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

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Abstract

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

Keywords: Bitter taste preferences, everyday sadism, DarkTriad, aggression, agreeableness

Introduction

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

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

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

Personality and Taste

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

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

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

Rationale of the Present Research

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

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

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

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

more hostile personality, this is likely to be expressed ina variety of "*interpersonally toxic behaviors"* (Furnham et al., 2013, p. 210).Originally, this included the three traits of Machiavellianism, psychopathy and narcissism, but studies by Chabrol and colleagues provided firstevidence that sadism constitutes a fourth unique component of noxious personality traits (Chabrol, Van Leeuwen, Rodgers, & Séjourné, 2009). Borrowing the term from Paulhus and Williams (2002), they called this extension of the DarkTriad "the Dark Tetrad" (Chabrol et al., 2009, p. 738). Recently, studies by Buckels et al. confirmed the unique power of everyday sadistic tendenciesto predict specific forms of aggressive behavior (Buckels, Jones, & Paulhus, 2013), which further supports the usefulness of the DarkTetrad concept.

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

Study 1

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

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

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

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

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

Method

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

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

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

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

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

Next, participants completed the ten-item personality inventory (TIPI) developed by Gosling and colleagues (Gosling, Rentfrow, & Swann, 2003). This inventory is a very brief measure of the Big Five personality dimensions.The TIPI assesses each factor with two items, and one of each pair is reversely phrased. Answers are given on 7-point scales ranging from 1 *(Disagree strongly)*to7 *(Agree strongly).* Means are calculated per trait, rendering five average scores. As is not unusual with such brief measures, internal consistency scores were low for some of the scales (extraversion: α = .79; agreeableness: α = .54; conscientiousness: α = .60; emotional stability: α = .74; openness: α = .53).

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

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

Results

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

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

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

withpsychopathy,everyday sadism, trait aggression, and negatively associated with agreeableness. Moreover, bitter taste preferences were significantly correlated with the other taste preferences (although negatively with sweet taste preferences). They were most strongly correlated with sour preferences, which themselves were significantly positively correlated with trait aggression and everyday sadism. Thus, we conducted separate multiple linear regressionanalyses with each of the antisocial personality variables that were significantly correlated with bitter taste preferences (i.e., psychopathy, everyday sadism, trait aggression, and agreeableness)as criteria and with the four taste preferences as predictor variables.The regression analyses for psychopathy and everyday sadism are detailed in Table 2a; the regression analyses for aggression and agreeableness are detailed in Table 2b. For sadism and psychopathy bitter taste preferences wasthe strongest and only significant predictor. For aggression andagreeablenessthere were no significant predictors. Overall, it appears that bitter taste preferences had themost robust association with participants' expressions of an antisocial personality.

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

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

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

Discussion

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

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

Study 2

Method

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

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

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.

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

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

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

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

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

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

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

Discussion

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

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

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

General Discussion

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

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

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

Limitations and outlook

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

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

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

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

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

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

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

Conclusions

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

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Conflict of interest

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

Variable	*M*	SD	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*
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)

	Psychopathy			Everyday sadism		
Independent variables	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)

	Trait aggression			Agreeableness		
Independent variables	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)

Variable	*M*	SD	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
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)

	Machiavellianism			Psychopathy			Narcissism			Everyday sadism		
Independent variables	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		–.07	–1.32		–.00	–.08		.01	.26
Sour foods and drinks		.040	.70		.03	.46		.11	1.96		.05	.87
Salty foods		–.082	–1.68		–.09	–1.93		–'.00	–.06		–.17	–3.49***

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

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

	Agreeableness		
Independent variables	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