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Disease avoidance and personality: A meta-analysis

Benjamin Oosterhoff [a,*], Natalie J. Shook [b], Ravi Iyer [c]

[a] Montana State University, Department of Psychology, 305 Traphagen Hall, Bozeman, MT 59717, USA
[b] West Virginia University, Department of Psychology, P.O. Box 6040, Campus Drive, Morgantown, WV 26505, USA
[c] Civil Politics Inc., Los Angeles, CA 90066, USA

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ABSTRACT

This study provides a meta-analysis of 21 published and unpublished studies using over 32,000 participants to evaluate how individual differences in disease avoidance (i.e., disgust sensitivity, germ aversion) are correlated with personality factors. Greater disease-avoidance traits were associated with greater neuroticism/emotionality ($r = 0.19$) and conscientiousness ($r = 0.08$), as well as lower openness to experience ($r = -0.11$) and extraversion ($r = -0.04$). Disease-avoidance traits were not significantly associated with agreeableness. Effect sizes were generally consistent across disease avoidance and personality measures and sample characteristics. Findings support behavioral immune system models of disease avoidance and underscore the importance of disease avoidance for behavioral tendencies.

1. Introduction

Over the past 20 years, there has been increased interest in the role of disease avoidance in shaping psychological processes and human behavior (Schaller & Park, 2011; Thornhill & Fincher, 2014). In our ancestral past, disease bearing microbes posed a significant threat to survival and reproduction. To promote fitness, psychological individual differences have evolved to serve disease-avoidance functions. Two commonly studied individual differences in disease avoidance are disgust sensitivity (Tybur, Lieberman, & Griskevicius, 2009) and germ aversion (Duncan, Schaller, & Park, 2009). A burgeoning body of evidence has connected these disease-avoidance indicators to a broad range of psychological processes, including psychopathology, social belief systems, and intergroup relations (see Shook, Oosterhoff, Terrizzi, & Clay, 2017, for a review).

One domain that is beginning to receive considerable attention is the intersection between disease avoidance traits and personality factors. Personality traits represent a distinct set of characteristics thought to organize and guide social beliefs and behavior in a manner that is consistent with individual tendencies (McCrae & Costa, 1999). Systematically linking disgust sensitivity and germ aversion to specific personality characteristics can help to elucidate the broader psychological implications of disease avoidance, indicate evolutionary processes that potentially contribute to personality development, and also inform models of the health implications of personality. Several studies have examined associations between disease-avoidance traits and personality (e.g., Olatunji, Haidt, McKay, & David, 2008; Tybur & de Vries, 2013). However, this research has produced inconsistent or inconclusive results, in that some studies have failed to replicate previously results while others have found evidence of effects in the opposite direction (see Shook et al., 2017). The current study builds on this body of research by presenting a meta-analysis on the intersection between disease-avoidance traits (disgust sensitivity, germ aversion) and basic personality characteristics (openness, extraversion, agreeableness, conscientiousness, neuroticism/emotionality).

1.1. Disease avoidance as an individual difference: A behavioral immune system perspective

Before the advances of modern medicine, parasites and infectious disease were an important determinant of survival and reproductive success. Physical and psychological adaptations are thought to have evolved to counter such threats, producing disease-reactive components of human biology, such as the physiological immune system. The physiological immune system is an effective means of combating many diseases. However, the reactive nature and high metabolic cost of activating the physiological immune system can leave individuals vulnerable to other potential

* Corresponding author at: Montana State University, 305 Traphagen Hall, Bozeman, MT 59717, USA.
E-mail address: benjamin.oosterhoff@montana.edu (B. Oosterhoff).

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threats (Le Vine, Koeningsknecht, & Stark, 2001). To compensate for these weaknesses, psychological processes are thought to have evolved to limit activation of the physiological immune system by reducing exposure to disease-bearing pathogens.

The Behavioral Immune System (BIS; Schaller, 2006) is a suite of psychological processes that evolved to serve a disease-avoidance function. The BIS consists of affective, cognitive, and behavioral processes that detect and respond to potential sources of contamination by preemptively distancing individuals from the perceived source of pathogens (Schaller & Duncan, 2007). The BIS may be activated by a wide range of sensory input that may indicate a pathogenic threat, including olfactory (e.g., the smell of garbage), auditory (e.g., the sound of someone vomiting), tactile (e.g., the feel of sticky substances), visual (e.g., the look of an open wound), or gustatory (e.g., taste of sour milk) stimuli. This sensory input evokes emotional (e.g., disgust; Curtis, Aunger, & Rabie, 2004; Oaten, Stevenson, and Case, 2009) and cognitive (e.g., memory and categorization bias; Miller & Maner, 2011) processes that lead to prophylactic behaviors (e.g., avoidance). Through the early detection and avoidance of potential contaminants, the likelihood of exposure to pathogens and infection is reduced, and the physiological immune system is not fully engaged, thus preserving physiological resources.

Although thought of as a universal system, there is individual variability in the reactivity of the BIS (Schaller & Duncan, 2007). Individuals reliably differ in their levels of disgust sensitivity and germ aversion. Trait-level disgust sensitivity is characterized by the affective disgust-related reaction to objects and situations that may increase exposure to disease-bearing pathogens (Tybur et al., 2009). Trait-level disgust sensitivity is often measured through self-reported ratings of how disgusted individuals find certain concepts or objects (Haidt, McCauley, & Rozin, 1994; Tybur et al., 2009). Similar to disgust sensitivity, germ aversion has been characterized as "aversive affective responses to a situation that connotes a relatively high likelihood of pathogen transmission" (Duncan et al., 2009, p. 542). Measures of germ aversion have participants rate their agreement with statements describing behavioral avoidance of situations that entail pathogen exposure (public restrooms), comfort with germ exposure, and preference for hygienic behaviors (hand washing). Disgust sensitivity and germ aversion are moderately correlated (e.g., Duncan et al., 2009), and they are often both used as indicators of disease avoidance (Terrizzi, Shook, & McDaniel, 2013).

Research on the evolutionary role of disgust sensitivity and germ aversion has received considerable empirical attention. Indeed, disgust sensitivity and germ aversion are thought to play meaningful roles in shaping the functional nature of interpersonal and intergroup relationships (de Barra, DeBruine, Jones, Mahmud, & Curtis, 2013), as well as sociocultural values and beliefs (Terrizzi et al., 2013). Disgust sensitivity and germ aversion may even contribute to the development and maintenance of certain types of psychopathology (Olatunji, Cisler, McKay, & Phillips, 2010). Greater disgust sensitivity has been found to be associated with more prejudicial attitudes (e.g., Terrizzi, Shook, & Ventis, 2010), stronger endorsement of politically conservative attitudes (e.g., Inbar, Pizarro, & Bloom, 2009), and more symptoms of specific phobias (e.g., Sawchuk, Lohr, Tolin, Lee, & Kleinknecht, 2000).

1.2. Disease avoidance and personality

To better understand the nature and function of disease avoidance, several studies have examined the intersection between disgust sensitivity, germ aversion, and personality. Several models of personality have been proposed (e.g., HEXACO, Five Factor Model, Big Five, NEO) and the nuances that differentiate these approaches have been well-documented (Dunlop et al., 2016). This study integrates research using a range of personality characterizations, including the Big Five, HEXACO, and variations of the NEO. The Big Five organizes personality into five core dimensions and accompanying aspects: Openness to experience (intellect and openness), Extraversion (enthusiasm and assertiveness), agreeableness (compassion and politeness), conscientiousness (orderliness and industriousness), and neuroticism (withdrawal and volatility DeYoung, Quilty, & Peter, 2007). These personality dimensions (or close variants) are represented across a wide array of personality models and measures (DeYoung et al., 2007). Measures of the Big Five notably differ from the HEXACO model of personality with respect to neuroticism and agreeableness. Specifically, neuroticism (labeled "emotionality") under the HEXACO model excludes anger and includes sentimentality, and agreeableness under the HEXACO model excludes sentimentality and includes (lack of) anger.

Despite these differences, various characterizations of personality share common themes which may be connected to disease avoidance. For instance, specific personality traits may encourage exploration (e.g., openness to experience) and social interaction (e.g., extraversion, agreeableness), which may increase the likelihood of encountering pathogens. Further, other personality characteristics encourage avoidance, tidiness, and cautious behavior (e.g., conscientiousness, neuroticism), which may lower the likelihood of encountering pathogens. Accordingly, specific personality traits may be more (i.e., conscientiousness, neuroticism) or less (i.e., openness to experience, extraversion, agreeableness) conducive to disease avoidance.

Empirical evidence examining the intersection between disease avoidance and personality has been heavily mixed. For instance, openness to experience promotes exploration, which may increase the likelihood of encountering potential contaminants. Some evidence suggests that those who are higher in disease-avoidance traits are less open to experience (Druschel & Sherman, 1999; Duncan et al., 2009). However, other studies have failed to find significant associations between openness to experience and disgust sensitivity (Druschel & Sherman, 1999; Olatunji et al., 2012, 2008).

Additionally, those who are more extraverted seek out interactions (and enjoy the presence of) other people. Given that contact with other people is a primary means of spreading infectious disease, those who are more sensitive to disease avoidance may be less extraverted and more reserved, potentially as a means of avoiding contact with others who may transmit pathogens. Some correlational evidence supports this proposition and has found that greater disgust sensitivity is associated with lower extraversion scores (Duncan et al., 2009). However, several other studies have failed to find significant associations among disease-avoidance measures and extraversion (e.g., Haidt et al., 1994; Olatunji et al., 2008), again raising the question as to whether disease avoidance is meaningfully related to extraversion. Agreeable dispositions may also potentially invite greater social interactions with others, which in-turn may increase the likelihood of infectious disease exposure (Mortensen, Becker, Ackerman, Neuberg, & Kenrick, 2010). However, correlational evidence linking disease-avoidance traits to lower agreeableness is sparse (Duncan et al., 2009; Tybur & de Vries, 2013). Furthermore, some studies have found that greater disgust sensitivity is associated with *higher* levels of agreeableness (Druschel & Sherman, 1999). Thus, the extent to which disease avoidance is connected with agreeableness is unclear.

Conscientiousness entails being neat and orderly, and some studies have found that higher conscientiousness is associated with higher germ aversion (Olatunji et al., 2012; Tybur & de Vries, 2013). However, several other studies have failed to find a link between conscientiousness and disgust sensitivity or germ aversion (Duncan et al., 2009; Olatunji et al., 2008). Thus, it is uncertain whether these constructs are related.

Neuroticism and emotionality are characterized by withdrawal and emotional volatility. Some evidence suggests that individuals who are higher in neuroticism tend to be more avoidant (Gray, 1990) and report more health complaints (Larsen, 1992). A large body of research has consistently linked greater anxiety symptoms (a component of neuroticism) with higher levels of disgust sensitivity and germ aversion (Olatunji et al., 2010). As such, greater neuroticism may be associated with greater sensitivity to disease avoidance, and several studies have found that those who are higher in disgust sensitivity or germ aversion tend to score higher on neuroticism/emotionality (Duncan et al., 2009; Olatunji et al., 2008; Tybur & de Vries, 2013; Tybur et al., 2009).

In sum, disease avoidance has clear conceptual implications for personality. Although several studies have examined links between personality and indicators of disease avoidance (i.e., disgust sensitivity and germ aversion), findings derived from these studies are either inconclusive (present effects that do not reject the null hypothesis) or inconsistent (present effects in opposite directions). The most consistent evidence supports the link between greater disease-avoidance traits and higher levels of neuroticism. Some evidence suggests that greater disease-avoidance traits may be associated with lower openness to experience, lower extraversion, lower agreeableness, and higher conscientiousness. However, not all studies have found evidence to support these results. Thus, the goal of this study was to provide a meta-analysis of published and unpublished research examining associations among disease-avoidance measures and personality traits. Based on BIS theory, it was expected that greater disease-avoidance traits would be associated with lower openness to experience, lower extraversion, lower agreeableness, greater conscientiousness, and greater neuroticism/emotionality.

2. Method

2.1. Literature search

Studies were identified using four primary techniques. First, published research was obtained through conducting literature searches within PsychINFO and Google Scholar. The search terms included "disease avoidance", "disgust and personality", "disgust and big five", "disgust and HEXACO", "disgust and openness", "disgust and agreeableness", "disgust and conscientiousness", "disgust and neuroticism", "disgust and extraversion", "germ aversion", "perceived vulnerability to disease" with the final hit counts as of December 2017. Search terms were limited to titles, topics, and abstracts within PsychINFO. To provide a manageable amount of responses, search terms were limited to titles in Google Scholar. Second, Google Scholar was also used to search each study that cited a measure of disgust sensitivity, perceived vulnerability to disease, or germ aversion. Third, references for studies identified in the literature searched were examined to potentially identify additional studies. Fourth, to obtain unpublished and in press research, a message was posted on the Society for Personality and Social Psychology listserv and we directly contacted researchers who have published studies examining disease avoidance.

Studies were eligible for inclusion if they reported correlations among disease avoidance and personality, used a normative (non-clinical) sample, and were written in English. The purpose of this study was to examine the link between disease-avoidance traits and personality in the general population. Thus, only correlational studies that examined these constructs with normative populations were included. Studies that manipulated disease salience or those that examined these constructs in clinical populations were not included in this study. Given the paucity of research in this area, these criteria excluded only a few studies ($n = 3$).

For the purpose of this study and consistent with prior research (Terrizzi et al., 2013), disease avoidance was characterized by individual difference measures thought to capture aversion or motivation to avoid objects that may present a threat of contamination. The disease avoidance measures that were considered included disgust sensitivity (the contamination disgust subscale [DS-R-Con; e.g., "I never let any part of my body touch the toilet seat in public restrooms"] and core disgust subscale [DS-R-Cor; e.g., "It bothers me to hear someone clear a throat full of mucous"] of the disgust scale-revised or affiliated subscales in the disgust scale [DS], the disgust propensity and sensitivity scale [DPSS] or the disgust propensity and sensitivity scale-revised [DPSS-R; e.g., "Disgusting things make my stomach turn"], the pathogen disgust subscale of the Three Domains of Disgust Scale [TDDS-P; e.g., "Rate how disgusting you find… stepping on dog poop"]), and the germ aversion subscale (e.g., "I prefer to wash my hands pretty soon after shaking someone's hand") of the perceived vulnerability to disease scale (PVD). If information concerning specific subscales of the DS, DS-R, TDDS, and PVD were unavailable, the mean scores for the overall scale were used. For studies that contained multiple measures of disease avoidance, effect sizes were averaged for overall analyses to avoid inflating the probability of a Type 1 error.

Personality incorporated any study that had at least one self-report measure of openness, extraversion, agreeableness, conscientiousness, or neuroticism/emotionality. This included measures of the Big Five, variations of the Neuroticism-Extraversion-Openness (NEO) scale, the HEXACO scale, the Ten-Item Personality Inventory (TIPI), and the 5-Dimension Personality Test (5-DPT). Similar to the disease avoidance measures, effects for research that had participants report on multiple measures of personality within the same domain were averaged.

Fig. 1 presents a flow diagram depicting study selection criteria. From this literature search, 9 published articles with independent samples fit the inclusion criteria and were included in the meta-analysis. Additionally, efforts to obtain data from unpublished sources resulted in the inclusion of 12 additional unpublished studies, resulting in 21 total studies (see Table 1). Studies were coded for authors' name, publication status (published versus unpublished), publication year, sample size, sample type (undergraduate or community), gender composition, and the type of disease-avoidance and personality measures used. Correlation coefficients were coded as the effect size measure of interest. Estimates from the data and study characteristics were extracted by the first author and an independent coder with a high degree of agreement (all $\kappa s = 1.0$).

2.2. Statistical methods

Primary analyses consisted of random-effect models which were calculated using Comprehensive Meta-Analysis (Borenstein, Hedges, Higgins, & Rothstein 2005), following procedures recommended by Hedges and Olkin (1985). Sensitivity analyses were performed to test whether removing each study effect (individually) from the overall model would drastically change the results. Meta-regression was used to determine if effect sizes were similar across gender composition of the sample, publication year, and sample size, and moderation and subgroup analyses were performed to ensure findings were comparable across sample population (community or student), disease-avoidance measure, and personality measure. For studies that contained multiple measures of disease avoidance or personality, only one measure was included in subgroup analyses. This measure was selected in the following order for disease avoidance (germ aversion, TDDS-P,

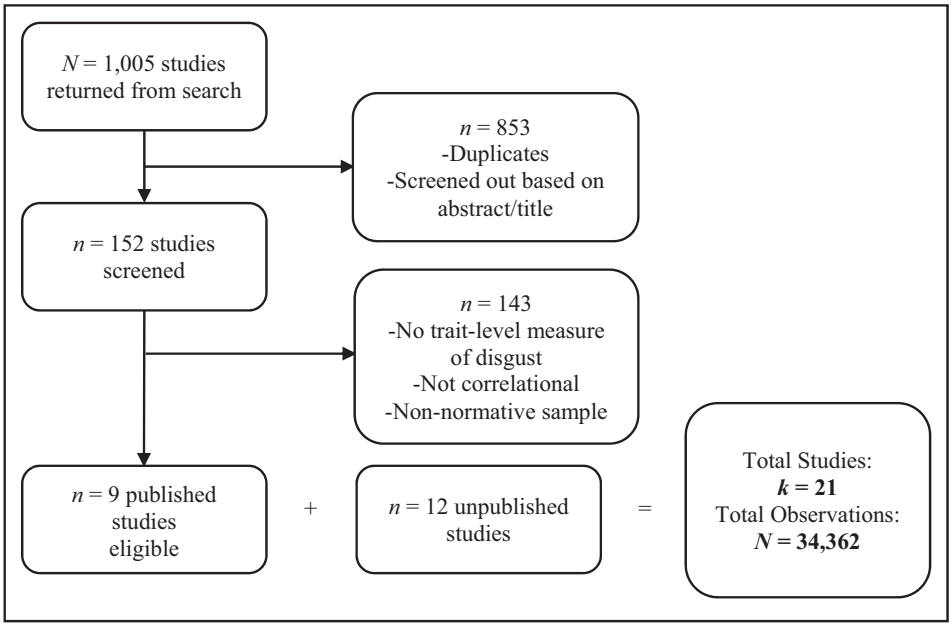

Fig. 1. Summary of study selection results.

DS-R-Con, DS-R-Cor) and personality (Big 5, HEXICO, NEO, 5-DPT, TIPI).[1] Publication bias was assessed by testing whether overall models were moderated by publication status, by evaluating funnel plots using rank correlation tests (Begg & Mazumdar, 1994), and by estimating Failsafe-N tests (Gleser & Olkin, 1996).

3. Results

3.1. Individual correlation estimates

Table 1 displays the study characteristics for all 21 studies included in the meta-analysis, and Table 2 displays the summary statistics for random-effects models for each personality characteristic. Disease-avoidance traits were generally related to personality in the anticipated ways. The strongest and most consistent effects were found for disease-avoidance traits and neuroticism/emotionality (see Fig. 2a). For 18 of the 20 studies, observed data indicated that greater disease-avoidance traits were moderately associated with higher levels of neuroticism/emotionality ($r = 0.19$, 95% CI: 0.14, 0.23). Links between disease-avoidance traits and openness to experiences were also fairly consistent, with greater disease-avoidance traits associated with lower openness to experience (see Fig. 2b). These negative effects were found in 16 of 19 studies, and the overall effect size was moderate ($r = -0.11$, 95% CI: −0.15, −0.08). Summary results also indicated that higher levels of disease-avoidance traits were associated with higher levels of conscientiousness (see Fig. 2c). Positive associations between disease-avoidance traits and conscientiousness were found in 12 out of 16 studies, and the overall effect was relatively small ($r = 0.08$, 95% CI: 0.03, 0.13). A small, negative association was also found between disease-avoidance traits and extraversion ($r = -0.04$, 95% CI: −0.07, −0.01). Negative correlations between disease-avoidance traits and extraversion were less consistent and found in 13 out of 18 studies (see Fig. 2d). Evidence was not found for a link between disease-avoidance traits and agreeableness ($r = -0.04$, 95% CI: −0.09, 0.01; see Fig. 2d). The I^2 statistic indicated that there was moderate to large variation in the effect sizes for each model (49.74–84.02).

[1] Observed scores used in these analyses are available in the supplemental material.

Sensitivity analyses were performed to evaluate whether any one study had an inordinate impact on the magnitude of the overall effect between disease-avoidance traits and personality. These analyses are displayed in the supplemental material. The effect sizes with one study deleted were relatively homogeneous for each model and ranged from $rs = -0.10$ to −0.13 for openness, $rs = -0.04$ to −0.05 for extraversion, $rs = -0.03$ to −0.06 for agreeableness, $rs = 0.07$–0.10 for conscientiousness, and $rs = 0.15$–0.19 for neuroticism/emotionality. Overall, these findings suggest that the interpretation of our results and overall magnitude of effects were not due to the inclusion of any one study. There was one exception concerning the interpretation of the agreeableness results. When excluding the moderate, positive association between agreeableness and disease-avoidance traits ($r = 0.22$) found in Duncan et al. (2009), the aggregate association between disease-avoidance traits and agreeableness became slightly stronger and significant ($r = -0.06$, 95% CI: −0.10, −0.02).

3.2. Publication bias

Publication bias was assessed by testing whether summary effects were moderated by publication status. Publication status was positively associated with the effect size of disease-avoidance traits on openness to experience and negatively associated with the effect size of disease-avoidance traits on extraversion (see Table 3). The correlation between disease-avoidance traits and openness to experience was almost twice as large for published studies ($r = -0.16$, 95% CI: −0.25, −0.08) compared to unpublished studies ($r = -0.09$, 95% CI: −0.15, −0.04). Additionally, disease-avoidance traits were not correlated with extraversion for published studies ($r = 0$, 95% CI: −0.06, 0.05) and negatively correlated with extraversion in unpublished studies ($r = -0.09$, 95% CI: −0.16, −0.01). Associations between disease-avoidance traits and agreeableness, conscientiousness, or neuroticism/emotionality did not differ based on publication status.

Publication bias was also evaluated by examining funnel plots (see supplemental material). Rank correlation tests were used to evaluate funnel plot asymmetry around the mean effect (Begg & Mazumdar, 1994). We did not find evidence of funnel plot asymmetry and accompanying publication bias for models predicting neuroticism/emotionality ($z = 1.30$, $p = .19$), openness

Table 1
Sample descriptions for all included studies.

	Study characteristics						Observed effect (*r*)				
	N	% Female	Sample	Disgust Measure	Personality Measure	Publication Status	Openness	Extraversion	Agreeableness	Conscientious	Neuroticism/ Emotionality
1. Haidt et al. (1994)	124	54	Student	DS	EYS	Published	–	−0.06	–	–	0.23
2. Druschel and Sherman (1999)	132	63	Student	DS	NEO-PI-R	Published	−0.03	−0.06	−0.10	−0.11	0.17
3. Olatunji et al. (2008)	247	66	Student	DSR-Con/ DSR-Cor	NEO-FFI	Published	−0.18	−0.07	0.09	0.05	0.34
4. Duncan et al. (2009)	661	74	Student	GA	Big 5	Published	−0.28	0.06	0.22	0.35	0.45
5. Tybur et al. (2009) Study 2	300	56	Student	TDDS-P	Big 5	Published	−0.11	0.08	0.04	−0.04	0.15
6. Tybur, Bryan, Lieberman, Hooper, and Merriman (2011) Study 2	477	68	Student	TDDS-P	NEO-PI-3	Published	−0.24	−0.05	−0.13	0.02	0.10
7. Olatunji et al. (2012) Study 3	200	61	Student	TDDS-P	Big 5	Published	−0.12	0.06	0.11	0.16	0.10
8. Tybur & de Vries 20,13[a]	476	50	Community	TDDS-P	HEXACO/ 5DPT	Published	−0.11	0.04	−0.17	0.14	0.18
9. Díaz, Soriano, and Beleña (2016) Study 2	280	67	Student	GA	EYES	Published	–	−0.03	–	–	0.12
10. Shook	306	86	Student	DSR-Con/ DSR-Cor/ GA	Big 5	Unpublished	0.06	−0.07	−0.01	0.15	0.01
11. Murray Study 1	97	78	Student	DSR-Con/ GA	Big 5	Unpublished	−0.08	−0.31	−0.21	−0.15	0.26
12. Murray Study 2	273	46	Student	GA	Big 5	Unpublished	−0.05	−0.04	−0.12	0.00	0.27
13. Murray Study 3	90	58	Student	DSR-Con/ GA	Big 5	Unpublished	−0.34	−0.20	−0.27	−0.02	0.16
14. Murray Study 4	412	73	Student	GA	Big 5	Unpublished	0.00	0.02	−0.07	0.08	0.12
15. Murray Study 5	183	67	Student	GA	Big 5	Unpublished	−0.11	−0.17	−0.09	0.20	0.22
16. Sevi et al.	169	71	Community	TDDS-P/ GA	TIPI	Unpublished	0.00	−0.02	0.01	0.10	−0.11
17. YourMorals Study 1	28,402	52	Community	DSR-Con/ DSR-Cor	Big 5	Unpublished	−0.10	−0.05	−0.04	0.04	0.18
18. YourMorals Study 2	956	51	Community	DSR-Con/ DSR-Cor	Big 5/ HEXACO	Unpublished	−0.10	−0.08	−0.10	0.06	0.20
19. Burke	176	42	Community	GA	Big 5	Unpublished	−0.10	–	–	–	0.30
20. Tybur Study 1	209	46	Community	DSR/ TDDS-P	HEXACO	Unpublished	−0.09	–	–	–	0.17
21. Tybur Study 2	192	42	Community	TDDS-P	HEXACO	Unpublished	−0.15	–	–	–	–

[a] Neuroticism was combined with Emotionality and Consciousness was combined with orderliness. DS = Disgust Scale, DSR = Disgust Scale-Revised, DSR-Con = Contamination subscale of the Disgust Scale Revised. DSR-Cor = Core subscale of the Disgust Scale Revised. GA = Germ Aversion subscale of the Perceived Vulnerability to Disease scale, TDDS-P = Pathogen Disgust subscale of the Three Domains of Disgust scale. EYS = Eysenck personality questionnaire. NEO-PI-R = NEO personality inventory, revised. NEO-FFI = NEO five factor inventory. Big 5 = Big 5 questionnaire. NEO-PI-3 = revision of the revised NEO Personality Inventory. HEXACO = Revised HEXACO personality inventory. TIPI = Ten item personality measure. 5DPT = 5 Dimensional Personality Test.

to experience ($z = 0.45$, $p = .65$), extraversion ($z = -1.48$, $p = .14$), conscientiousness ($z = -1.08$, $p = .28$), or agreeableness ($z = -0.45$, $p = .65$). As the inclusion of unpublished data may alter tests of publication bias, these analyses were performed with and without the unpublished data and demonstrated a similar pattern of findings ($zs = -1.37$ to 0.78, $ps = 0.19$–0.70).

Lastly, publication bias was assessed through Gleser & Olkin's (1996) Failsafe-N tests. Results from these analyses most strongly support the robustness of findings regarding neuroticism/emotionality and extraversion. Specifically, 35 additional null-result findings would be needed to diminish the association between disease avoidance and neuroticism/emotionality and 24 additional null-result findings would be needed to diminish the link between disease avoidance and extraversion. Additionally, 17 additional null-result findings would be needed to diminish the link between disease avoidance and both openness to experience and agreeableness, and 14 additional null-result findings would be needed to diminish the link between disease avoidance and conscientiousness.

3.3. Moderation and subgroup analyses

Moderation analyses were used to test whether the association between disease-avoidance traits and personality varied by gender, publication/data collection year, sample size, sample population, the disease-avoidance measure used, or the personality measure used. Given the small number of studies included in these analyses and potential low power, we also present effect sizes for separate subgroups. Table 3 displays the results from the moderator and subgroup analyses. Meta-regressions indicated that gender, publication year, and sample size were not significantly associated with the correlations between disease-avoidance traits and any of the personality traits. Additionally, correlations between disease-avoidance traits and personality were consistent across undergraduate student and community samples (see Table 3). Given the large amount of heterogeneity in disease-avoidance measures, moderation analyses for the disease-avoidance measure primarily focused on comparing findings from studies that used a disgust sensitivity measure with those that used a germ aversion measure. There was a significant effect of disease-avoidance measure used for neuroticism/emotionality. The correlation between disease-avoidance traits and neuroticism/emotionality was almost twice as large for studies that used a measure of germ aversion ($r = 0.25$, 95% CI: 0.10, 0.39) relative to disgust sensitivity ($r = 0.15$, 95% CI: 0.09, 0.29). We also found a significant effect of disease avoidance measure used for conscientiousness. When examining effects by subgroup, neither estimate was significant. However, the general trend of these analyses was similar to neuroticism/emotionality, with stronger effects trending for measures of germ aversion relative to disgust sensitivity. Associations between disease-avoidance traits and openness to experience, extraversion, or agreeableness

Table 2
Random-effects summary estimates.

	k	*r*	95% CI	*Q*	*p*	I^2
Openness to Experience	19	−0.11	−0.15, −0.08	55.39	<0.001	67.51
Extraversion	18	−0.04	−0.07, −0.01	33.83	<0.001	49.74
Agreeableness	16	−0.04	−0.09, 0.01	83.23	<0.001	81.98
Conscientiousness	16	0.08	0.03, 0.13	93.89	<0.001	84.02
Neuroticism/Emotionality	20	0.19	0.14, 0.23	104.65	<0.001	81.84

Notes: CI = Confidence Interval. P values represent null-hypothesis test for the Q statistic.

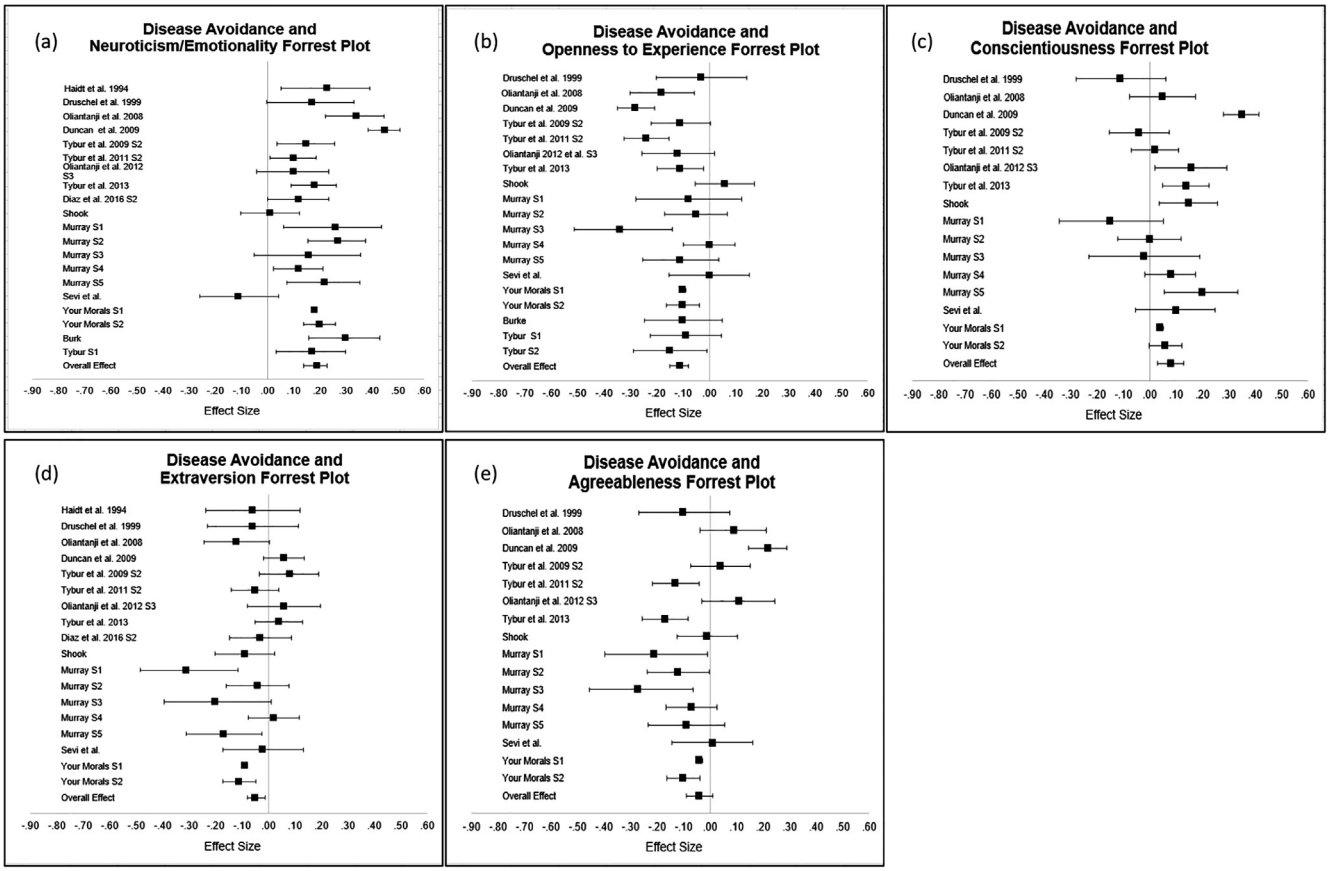

Fig. 2. *a–e.* Forrest plots of effect sizes for associations between disease avoidance and personality traits.

did not appear to differ based on whether a measure of disgust sensitivity or germ aversion was used. Analyses testing the moderating effect of personality measure primarily focused on comparing studies that used the Big Five to those that used other personality measures. Overall, there did not appear to be any evidence that the personality measure used moderated the effect between disease-avoidance trait and personality.

4. Discussion

The purpose of this study was to organize and meta-analyze research examining the intersection between disease avoidance and personality. The systematic review revealed 9 published studies and 12 unpublished studies using over 32,000 participants that examined associations among disgust sensitivity, germ aversion, and several diverse measures of personality. Overall, the findings indicated that disease-avoidance traits are linked with personality traits in manners consistent with BIS theory. Specifically, greater individual differences in disease avoidance were consistently associated with lower openness to experience, lower extraversion, higher conscientiousness, and higher neuroticism/emotionality. These effects were robust as we found little evidence that results were primarily driven by sample or study characteristics.

The BIS is thought to motivate more cautious behavior in an effort to limit potential contact with pathogens. In this meta-analysis, we found that greater disease avoidance represented by higher disgust sensitivity and germ aversion was associated with lower openness to experience. The size of this effect was small to moderate. Potentially, those who are more sensitive to disgust or have greater germ aversion are less open to experience to avoid contact with potential contaminants. These findings are consistent with cross-cultural research which has found that individuals living in regions of the world with higher historical disease prevalence rates endorse lower levels of openness to experience (Schaller & Murray, 2008). Overall, our results support the BIS model, and suggest that disease avoidance may have important implications for how individuals rate their own personal characteristics and tendencies, particularly in the context of exploration. However, moderation analyses indicated that the link between

Table 3
Moderation and subgroup analyses.

	Moderation analyses																								
	Openness to Experience					Extraversion					Agreeableness					Conscientiousness					Neuroticism/Emotionality				
	B	95% CI	Q	z	R^2	B	95% CI	Q	z	R^2	B	95% CI	Q	z	R^2	B	95% CI	Q	z	R^2	B	95% CI	Q	z	R^2
Pub. Status	0.10	0.02, 0.17	6.81*	2.61	0.25	−0.08	−0.14, −0.01	6.43*	−2.54	0.26	−0.10	−0.22, 0.02	3.02	−1.74	0.16	−0.04	−0.16, 0.08	0.43	−0.65	0.02	−0.05	−0.16, 0.06	0.96	−0.98	0.04
Sample	0.03	−0.06, 0.12	0.46	0.68	0.02	0.00	−0.08, 0.08	0.00	0.02	0.00	−0.05	−0.19, 0.09	0.56	−0.75	0.03	0.01	−0.13, 0.15	0.02	0.13	0.01	−0.04	−0.16, 0.09	0.39	−0.62	0.02
Personality Measure	0.01	−0.08, 0.11	0.12	0.34	0.01	0.01	−0.07, 0.08	0.04	0.20	0.01	0.05	−0.08, 0.17	0.69	0.83	0.04	0.04	−0.10, 0.18	0.41	0.64	0.03	0.05	−0.07, 0.17	0.78	0.88	0.04
Disease Measure	−0.01	−0.10, 0.09	0.03	0.17	0.01	0.05	−0.04, 0.13	1.25	1.12	0.06	0.06	−0.07, 0.19	0.92	0.96	0.05	0.13	0.01, 0.24	5.38*	2.32	0.22	0.11	0.01, 0.22	4.27*	2.07	0.16
Gender	0.07	−0.29, 0.42	0.17	0.41	0.01	−0.06	−0.45, 0.34	0.14	−0.38	0.01	0.33	−0.20, 0.86	1.73	1.32	0.09	0.30	−0.21, 0.81	1.58	1.25	0.08	−0.22	−0.71, 0.26	0.93	−0.96	0.04
Pub. Year	−0.01	−0.03, 0.02	0.55	0.74	0.11	0.00	−0.01, 0.01	0.57	0.76	0.08	0.00	−0.04, 0.04	0.00	0.07	0.01	0.02	−0.02, 0.06	1.12	1.06	0.25	0.00	−0.02, 0.02	0.20	−0.45	0.04
Sample Size	0.01	−0.01, 0.01	0.02	0.14	0.01	0.01	−0.01, 0.01	0.05	−0.21	0.01	0.01	−0.01, 0.01	0.00	0.07	0.01	0.01	−0.01, 0.01	0.07	−0.26	0.01	0.01	−0.01, 0.01	0.00	−0.01	0.00

	Subgroup analyses														
	Openness to Experience			Extraversion			Agreeableness			Conscientiousness			Neuroticism/Emotionality		
	k	*r*	95% CI	*k*	*r*	95% CI	*k*	*r*	95% CI	*k*	*r*	95% CI	*k*	*r*	95% CI
Pub. Status															
Published	7	−0.16	−0.25, −0.08	9	0.00	−0.06, 0.05	7	0.01	−0.13, 0.15	7	0.09	−0.06, 0.24	9	0.21	0.11, 0.31
Unpublished	12	−0.09	−0.15, −0.04	9	−0.09	−0.16, −0.01	9	−0.07	−0.12, −0.02	9	0.06	0.00, 0.12	11	0.16	0.09, 0.24
Sample															
Student	12	−0.13	−0.21, −0.05	14	−0.04	−0.10, 0.02	12	−0.03	−0.12, 0.06	12	0.07	−0.02, 0.16	14	0.20	0.12, 0.27
Community	7	−0.09	−0.11, −0.08	4	−0.04	−0.13, 0.05	4	−0.08	−0.27, 0.07	4	0.06	−0.03, 0.15	6	0.17	0.04, 0.29
Personality Measure															
Big 5	11	−0.12	−0.19, −0.06	10	−0.04	−0.12, 0.04	6	−0.08	−0.18, 0.03	6	0.06	−0.02, 0.14	11	0.21	0.12, 0.25
Other	8	−0.11	−0.18, −0.03	8	−0.04	−0.08, −0.01	10	−0.03	−0.13, 0.08	10	0.09	−0.02, 0.19	9	0.15	0.07, 0.21
Disease Measure															
Disgust	14	−0.11	−0.16, −0.06	13	−0.06	−0.12, −0.01	12	−0.06	−0.12, 0.01	12	0.05	0.00, 0.10	14	0.15	0.09, 0.21
Germ Av.	5	−11	−0.27, 0.05	5	−0.02	−0.13, 0.10	4	−0.01	−0.34, 0.33	4	0.16	−0.18, 0.47	6	0.25	0.10, 0.39

Notes: * $p < .05$. Pub. = Publication. Av. = Aversion. B = Unstandardized Beta Coefficient. CI = Confidence Interval. Pub. Status coded as 1 = unpublished, 2 = published. Sample coded as 1 = undergraduate, 2 = community. Personality Measure coded as 1 = non-Big Five, 2 = Big Five. Disease Measure coded as 1 = Germ aversion, 2 = Disgust sensitivity. Observed scores used in the subgroup analyses are available in the Supplemental Material.

disease-avoidance traits and openness to experience may be larger in published studies relative to unpublished studies. These findings may indicate a publication bias and suggest that the general link between disgust sensitivity and openness is likely smaller than what is currently presented in the literature.

Also consistent with BIS theory, we found that greater disease-avoidance traits were associated with greater conscientiousness. Conscientiousness entails personal tendencies of being neat and orderly, which may act as a means of limiting contact with pathogens. Linking disease avoidance with conscientiousness is especially notable considering that these constructs were found to be significantly associated in only *one* of the nine available published studies, suggesting that this connection has not yet been well established in the existing literature. Similar to openness, the relative size of this effect was small. The small effect may be due to the wide variety of non-disease related tendencies affiliated with conscientiousness (e.g., concern with etiquette) or that the disease-related tendencies involve specific actions (maintaining an orderly space) rather than avoidance, which may be more broadly applied across situations.

Although less consistent, results from this meta-analysis also demonstrate that disease-avoidance traits may be linked with lower extraversion. Extraversion often entails greater socialness and personal interactions with other people. Given that other people are often a source of potential infectious disease threat, it is possible that those higher in disease-avoidance traits endorse less extraversion as a means of limiting contact with others and the affiliated risk for pathogen exposure. Similar to openness to experience, these findings are consistent with research which indicates that individuals from regions with historically higher disease prevalence endorse lower extraversion compared to those from regions with lower historical disease prevalence (Schaller & Murray, 2008). Interestingly, the effect between disease-avoidance traits and extraversion was not found in published research and appears to be larger in unpublished studies. Of the nine published studies included in this meta-analysis, five studies reported small negative correlations between disease-avoidance traits and extraversion and four studies reported a small *positive* association between disease-avoidance traits and extraversion. Of these four studies, three used the pathogen disgust subscale of the TDDS, which may explain the difference found in publication status.[2] Germ aversion and the DSR-Con/DSR-Cor subscales incorporate items that involve behavioral avoidance of stimuli that may be pathogen bearing, whereas the TDDS-P focuses explicitly on reports of disgust. It is possible that extraversion is more closely tied to the behavioral elements of disease avoidance rather than the disgust reaction.

The strongest link between disease avoidance and personality was found with neuroticism/emotionality. Aggregated effect sizes from 20 studies indicated that those who endorsed greater disease-avoidance traits also endorsed greater neuroticism. These effects were unsurprising given that neuroticism/emotionality is characterized by experiencing adverse emotional states, which may include heightened disgust. Further, neuroticism often encompasses high levels of anxiety and there is a relatively large body of research linking anxiety disorders with disgust sensitivity and germ aversion (see Cisler, Olatunji, & Lohr, 2009 for review). The links between disease-avoidance traits and neuroticism appeared to be stronger for studies utilizing measures of germ aversion relative to disgust sensitivity. Germ aversion may be a more direct measure of behavioral tendencies designed to limit exposure to germs and pathogens relative to disgust sensitivity. Additionally, the disease concerns assessed by germ aversion may reflect the greater health-related vigilance that characterizes neuroticism (e.g., Zonderman, Leu, & Costa, 1986).

We did not find consistent evidence of an association between disease-avoidance traits and agreeableness. However, effects were trending in the anticipated direction and became significant in sensitivity analyses when only one study was omitted (Duncan et al., 2009). Scholars have proposed that the helpful and cooperative nature which characterizes elevated levels of agreeableness may facilitate greater social interaction and subsequent disease exposure (Mortensen et al., 2010). Findings from this meta-analysis partially support this proposition, but ultimately suggest that more research is needed to understand whether disease-avoidance traits relate to agreeableness.

4.1. Implications for theory

Overall, the consistent nexus between disease-avoidance traits and personality poses several important implications for research and theory. First, the general pattern of findings demonstrated in this meta-analysis provides support for the disease-avoidance function of germ aversion and disgust sensitivity and highlight that these constructs are connected to general personal tendencies. Establishing these connections raises important questions concerning whether disease avoidance tendencies and personality share similar developmental origins and are dynamically connected over time. Additionally, the small effect sizes found between disease-avoidance traits and personality suggests that although these constructs are meaningfully related, they represent very distinct individual differences. As such, examining differential relations between personality and disease avoidance measures may be an important direction for future research.

These findings also raise important questions concerning whether disease avoidance may shape personality or vice versa. Experimental research indicates that exposing individuals to disease cues leads to lower levels of openness to experience and lower agreeableness (Mortensen et al., 2010), which suggests that activating the BIS may (at least momentarily) alter personality. Evolutionarily, disease threat may have been one adaptive challenge to the human species that influenced the development of specific psychological tendencies, such as personality. Although there has been a paucity of research examining the origins of individual differences in disease avoidance traits, scholars have interpreted links between disease avoidance and personality within the context of cost-benefit relations (Kupfer & Tybur, 2017), and it is possible that changes in the perceived benefits affiliated with personality (new experiences, social interaction, tidiness) may promote or dampen BIS reactivity overtime. Thus, connections between personality and BIS may be bi-directional, and more research is needed to understand causal connections between these constructs.

Connecting personality with disease avoidance also has important implications for health. A large body of research has sought to elucidate the connection between different facets of personality and various indicators of health, including inflammation (e.g., Jonassaint et al., 2010), heart disease (e.g., Steptoe & Molloy, 2007), and health behaviors (e.g., Raynor & Levine, 2009). Prior research has found that those who are more sensitive to disgust and contamination report fewer recent infections (Stevenson, Case, & Oaten, 2009). Thus, one additional avenue through which personality is connected to health may be through disease avoidance tendencies. Future research seeking to better understand the health implications of personality may benefit from incorporating disease avoidance traits into their theoretical models.

Findings from this study also have important methodological implications. Prior research has used personality characteristics as a means of establishing convergent and discriminant validity

[2] Post-hoc analyses indicate that the link between disease-avoidance traits and extraversion is moderated by use of TDDS-P. These analyses are available in the supplemental material.

with disease avoidance measures (e.g., Duncan et al., 2009; Tybur et al., 2009), yet established research has demonstrated a large amount of heterogeneity in the magnitude and direction of associations between these constructs. Findings from this study help clarify these nuanced associations and provide scholars with an important means of validating novel disease avoidance measures. Such efforts may be especially useful as the disease avoidance field is relatively new and appears to be gaining interest across a wide breadth of psychological disciplines (Shook et al., 2017). With the knowledge gained from this study, future research seeking to validate novel measures of disease avoidance may generate clear, a priori hypotheses concerning how and to what extent their measure should be connected with personality, thus increasing the validity of the scale.

4.2. Limitations and future directions

Although this study had many strengths, such as the inclusion of several sources of unpublished data, findings should be taken in light of certain limitations. Data were correlational, and causal inferences cannot be made. Future research may benefit from manipulating disease avoidance and examining change in personality characteristics. Future research may also benefit from examining links between disease-avoidance traits and personality longitudinally, which may help determine temporal sequencing among these associations. Additionally, few studies included potentially important covariates in their models, which may have accounted for certain study findings. For instance, prior research has found that disgust sensitivity and neuroticism are positively associated with trait anxiety (Gershuny & Sher, 1998; Thrope, Patel, & Simonds, 2003). It is possible that associations between these constructs are due to higher levels of anxiety more broadly and are not specific to disease avoidance. Future research is needed that accounts for these constructs. Prior research indicates meaningful differences among the HEXACO and Big Five model of personality, particularly for agreeableness and neuroticism. In the current research, only two studies reported effects for agreeableness and neuroticism using the HEXACO model of personality. Although this low number of studies precluded the test of moderating effects using the HEXACO model of personality, the individual observed effects were consistent with the overall random-effects model suggesting a similar pattern of relations across these different characterizations of personality. These findings may indicate that the common features of neuroticism and emotionality may be responsible for connections with disease avoidance found in this study.

Although this study used estimates derived from 21 studies and over 32,000 participants, one study contributed estimates derived from 28,402 observations. As such, the overall estimates are likely disproportionately weighted by the results from this one study. However, the findings were identical when omitting this study from the overall models via sensitivity analyses. Thus, although the overall models may be disproportionately weighted by one study, the findings from this study strongly aligned with those derived from the other studies included in the meta-analysis, suggesting that inclusion of this study did not introduce a meaningful amount of bias. The current research focused specifically on studies that assessed disease avoidance through self-report indicators. It is important to note that other research has examined connections between disease avoidance and personality utilizing country-level indicators of health (Schaller & Murray, 2008) and through experimentally manipulating disease salience (Mortensen et al., 2010). Although our findings are consistent with research using these methodologies, the relative effect sizes may vary depending on the specific methodology used and accompanying assumptions (Tybur, Frankenhuis, & Pollet, 2014). Thus, future research should consider the methodology used when evaluating potential connection between disease avoidance and personality.

Future research should also consider isolating and unpacking the independent, facet-level associations between personality and disease avoidance. The current study meta-analyzed unadjusted bivariate correlations among personality and disease avoidance. Personality characteristics are often correlated (e.g., Tybur & de Vries, 2013), and it is possible that some study findings are due to shared variance among personality characteristics. Further, the overall effects found in this study were relatively small, which may reflect the broad traits captured by the included personality measures. Examining links between disease avoidance and facet-level personality characteristics may produce larger effects and provide more nuanced insight into whether and how personality is connected with disease avoidance.

4.3. Conclusion

The BIS is a collection of mechanisms that have important implications for a variety of psychological processes. Connecting the BIS with personality characteristics helps elucidate the far-reaching implications of these constructs. Our findings demonstrate that disgust sensitivity and germ aversion are meaningfully linked with personality in manners consistent with BIS theory. Research should continue to investigate the role of the BIS as an individual difference in cognition and behavior. Such endeavors will likely enhance theory and knowledge concerning the evolutionary basis of the BIS.

Data availability

The data associated with this research are available in the main text and supplemental file.

Pre-registration

This study was not preregistered in an independent, institutional registry.

Author contributions

BO: contributed to study design, data collection, statistical analyses, data interpretation, and manuscript writing. NJS contributed to study design, data interpretation, and manuscript writing. RI contributed to manuscript writing.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jrp.2018.09.008.

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** *indicates that the study was included in the meta-analyses.*

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