions that are used as stimuli. Thereby, taste differences covary with the complexity of
167 the stimulus. With again other measurements, participants do not actually taste the stimulus, but

168 instead indicate their liking on a checklist of items, which assesses the attitude towards the
169 semantic stimulus and not hedonic ratings of the actual food item. It is important to note that this
170 research used solely self-reported likability of food names, and that no actual food stimuli were
171 administered to participants. The term taste preference thus refers to the likability rating of the
172 verbal concept of the taste category and food items, respectively (cf. Drewnowski, 1997, p. 241).

173 It was hypothesized that bitter taste preferences would be positively associated with
174 the Dark Tetrad personality traits (i.e., the Dark Triad and everyday sadism; Buckels et al., 2013;
175 Chabrol et al., 2009; Paulhus & Williams, 2002). Furthermore, we assessed the related constructs
176 of trait aggression and agreeableness (cf., O'Boyle et al., 2014). Being agreeable means to be
177 altruistic, empathic, kind, trustworthy, and compliant. Naturally, the extent to which a person is
178 agreeable is inversely related to that person's Dark Tetrad characteristics. Moreover, differences
179 in agreeableness explain substantial portions of the variance in the Dark Triad traits (O'Boyle et
180 al., 2014). To examine the predictive power of bitter in relation to sweet, sour, and salty
181 preferences, participants indicated all of their general taste preferences. Moreover, as previous
182 research (Meier et al., 2012) used preference ratings for sample items of each taste category, we
183 decided to additionally use such a food-specific measure of taste preferences. However, we had
184 some methodological concern regarding the bitter items on this list, because it seemed unclear as
185 to how bitter these items actually taste in the way they are typically consumed. For example, tea
186 is often consumed sweetened and thus its bitter taste is likely to be masked (Drewnowski &
187 Gomez-Carneros, 2000). Similarly, cottage cheese seems to taste more salty than bitter and
188 ginger ale predominantly sweet. Thus, due to the bitter items' poor face validity, we refrained
189 from formulating precise predictions regarding them. Moreover, previous research has shown that
190 assessing taste preference is not a simple endeavor. For example, many preference measures

191 often yield low reproducibility or are influenced by social desirability (Asao, Luo, & Herman,
192 2012). Thus, we included this list for exploratory reasons.

193 Finally, we briefly assessed the Big Five personality dimensions for overall consistency
194 checks (cf. O'Boyle et al., 2014). The Big Five is arguably the most dominant model in
195 personality psychology (Costa & McCrae, 1992; McCrae & Costa, 2008). Each of the five factors
196 encompasses a number of often co-occurring, more specific characteristics. They are typically
197 labeled openness to experience (e.g., wide interests, imaginative), conscientiousness (e.g.,
198 organized, planning), extraversion (e.g., assertive, talkative), agreeableness (e.g., kind,
199 sympathetic), and neuroticism (e.g., moody, anxious). They are an empirically based taxonomy
200 of personality traits, derived statistically through factor analysis. Thus, they are very likely to
201 occur together, but this is not necessarily so. For example, a person who often is moody is, not
202 necessarily but very likely, also anxious.

203 **Method**

204 **Participants.** We recruited 500 participants via Amazon Mechanical Turk (MTurk) for a
205 study on personality and taste preferences. MTurk is an online labor marketplace that is
206 commonly used in psychological research. The data has been reported to be of high quality
207 compared to both offline and other online methods (for a detailed evaluation of MTurk as a data
208 collection instrument, see Buhrmester, Kwang, & Gosling, 2011; Paolacci, Chandler, & Ipeirotis,
209 2010). In accordance with online payment norms, they received US\$0.60 for completing the
210 survey. Four additional people completed the survey without taking the payment, which left us
211 with a final sample of 504 participants (247 female; 257 male) with a mean age of 34.71 years
212 ($SD = 11.54$; range = 18-74 years). A major advantage of MTurk participants is the fact that they
213 constitute a representative community sample compared to undergraduate university students.
214 This heterogeneity was reflected in participants' age range and their diverse educational

215 backgrounds. Specifically, 117 people completed high school, 149 people completed some
216 college, 175 people obtained a Bachelor's degree, 53 people had a Master's degree, and 9 people
217 a Ph.D. degree.

218 **Materials and procedure.**At first, participants indicated their preference of various food
219 items representing sweet (e.g., candy, chocolate cake), sour (e.g., lemons, vinegar), salty (e.g.,
220 beef jerky, bacon), and bitter tastes (e.g., coffee, radishes). The list of items was taken from
221 Meier et al. (2012, p. 166), with the only difference being that we did not assess the preference for
222 spicy items. This amounted to a total of 40 items, with 10 items per taste category, presented in
223 randomized order. All items were listed on one survey page and participants indicated their liking
224 of each food item on 6-point scales ranging from 1 (*Dislike Strongly*) to 6 (*Like Strongly*). Mean
225 scores were calculated (sweet items: Cronbach's $\alpha = .81$; bitter items: $\alpha = .73$; sour items: $\alpha = .71$;
226 salty items: $\alpha = .71$), and we refer to these mean scores as the food-specific measure of taste
227 preferences. Next, participants indicated on the same 6-point scales how much they generally
228 liked sweet, sour, salty, and bitter foods and drinks, respectively. We refer to these four items as
229 the general measure of taste preferences.

230 As the first personality measure, participants completed the short form of the Buss-Perry
231 aggression questionnaire (BPAQ-SF; $\alpha = .91$). The original version was developed by Buss and
232 Perry (1992) and consisted of 29 items and was later shortened to a concise 12-item measure
233 (Bryant & Smith, 2001). The questionnaire assesses four dimensions of aggression, namely,
234 verbal aggression, physical aggression, anger, and hostility. Items of the short form include "*I*
235 *have threatened people I know.*" and "*Given enough provocation, I may hit another person.*," to
236 which participants respond on 5-point scales ranging from 1 (*Very unlike me*) to 5 (*Very like*
237 *me*). Scores of all items are collapsed into one average aggression score.

238 The second personality measure was the 12-item DarkTriad measure developed by
239 Jonason and Webster (2010). Specifically, this measure assesses the three socially undesirable
240 personality traits of Machiavellianism ($\alpha = .88$; e.g., “*I tend to manipulate others to get my*
241 *way.*”), psychopathy ($\alpha = .86$; e.g., “*I tend to be callous or insensitive.*”), and narcissism ($\alpha = .87$;
242 e.g., “*I tend to want others to pay attention to me.*”) with four items per trait. Answers were given
243 on a 9-point scale ranging from 1 (*Disagree strongly*) to 9 (*Agree strongly*). These personality
244 traits are argued to overlap, but yet be distinct psychological constructs (e.g., Paulhus &
245 Williams, 2002). For this reason, mean scores are assessed by the trait and treated as separate
246 variables.

247 Next, participants completed the ten-item personality inventory (TIPI) developed by
248 Gosling and colleagues (Gosling, Rentfrow, & Swann, 2003). This inventory is a very brief
249 measure of the Big Five personality dimensions. The TIPI assesses each factor with two items,
250 and one of each pair is reversely phrased. Answers are given on 7-point scales ranging from 1
251 (*Disagree strongly*) to 7 (*Agree strongly*). Means are calculated per trait, rendering five average
252 scores. As is not unusual with such brief measures, internal consistency scores were low for some
253 of the scales (extraversion: $\alpha = .79$; agreeableness: $\alpha = .54$; conscientiousness: $\alpha = .60$; emotional
254 stability: $\alpha = .74$; openness: $\alpha = .53$).

255 As the last personality measure, participants completed the Comprehensive Assessment of
256 Sadistic Tendencies (CAST; $\alpha = .91$) developed by Buckels and Paulhus (2013). This measure
257 assesses verbal (e.g., “*When making fun of someone, it is especially amusing if they realize what*
258 *I’m doing.*”), physical (e.g., “*I enjoy tormenting people.*”), and vicarious everyday sadism (e.g.,
259 “*I sometimes replay my favorite scenes from gory slasher films.*”), with a total of 18 items.
260 Answers are rendered on 5-point scales from 1 (*Strongly disagree*) to 5 (*Strongly*
261 *agree*). Respective items were reverse-scored and a mean everyday sadism score was calculated.

262 Finally, participants responded to a number of demographic variables, such as their sex, age, and
263 nationality.

264 **Results**

265 We conducted all analyses separately for the two measures of taste preferences. First,
266 results of the general taste preference measure are reported. This includes bivariate correlations
267 and multiple regression analyses. In the regression analyses, taste preferences are treated as a
268 predictor of personality characteristics, because we were interested in the extent to which bitter
269 taste preferences are associated with antisocial personality variables when controlling for the
270 impact of the other taste preferences (i.e., sweet, sour, salty). As discussed in the Introduction,
271 many of the relationships between taste and personality are likely to be reversed or bidirectional.
272 Hence, although we use taste preferences as the independent variables, we do not suggest that this
273 is the only pathway of influence.

274 Second, we report the same analyses for the food-specific taste preference measure. All
275 bivariate correlations reported in this article were performed by controlling for a false discovery
276 rate (Benjamini & Hochberg, 1995) of no more than 0.05. The false discovery rate controls for
277 falsely rejected null hypothesis, that is, for Type I error, and is especially relevant when running
278 multiple comparisons. Thus, the significance of the correlation coefficients reported here relies on
279 a false discovery rate rather than standard significance tests. Finally, as this was an online study
280 that relied solely on self-reported measures, we performed consistency checks to evaluate the
281 quality of our data. These are reported in the last section. The same structure and method of
282 analyses apply to Study 2.

283 **General measure of taste preferences.** Means, standard deviation, and bivariate
284 correlations of the four taste types and all personality measures are shown in Table 1. In line with
285 our hypothesis, general bitter taste preferences were positively associated

286 with psychopathy, everyday sadism, trait aggression, and negatively associated with
287 agreeableness. Moreover, bitter taste preferences were significantly correlated with the other taste
288 preferences (although negatively with sweet taste preferences). They were most strongly
289 correlated with sour preferences, which themselves were significantly positively correlated with
290 trait aggression and everyday sadism. Thus, we conducted separate multiple linear
291 regression analyses with each of the antisocial personality variables that were significantly
292 correlated with bitter taste preferences (i.e., psychopathy, everyday sadism, trait aggression, and
293 agreeableness) as criteria and with the four taste preferences as predictor variables. The regression
294 analyses for psychopathy and everyday sadism are detailed in Table 2a; the regression analyses
295 for aggression and agreeableness are detailed in Table 2b. For sadism and psychopathy bitter
296 taste preferences were the strongest and only significant predictor. For aggression
297 and agreeableness there were no significant predictors. Overall, it appears that bitter taste
298 preferences had the most robust association with participants' expressions of an antisocial
299 personality.

300 **Food-specific measure of taste preferences.** We also calculated the correlations of the
301 food-specific taste preference measure and personality traits (see Table 1). Mean bitter food
302 preferences were significantly positively correlated only with openness, but not with any of the
303 antisocial personality variables. Next, we examined whether we could replicate findings from
304 Meier et al. (2012, Study 2). Indeed, sweet taste preferences and agreeableness were significantly
305 positively correlated, $r(504) = .16, p < .001$. Moreover, this association held when controlling for
306 the other three taste categories, $r(499) = .15, p = .001$.

307 **Consistency checks.** To validate the coherence of our data, we conducted consistency
308 checks regarding the Dark Triad measures and the Big Five factors. Our findings were clearly in
309 line with the results of the meta-analytic review by O'Boyle and colleagues (2014). For

310 Machiavellianism, our results yield especially high congruency, in that it was negatively
311 associated with emotional stability, agreeableness, and conscientiousness. Similarly, psychopathy
312 showed negative correlations with agreeableness, conscientiousness, and openness. Again
313 confirming the meta-analysis, narcissism was positively associated with extraversion and
314 negatively with agreeableness. Counter to the meta-analytic results, narcissism was positively
315 related to neuroticism, which, however, confirms some of the previous literature (e.g., Campbell
316 & Miller, 2013). Thus, the overall correlations between the Big Five factors and the Dark Triad
317 measures were consistent with those reported in the meta-analysis. Moreover, our findings affirm
318 that agreeableness is a key correlate of the Dark Triad. It is of further importance that out of the
319 Big Five agreeableness was the only factor that was associated with general bitter taste
320 preferences, which further suggests that bitter taste preferences are specifically linked to people's
321 dark side of their personality.

322 **Discussion**

323 This first study showed the expected correlations between general bitter taste preferences
324 and a number of noxious personality and behavioral tendencies. Specifically, psychopathy,
325 everyday sadism, and trait aggression were significantly positively correlated, and agreeableness
326 was significantly negatively correlated with general bitter taste preferences. The most robust
327 associations were found for everyday sadism and psychopathy, which held even after controlling
328 for the other taste preferences. In fact, general bitter taste preferences were the strongest predictor
329 compared to the other taste preferences. Taken together, the results suggest that how much people
330 like bitter tasting foods and drinks is stably tied to how dark their personality is. The results of
331 the food-specific bitter preference measure did not reveal any significant correlations with an
332 antisocial personality trait.

333 To target whether this inconsistency between the taste preference measures is linked to
334 the hypothesized issues regarding the bitter items, we conducted a second study that included
335 taste ratings for each of the items. The fact that openness to experience was positively correlated
336 with the food-specific measure of bitter taste preferences indirectly replicates previous findings
337 that openness to experience is associated with increased vegetable and fiber consumption (De
338 Bruijn, Kremers, van Mechelen, & Brug, 2005; Goldberg & Strycker, 2002; C. Keller & Siegrist,
339 2015), which often taste bitter, and that caffeine intake is positively associated with experience
340 seeking and sensation seeking (Mattes, 1994).

341 Study 2

342 Method

343 **Participants.** We recruited 500 participants via MTurk for a study on personality and taste
344 preferences in exchange for US\$1. Eight participants did not submit their results for approval and
345 thus participated unpaid. We then checked for double participation regarding our Study 1. Indeed,
346 of the 500 participants, 59 had already participated in our Study 1. They were thus excluded from
347 the analysis. This left us with a final sample of 449 participants (214 female; 235 male) with a
348 mean age of 36.58 years ($SD = 11.35$; range = 19-75 years). As in our first study, the sample
349 varied in their level of age and educational attainment. Specifically, 119 people completed high
350 school, 115 people completed some college, 159 people obtained a Bachelor's degree, 49 people
351 had a Master's degree, and 7 people had a Ph.D. degree.

352 **Materials and procedure.** The materials and procedure were very similar to that used in
353 Study 1.¹ We reduced the food item list down to 20 items, assessing only the preference for sweet
354 and bitter items (sweet items: $\alpha = .72$; bitter items: $\alpha = .72$). Moreover, we added an “I don’t have
355 an opinion” option to each of the 20 food items and assessed people’s sweetness, sourness,
356 saltiness, and bitterness ratings of each of these items. We included this modification to further
357 investigate the divergence of the food-specific preferences and the general taste category ratings.
358 A reason for this divergence could be related to the way the food is consumed. Drinking coffee
359 with sugar and milk, for example, successfully masks most of its bitterness. Similar adjustments
360 in preparation can lead to a number of items losing its originally bitter taste. We thus additionally
361 assessed taste ratings of the food items. Another modification was a split of our general measure
362 of bitter taste into two variables. Specifically, we asked participants for their preference of foods
363 and drinks separately to increase reliability of this variable. We then calculated a mean score for
364 each of the taste categories. Bitter ($\alpha = .74$), sweet ($\alpha = .71$), and sour ($\alpha = .69$) taste preferences
365 yielded acceptable reliability rates, while salty taste preferences did not ($\alpha = .29$; somewhat
366 expectedly due to a lack of salty drinks). Therefore, only salty foods were included in the
367 subsequent analyses. The personality variables were assessed exactly as in Study 1 and reliability
368 scores were very similar (Machiavellianism: $\alpha = .87$; psychopathy: $\alpha = .83$; narcissism: $\alpha = .89$;
369 sadism: $\alpha = .89$; aggression: $\alpha = .90$; extraversion: $\alpha = .75$; agreeableness: $\alpha = .53$;
370 conscientiousness: $\alpha = .57$; emotional stability: $\alpha = .74$; openness: $\alpha = .55$).

371 **Results**

¹ We combined three studies under one link. Specifically, apart from the measures relevant to this study that are described in detail in the main text, participants responded to differential measures of approach and avoidance personality traits and to socioeconomic status items.

372 **General measure of taste preferences.** Descriptive statistics and intercorrelations of the
373 four taste types and all personality measures are shown in Table 3. The results mostly replicate
374 our findings from the first study, in that bitter taste preferences were positively associated with
375 psychopathy and everyday sadism, and negatively associated with agreeableness. In contrast to
376 Study 1, trait aggression was not significantly correlated with bitter taste preferences, whereas
377 Machiavellianism and narcissism now were. We again calculated separate multiple linear
378 regression analyses for each of the significantly-associated personality variables as the criteria
379 and with the four taste preferences as predictor variables. Bitter taste preferences remained a
380 significant predictor in all regressions except for agreeableness. Moreover, all regression
381 equations were significant. The detailed coefficients and statistics for the Dark Tetrad variables
382 and agreeableness can be found in Tables 4a and 4b. Further differences to our initial results
383 emerged: Sweet preferences were the only significant predictor of agreeableness (which is in line
384 with Meier et al., 2012), and salty taste preferences were a significant negative predictor of
385 everyday sadism. There were no other significant predictors.

386 **Food-specific measure of taste preferences.** The correlational pattern of food-
387 specific bitter taste preferences and the personality measures was again different from the pattern
388 of the general measure. Mean bitter preferences were significantly positively correlated with
389 extraversion, $r(449) = .13, p = .008$, and openness, $r(449) = .16, p = .001$. To further investigate
390 this discrepancy between general and food-specific measures of bitter taste preferences, we
391 looked at the taste ratings of the bitter items. The results showed that of the 10 bitter items, only
392 half were perceived as predominantly bitter. Specifically, for coffee, beer, radishes, tonic water,
393 and celery, bitterness received the highest rating and was significantly different from the second
394 highest taste category (all $p < .001$). For cottage cheese, ginger ale, grapefruit juice, rye bread, and
395 tea, however, bitterness did not receive the highest rating. T-tests for dependent samples showed

396 that these items were rated to be significantly less bitter than the respective highest rated taste
397 category (all $p < .001$). Based on these taste ratings, we combined the five items that were rated as
398 mainly bitter into a composite bitter food preference score ($\alpha = .57$), and calculated correlations
399 with all personality measures and sweet food preferences.² Descriptive statistics and bivariate
400 correlations are displayed in Table 3. The correlations of this new bitter taste preference score did
401 not substantially differ from the overall food-specific preference score. Extraversion and openness
402 remained significant Big Five correlates of food-specific bitter preferences. Agreeableness was
403 significantly positively correlated with sweet food preferences, but not with bitter preferences.
404 Bitter food preferences remained a significant predictor of extraversion, $\beta = .17$, $t = 3.52$, $p <$
405 $.001$, and openness to experience, $\beta = -.15$, $t = 3.15$, $p = .002$, while sweet food preferences did
406 not, and the regression equations were significant, $R^2 = .029$, $F(2, 446) = 6.66$, $p = .001$ for
407 extraversion, and $R^2 = .022$, $F(2, 446) = 4.99$, $p = .007$ for openness.

408 Finally, we again tested whether we could replicate findings from Meier et al. (2012,
409 Study 2). Indeed, sweet food preferences and agreeableness were significantly positively
410 correlated. Moreover, this association remained identical when controlling for bitter food
411 preferences, $r(446) = .12$, $p = .013$.

412 **Consistency checks.** As in Study 1, we conducted consistency checks regarding the Dark
413 Triad measures and the Big Five factors. Our findings are clearly in line with our first findings
414 and thus again confirm the results of the meta-analysis by O'Boyle and colleagues (2014).
415 Specifically, Machiavellianism was negatively correlated with agreeableness, conscientiousness,
416 and emotional stability. Psychopathy had significant negative correlations with all personality

²All ten sweet items were clearly rated as predominantly sweet (all $p < .001$) and were thus left combined.

417 measures except extraversion. Finally, narcissism showed significant negative correlations with
418 agreeableness, conscientiousness, and emotional stability. This correlational pattern clearly points
419 to the consistency of our data. Moreover, general bitter taste preferences were negatively
420 associated with expressions of agreeableness but with none of the other Big Five measures,
421 which again points to the specific relation between bitter taste preferences and noxious
422 personality expressions.

423 **Discussion**

424 Most of the results from our second study were in line with the first study, again
425 confirming the hypothesis that general bitter taste preferences are associated with malevolent
426 personality traits. This study revealed even more robust associations that remained strong and
427 significant when controlling for the other taste categories. We were unable to confirm the
428 association with trait aggression. As this correlation was already minor in the first study, this
429 result is not too surprising. The relation to trait aggression must therefore be regarded as
430 inconclusive. Considering the sample size, this is not a matter of a lack of statistical power. Thus,
431 if there is a relationship, it is small and not reliable. Additionally, this study revealed a
432 comparably strong association with narcissism—a relation that was close to zero in the first
433 study. Although this correlation appeared as robust in this study, the conclusion that narcissism is
434 associated with bitter taste preferences must be regarded as tentative. Finally, in a regression
435 analysis that included all taste preferences as predictor variables, sweet taste preferences were a
436 significant predictor of agreeableness. In sum, general bitter taste preferences emerged as a robust
437 predictor for Machiavellianism, psychopathy, narcissism, and everyday sadism.

438 The food-specific measure of bitter preferences again revealed correlations inconsistent
439 with the general measure. To examine this inconsistency, we assessed taste ratings of the bitter
440 items. We supposed that some of the bitter food items might not be rated as mainly bitter.

441 Although, as expected, half of the bitter items were not perceived as predominantly bitter, the
442 mean preference score of the remaining five food items did not reveal correlations with any of the
443 Dark Tetrad measures either. Overall, this restrains us from drawing conclusions regarding why
444 the food-specific measure yielded such different results. Finally, the food-specific bitter preference
445 score was reliably correlated with openness to experience, reconfirming previous research (De
446 Bruijn et al., 2005; Goldberg & Strycker, 2002; C. Keller & Siegrist, 2015; Mattes, 1994).

447 **General Discussion**

448 The present results provide the first empirical evidence for the hypothesis that bitter taste
449 preferences are linked to malevolent personality traits. This hypothesis was largely deduced from
450 previous research showing that sweet taste experiences are related to personality processes (e.g.,
451 Meier et al., 2011) and, in particular, that bitter taste experiences are causally linked to hostile
452 thoughts and behavior (Sagioglou & Greitemeyer, 2014). We reasoned that this power of taste
453 experiences to elicit hostile behavior would be paralleled by a chronic association, in that
454 increased preferences for bitter tastes would be related to elevated levels of malevolent
455 personality traits. The two studies confirm the presence of a stable association when testing a
456 large community sample with substantial variety in age and educational level. Particularly robust
457 associations were found for everyday sadism, which was significantly predicted by general bitter
458 taste preferences when controlling for third variables across both studies. Overall, for the general
459 preference measure, Study 2 yielded more robust associations than did Study 1. Specifically, all
460 DarkTetrad traits were significantly associated with bitter taste preferences when controlling for
461 other taste preferences.

462 To our knowledge, this is the first research linking taste preferences to
463 antisocial personality traits. Overall, research relating what people like to eat to their personality is
464 still in its early stages. This is somewhat surprising, considering that eating and drinking are such

465 ubiquitous and universal phenomena. In his comprehensive review, Funder (2001) has criticized
466 the lack of substantive research linking personality to basic, real-world phenomena. Taste
467 preference can certainly be regarded as a real-world aspect of life. In fact, although the study of
468 the sense of taste may primarily fall under the purview of the biochemical sciences, it has often
469 been argued to be much more than a mere chemosensory system (e.g., Eaton et al., 2012). Quite
470 possibly, the modern *Homo sapiens*' complex emotional system may be built on the evolutionary
471 rudiment of affective responses to oral intake (Dess, 1991; Garcia & Hankins, 1975; Rozin,
472 1999). Taste preferences may thus figure similarly prominently in the development of
473 personality.

474 **Limitations and outlook**

475 The present studies employed two complementary measures of bitter taste preferences.
476 While one measure was general in nature asking participants straightforward questions regarding
477 their preference for bitter, sweet, sour, and salty foods and drinks, respectively, the other measure
478 assessed preferences more specifically by measuring the preference for several sample food items
479 in each category. This measure was more indirect, because the items were not explicitly
480 categorized as being bitter, sweet, sour, or salty, and were presented in randomized order, which
481 prevented categorization by the participants. We relied on a list from Meier and colleagues (2012)
482 who used these items in a series of studies on personality and sweet taste preferences. Whereas
483 each of the sweet items were rated as distinctly sweet, the bitter items were not. We supposed that
484 this invalidity of selected bitter items contributed to the discrepancy between the findings by the
485 food-specific and the general measure. We did not find support for this assumption, as the
486 composite measure that excluded the five items that were not rated as predominantly bitter yielded
487 similar results to the composite measure that included all ten items. This is in line with the

488 finding that general taste preferences and specific food preferences are not necessarily congruent
489 (Frank & van der Klaauw, 1994).

490 Further inconsistencies between the general and food specific measure arose. First, only
491 the general taste preference measure was associated with less agreeableness. This raises questions
492 as to which specific connotation of the general measure produced this correlation. We can only
493 speculate about an answer. Possibly, this measure targeted a specific stereotype that people who
494 like bitter foods also have a bitter personality. That is, participants may have based their
495 judgment of agreeableness (i.e., how “critical, quarrelsome”, and how “sympathetic, warm” they
496 perceived themselves) on their previously indicated preference for bitter foods. The stereotypic
497 and linguistic connection of bitterness to disagreeable personality characteristics may thus have
498 yielded this association. The fact that only the food-specific measure replicated previously
499 reported correlations between bitter taste preferences and openness to experience tentatively
500 supports the notion that our general measure may have captured the stereotype more than actual
501 liking.

502 Moreover, only everyday sadism (and with a strong tendency psychopathy) was
503 consistently and robustly associated with general bitter taste preferences. This finding seems
504 particularly intriguing in a number of ways. For one, everyday sadism and psychopathy, but not
505 other antisocial personality traits, are related to unprovoked aggression (Book & Quinsey, 2004;
506 Buckels et al., 2013; Jones & Paulhus, 2010). This parallels findings from experimental research
507 showing that bitter taste experiences led to unprovoked hostility toward a research assistant
508 (Sagioglou & Greitemeyer, 2014, Study 3). Moreover, everyday sadists by definition ascribe a
509 positive valence to negative stimuli. Developmentally, this may be due to frequently experiencing
510 bitter tastes in a positive social environment (cf. Johnson, Bellows, Beckstrom, & Anderson,
511 2007). This may result in an ambivalence contributing to everyday sadistic tendencies: perceiving

512 the bitter stimulus in a reinforcing context while at the same time sensing the need to reject it.
513 Also, in preferring bitter tasting foods more than less sadistic people, everyday sadists may
514 perceive them as positive due to their potential to cause distaste, that is, to cause a negative
515 experience in other people. There are findings that support this reasoning to some extent. Macht
516 and Mueller (2006) examined how emotional reactions to an anger-inducing (a woman being
517 raped) versus a sadness-inducing (a boy crying at the loss of his father) versus a neutral film clip
518 varied depending on the sensitivity to the bitter tasting compound PROP. They found that people
519 highly sensitive to PROP, that is, people who typically show lower acceptance of bitter foods
520 (Drewnowski, Henderon, & Shor, 1997; Duffy & Bartoshuk, 2000; K. L. Keller, Steinmann,
521 Nurse, & Tepper, 2002), were more emotionally aroused by the anger-inducing film clip than
522 were people who were less sensitive to PROP. Importantly, PROP supertasters responded with
523 less joy and decreased mood and an increase in negative emotions towards the film clip than their
524 less-tasting counterparts. This pattern unfolds a particular positive relationship between less
525 sensitivity to, and thereby, increased liking of bitter foods, and enjoyment of sadistic content (but
526 see also Herbert, Platte, Wiemer, Macht, & Blumenthal, 2014, who attribute this connection to a
527 phylogenetically-based functional relationship). Whether this connection holds for bitter taste
528 preferences in particular remains for future research to investigate. Similarly, it seems an
529 intriguing endeavor to investigate this relation experimentally. Based on the correlational patterns
530 of these findings, inducing bitter taste experiences may increase variants of sadistic behavior, that
531 is, physical sadism, verbal sadism, and vicarious sadism, such as the enjoyment of violent media
532 (see Buckels and Paulhus, 2013; Greitemeyer, 2015).

533 A further limitation of this study is that both taste preference measures relied on self-
534 reports. Yet, studies using hedonic methods (where participants first try and then rate stimuli) and
535 those using self-report ratings have yielded similar results in the past (e.g., Davis, Strachan &

536 Berkson, 2004; Saliba et al., 2009). Furthermore, hedonic preference methods would not allow
537 for online testing, which would naturally limit the representational quality and size of the sample,
538 and thereby introduce new issues. Nevertheless, it certainly seems a promising endeavor for
539 future research to re-examine the present hypothesis with hedonic taste ratings in the laboratory.
540 This could reveal whether the preferences for different bitter foods differentially predict
541 malevolent personality traits. Moreover, in light of the findings by Macht and Mueller (2006) it
542 appears intriguing to investigate how sensitivity to bitter compounds may inform an increased
543 development of antisocial personality traits. Taste sensitivity itself is genetically determined and
544 has been linked to a number of personality variables such as increased emotional reactivity. Thus,
545 there may be more factors on the food-related side that relate to the development of an antisocial
546 personality.

547 **Conclusions**

548 The present research has demonstrated that bitter taste preferences are associated with
549 more pronounced malevolent personality traits, especially robustly with everyday sadism. The
550 sample was a large community sample, thereby representing a wide section of the population.
551 Clinical research revealed that one typical behavioral manifestation of psychopathy is unusually
552 intense eye contact (Kosson, Steuerwald, Forth, & Kirkhart, 1997; Rimé, Bouvy, Leborgne, &
553 Rouillon, 1978). In establishing a robust link between taste preferences and personality traits, this
554 research reveals furtherreal-world behavioral correlates of antisocial personality traits.

555

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Conflict of interest

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Table 1. Means, standard deviations, and bivariate correlations among variables (Study 1)

<i>Variable</i>	<i>M</i>	<i>SD</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>	<i>10</i>	<i>11</i>	<i>12</i>	<i>13</i>	<i>14</i>	<i>15</i>	<i>16</i>	<i>17</i>	<i>18</i>
1. Bitter foods and drinks	2.78	1.42	—																	
2. Sweet foods and drinks	4.82	1.25	-.15**	—																
3. Sour foods and drinks	3.74	1.32	.36***	.15**	—															
4. Salty foods and drinks	4.61	1.14	.25***	.13**	.18***	—														
5. Mean bitter preferences	3.61	0.87	.46***	-.08	.34***	.17***	—													
6. Mean sweet preferences	4.56	0.74	.02	.58***	.19***	.17***	.34***	—												
7. Mean sour preferences	3.68	0.83	.33***	.08	.45***	.16**	.67***	.48***	—											
8. Mean salty preferences	4.13	0.81	.25***	.17***	.21***	.43***	.47***	.52***	.54***	—										
9. Machiavellianism	3.26	1.94	.10	-.01	.09	.09	.10	-.02	.03	.04	—									
10. Psychopathy	2.84	1.86	.14**	-.06	.07	.07	.07	-.11*	-.04	.01	.66***	—								
11. Narcissism	3.92	1.99	.02	.05	.07	.05	.00	-.04	-.02	-.06	.52***	.41***	—							
12. Everyday sadism	1.77	0.66	.14**	-.06	.11*	-.03	.08	-.09	.01	.02	.62***	.64***	.43***	—						
13. Aggression	2.12	0.83	.11*	.01	.10*	.05	.04	-.03	-.01	.07	.56***	.60***	.42***	.62***	—					
14. Extraversion	3.61	1.75	.06	-.04	-.01	.00	.09	-.02	.03	.03	.07	-.11*	.13**	.07	-.07	—				
15. Agreeableness	5.28	1.33	-.11*	.07	-.07	.01	-.03	.16***	.08	.04	-.46***	-.63***	-.32***	-.47***	-.59***	.09	—			
16. Conscientiousness	5.45	1.29	.00	.01	-.09*	-.03	.04	.13**	.05	.03	-.27***	-.33***	-.20***	-.27***	-.36***	.15**	.36***	—		
17. Emotional Stability	4.95	1.52	-.02	-.06	-.07	-.08	.05	.03	.06	.03	-.24***	-.24***	-.21***	-.13**	-.48***	.18***	.31***	.33***	—	
18. Openness	4.97	1.33	.05	-.00	.09	.02	.17***	.05	.10	.02	-.04	-.15**	-.05	-.08	-.10*	.20***	.18***	.07	.15**	—

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

Table 2a. Multiple regression analysis of dark tetrad factors related to bitter taste preferences (Study 1)

Independent variables	Psychopathy			Everyday sadism		
	R ²	β	t	R ²	β	t
	.024*			.032**		
Bitter foods and drinks		.11	2.18*		.12	2.46*
Sweet foods and drinks		-.06	-1.21		-.04	-.95
Sour foods and drinks		.03	.64		.09	1.81
Salty foods and drinks		.04	.89		-.07	-1.6

Note. * $p < .05$., ** $p < .01$., *** $p < .001$

Table 2b. Multiple regression analysis of trait aggression and agreeableness (Study 1)

Independent variables	Trait aggression			Agreeableness		
	R ²	β	t	R ²	β	t
	.018			.020*		
Bitter foods and drinks		.09	1.77		-.09	1.84
Sweet foods and drinks		.01	.23		.06	1.31
Sour foods and drinks		.07	1.39		-.06	-1.18
Salty foods and drinks		.01	.16		.04	.84

Note. * $p < .05.$, ** $p < .01.$, *** $p < .001$

Table 3. Means, standard deviations, and bivariate correlations among variables (Study 2)

<i>Variable</i>	<i>M</i>	<i>SD</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>	<i>10</i>	<i>11</i>	<i>12</i>	<i>13</i>	<i>14</i>	<i>15</i>	<i>16</i>
1. Bitter foods and drinks	2.46	1.27	—															
2. Sweet foods and drinks	4.71	1.13	-.17***	—														
3. Sour foods and drinks	3.19	1.26	.53***	.11*	—													
4. Salty foods	4.70	1.21	.13**	.24***	.17***	—												
5. Mean bitter preference	3.71	0.89	.36***	-.22***	.25***	.04	—											
6. Mean sweet preference	4.70	0.69	.02	.55***	.22***	.24***	.16**	—										
7. Machiavellianism	3.10	1.82	.18**	-.04	.11*	-.05	.05	-.13**	—									
8. Psychopathy	2.76	1.74	.17***	-.11*	.08	-.09	-.02	-.14**	.64***	—								
9. Narcissism	3.58	1.98	.17***	-.01	.17***	.03	.09	-.02	.55***	.35***	—							
10. Everyday sadism	1.72	0.59	.20***	-.05	.12**	-.13**	.10	-.07	.52***	.54***	.38***	—						
11. Aggression	2.07	0.80	.04	.00	.07	-.02	-.02	-.10	.49***	.53***	.39***	.60***	—					
12. Extraversion	3.50	1.63	.03	-.08	.06	-.08	.16**	-.05	.11*	-.10	.10	.06	-.07	—				
13. Agreeableness	5.19	1.32	-.11*	.11*	-.09	.02	-.01	.12*	-.38***	-.60***	-.27***	-.43***	-.57***	.04	—			
14. Conscientiousness	5.42	1.22	-.05	.04	-.05	-.03	-.06	.07	-.24***	-.28***	-.22***	-.27***	-.33***	.08	.34***	—		
15. Emotional Stability	4.96	1.45	.05	-.04	.03	-.10	.06	.04	-.20***	-.25***	-.20***	-.15**	-.48***	.23***	.37***	.42***	—	
16. Openness	5.02	1.25	.08	-.04	.09*	-.03	.14**	-.01	-.09	-.18***	.04	-.11*	-.14**	.28***	.14**	.07	.20***	—

Note. * $p < .05$., ** $p < .01$., *** $p < .001$

Table 4a. Multiple regression analysis of dark tetrad factors related to bitter taste preferences (Study 2)

Independent variables	Machiavellianism			Psychopathy			Narcissism			Everyday sadism		
	R ²	β	t	R ²	β	t	R ²	β	t	R ²	β	t
	.038**			.042***			.038**			.064***		
Bitter foods and drinks		.17	2.88**		.15	2.67**		.11	1.97*		.19	3.37***
Sweet foods and drinks		.00	0.01		–	–1.32		–	–.08		.01	.26
Sour foods and drinks		.040	.70		.03	.46		.11	1.96		.05	.87
Salty foods		–	–1.68		–	–1.93		–	–.06		–	–3.49***
	.082			.09			.00			.17		

Note. * $p < .05$., ** $p < .01$., *** $p < .001$

Table 4b. Multiple regression analysis of agreeableness
(Study 2)

Independent variables	Agreeableness		
	R ²	β	t
	.025*		
Bitter foods and drinks		-.05	-.81
Sweet foods and drinks		.11	2.21*
Sour foods and drinks		-.08	-1.37
Salty foods		.01	.25

Highlights

- Bitter taste preferences are positively associated with antisocial personality traits
- Bitter taste preferences most robustly predict everyday sadism
- Results suggest close relationship between the gustatory system and personality