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Review

Bidirectional interplay of disgust and morality: Meta-analytic investigations

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ABSTRACT

Two separate meta-analyses were conducted to test the hypotheses that moral transgressions elicit disgust and that inducing disgust may intensify moral judgments. The data supported both the elicitation hypothesis ($k = 78$; $g = 0.55$) and the amplification hypothesis ($k = 101$; $g = 0.40$). When examining the moderating effects of person- and measurement-related characteristics, a stronger link between morality and disgust was found in Western and Caucasian cultures compared to Asian and Eastern cultures. Trait disgust sensitivity, as opposed to state disgust sensitivity, had a more pronounced impact on moral attitudes. Disgust was most strongly associated with violations of purity and deontological morality, particularly in relation to sex- and religion-related issues. Larger effects were also observed when the direction of disgust aligned with the orientation of moral judgment. Keeping in mind the limitation of substantial heterogeneity, these findings underscore the importance of methodological approaches, sample characteristics, and individual differences in studying the bidirectional relationship between disgust and morality.

1. Introduction

The last three decades have witnessed the emergence of numerous studies exploring the relationship between moral transgressions and the emotion of disgust. This body of work is based on the assumption that moral transgressions elicit disgust, and that inducing disgust intensifies moral judgments. However, the debate on the relationship between disgust and morality remains unresolved, raising questions about whether moral transgressions can trigger true, physical disgust or whether "moral disgust" is merely a linguistic artifact (Landy & Goodwin, 2015; Mancini & Gangemi, 2021).

1.1. Challenges in researching the interplay between disgust and morality

Several challenges complicate drawing definitive conclusions about the connection between disgust and moral judgments. These include issues related to how moral judgments and disgust are manipulated, particularly concerning the orientation of such emotions and attitudes (Tobia, 2014; Tobia, Chapman, & Stich, 2013). It is well-established that variations in self-other or actor-observer perspectives consistently impact judgment (Choi & Nisbett, 1998; Jones & Nisbett, 1971), including moral judgments (Nadelhoffer & Feltz, 2008; Tobia, Buckwalter, & Stich, 2013). Additionally, differences in sample characteristics may affect the relationship between disgust and morality. For example, Tobia and colleagues suggested that sample characteristics may influence the effect of cleanliness on moral judgments. Specifically, a cleanliness (Lysol) prime affected students and philosophers differently. The cleanliness manipulation caused students to give higher ratings in both the actor and observer conditions. In contrast, it caused philosophers to give higher ratings in the actor condition but lower ratings in the observer condition (Tobia, Chapman, & Stich, 2013). Taken together, these findings indicate that the impact of cleanliness on moral judgment may vary depending on individual characteristics, perspectives, social status, and differing levels of expertise and ethical reasoning.

1.2. Distinctive association of disgust with different types of moral transgressions

Recent psychological studies have considered morality as a multi-domain construct and another debated topic is whether disgust is more strongly associated with certain types of moral transgressions than

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others. For instance, Shweder et al. (1997) proposed three main "ethics" – autonomy, community, and divinity – each comprising a set of interrelated moral claims that protect different entities, such as altruism, justice, respect, loyalty, authority, and purity. Similarly, Haidt and colleagues differentiated moral domains into five intuitive "foundations" – harm/care, fairness/reciprocity, ingroup/loyalty, authority/respect, and purity/sanctity – considered as innate elements of moral judgment developed through evolution (Graham et al., 2009; Graham & Haidt, 2012; Haidt, 2001; Haidt & Graham, 2007; Haidt & Joseph, 2004, 2008).

Several studies suggest that disgust is most closely associated with violations of purity and divinity norms (Graham et al., 2011; Kollareth & Russell, 2017; Rozin et al., 1999). However, disgust may also function as a repulsive mechanism against individuals who transgress norms that maintain social order, such as those related to fairness, authority, and loyalty. For example, facial expressions of disgust have been found to be more intense not only in response to purity violations but also to fairness violations (Cannon et al., 2011).

It must be emphasized, however, that the evolutionary-based view of moral foundations being innate has not received empirical support, and that morality, to a very large extent, seems to be learned, as could the connection between disgust with moral violations be learned (Railton, 2017).

1.3. Deontological and altruistic guilt

Mancini and colleagues have proposed a dualistic theory of morality, distinguishing between two types of guilt: deontological and altruistic (Basile & Mancini, 2011; Mancini, 2018; Mancini & Gangemi, 2015; Mancini & Gangemi, 2021). Deontological guilt arises when individuals violate an internal moral norm they are committed to upholding, even if no harm results from the transgression. In contrast, altruistic guilt emerges when an altruistic goal, such as benefiting another person, is compromised. A typical example of altruistic guilt is "survivor's guilt" (Castelfranchi, 1994), where merely not sharing the same fate as the unfortunate other can induce guilt (Mancini & Gangemi, 2011). An example of deontological norm is the "do not play God" rule, which asserts that no one has the moral right to make ultimate decisions about another's life or death or to overstep the boundaries of their social role or function (Mancini & Gangemi, 2011). The original sin in the Bible is perhaps the most well-known example of a deontological transgression, where eating the forbidden fruit was sinful not because it caused harm, but because it was an act of disobedience to God (Mancini & Gangemi, 2021).

Deontological morality emphasizes adherence to moral duties and rules that individuals believe are inherently right, rather than focusing on the outcomes or consequences of their actions. This approach contrasts with consequentialist morality. This distinction is commonly applied in moral psychology, particularly in research involving the classic "trolley dilemma", which illustrates how individuals differ in their reliance on deontological versus consequentialist reasoning. For instance, some individuals refuse to divert the trolley because they consider it morally wrong to directly cause the death of one person, even if it would save more lives, exemplifying a deontological perspective. Conversely, others choose to divert the trolley to save the greatest number of lives, even at the cost of sacrificing one person, reflecting a consequentialist approach (Mancini & Gangemi, 2015).

The distinction between deontological and altruistic morality is also clinically relevant, as OCD patients seem to be particularly sensitive to deontological guilt (Basile et al., 2014). Evidence shows that obsessive concern over a harmful event, such as a gas explosion, is drastically reduced in individuals with OCD when they do not have direct responsibility. Patients' concerns are not for the victims of the explosion but for being responsible and guilty for it (Lopatka & Rachman, 1995). Similarly, the concerns of individuals with OCD often involve religious or sexual sins, even if their behavior is not harmful to anyone.

1.4. The relationship between disgust and deontological guilt

Morality appears to be strongly linked to the emotion of disgust, particularly when its deontological aspects are considered. For example, deontological guilt – compared to altruistic guilt – elicits a stronger Macbeth effect, characterized by increased mental accessibility of cleansing-related words and a greater tendency to use cleaning products (Mancini & Gangemi, 2011, p. 400). Similarly, D'Olimpio and Mancini (2014) found that inducing deontological guilt produces more obsessive-compulsive-like washing behaviors compared to inducing altruistic guilt (replicated by Ottaviani et al., 2019). The privileged relationship between deontological guilt and disgust is further supported by an fMRI investigation showing that deontological guilt activates brain regions closely linked to the emotion of disgust, such as the insula (Basile et al., 2011). Consistent with these findings, anodal and cathodal transcranial direct current stimulation were used to indirectly increase or decrease insular excitability, respectively enhancing or reducing disgust and the severity of moral judgments in the deontological, but not in the altruistic, domain (Ottaviani et al., 2018; Salvo et al., 2022).

1.5. The present study

Most theorists have explored the relevance of disgust to moral judgment in two primary ways: How disgust is elicited by moral transgressions (*the elicitation hypothesis*) and how the experience of incidental disgust intensifies moral judgments (*the amplification hypothesis*) (Landy & Goodwin, 2015). Accordingly, we conducted two separate meta-analyses to identify which moderators –such as the type of morality involved, person-related characteristics, and measurement-related factors – most significantly influence the relationship between disgust and morality in its elicitation (Study 1) and amplification (Study 2) effects. As detailed later, due to an insufficient number of studies, in some instances it was not possible to test for moderators of interest.

2. Method

2.1. Identification and selection of studies

Two search strategies were employed to systematically collect empirical studies on the relationship between disgust and morality. First, we searched the PsycInfo, PubMed, and Web of Science databases through October 28, 2021, using the following keywords: moral* (including moral, morality, morally), OR ethic* (including ethic, ethics, ethical, ethically), OR guilt* (including guilt, guilty), OR judg* (including judge, judgment), OR dilemma, OR deontological, OR altruistic, AND disgust* (including disgust, disgusted, disgusting), OR wash* (including wash, washing), OR clean* (including clean, cleaning, cleanse, cleansing, cleanliness), OR dirt* (including dirt, dirty, dirtiness). Second, we reviewed the reference lists of previous systematic reviews to identify additional relevant studies.

The search was restricted to English-language, peer-reviewed international publications and studies involving human participants. The inclusion criteria for our analyses were as follows:

(a) Studies utilizing a design suitable for calculating one or more effect sizes (e.g., randomized within-subject design, control group design, correlational studies);
(b) Studies conducted on both healthy and clinical samples;
(c) Studies using a comparator: control group versus experimental group (for Study 1: neutral task vs. moral task; for Study 2: baseline/emotionally neutral task vs. disgust-inducing task);
(d) Studies in which the outcomes were as follows: for Study 1, levels of disgust measured through behavioral (e.g., physical cleansing), physiological (e.g., heart rate variability, facial expression), or self-report (e.g., emotion rating) responses; for Study 2, moral

judgment/attitude (e.g., moral vignettes, moral dilemmas, questionnaires on political orientation, religiosity, intergroup attitudes), moral behavior (e.g., trusting others, rewarding others, volunteering), or moral emotions (e.g., guilt).

As illustrated in Fig. 1, a total of 16,898 results were retrieved. After removing 2453 duplicate studies, we screened 1189 abstracts for further evaluation. The current meta-analyses are based on data extracted from 94 papers (170 studies) that met the inclusion criteria (see Table S1). Among the 170 studies, 78 were included in Study 1, and 101 in Study 2. Nine studies that used trait/dispositional measures of both disgust and morality, where the causality of the effect (disgust affecting morality or morality affecting disgust) could be considered bidirectional, were included in both Study 1 and Study 2. Studies with a within-subject design, particularly those assessing emotional responses (e.g., self-reported sadness, anger, disgust, happiness) to different moral violations, were included in Study 1 (see the Supplemental Material for details on the inclusion criteria). Since the primary focus of this meta-analysis is the relationship between disgust and morality, correlational data assessing this relationship were also included. Overall, 39 papers (62 correlational studies) were selected and included (Study 1 = 9 papers, 13 studies; Study 2 = 30 papers, 49 studies).

2.2. Coding

A standardized data coding form was developed to extract the following information from each study: (a) authors and publication year; (b) study design; (c) characteristics of the study sample (age, sex, size, subgroups, ethnic group); (d) method used to measure disgust and morality as independent variables; (e) method used to measure disgust and morality as dependent variables; (f) outcomes of interest; (g) brief results. Each study was included only once in each meta-analysis (Cooper, 2009).

For state measures (e.g., induction of incidental disgust or moral threat induction), when studies had more than a control condition, our choice was the most neutral condition.

When studies had more than one experimental condition (e.g., different domains of moral violation), our choice was motivated by theoretical assumptions accounting for the distinction between deontological and altruistic morality. Since the deontological morality, especially "victimless" deontological morality, is more closely related to the domains of authority and purity/divinity than other domains, we

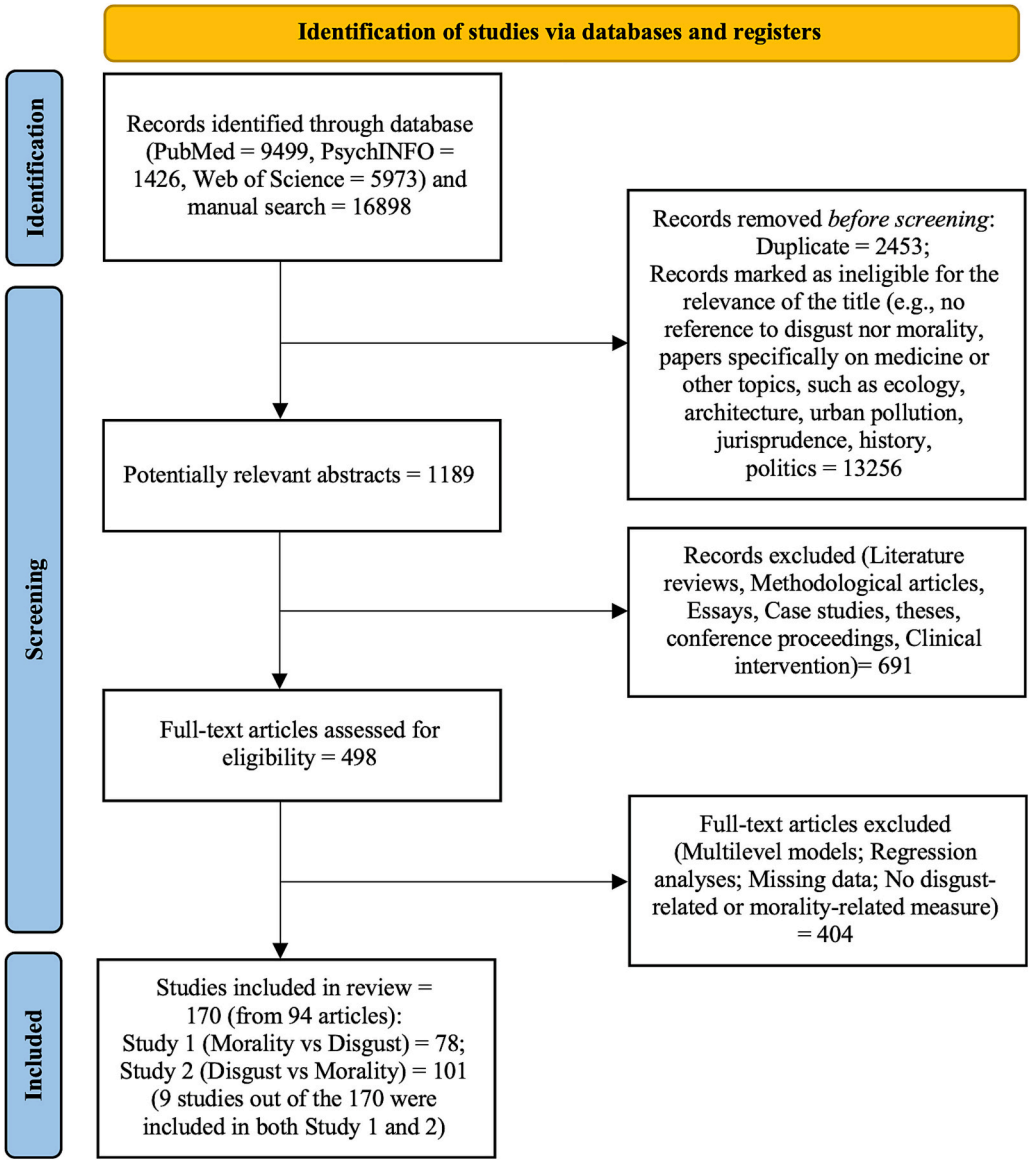

Fig. 1. PRISMA flowchart showing study selection for the meta-analyses.

prioritized these two domains as representative of this kind of morality. Nonetheless, since the domain of purity is biased toward pathogen or disgusting contents, when other domains were measured and data were available, we preferred to exclude purity in favor of another moral domain – the first considered being authority. Other domains, such as fairness and harm, were chosen with the aim of having a comparable number of studies for moderator analysis, especially when analyzing the MFT domains as moderator. Finally, we opted, where possible, to choose a moral domain other than loyalty. This was motivated by the fact that, although loyalty can be considered as a deontological subdomain, it seems to be very sensitive to cultural differences and individual's political orientation (Mancini et al., 2022; Ottaviani et al., 2018; Voelkel & Brandt, 2019).

Studies included in the meta-analyses measuring dispositional traits were mostly correlational. The only studies comparing two groups were Chapman and Anderson (2014, Study 1) and Olatunji et al. (2017), in which high-disgust sensitivity group versus low-disgust sensitivity group were compared. In these cases, we considered the high-sensitivity as the experimental one, and the low-sensitivity group as the control. When state and trait measures were both assessed, but data were only available for one measure, we opted for the available measure.

2.3. Data analysis

For each study (or subsample), a Hedges' g effect size -which represents the difference between means in units of the pooled standard deviation- and 95 % confidence intervals were computed using ProMeta Version 3.0 (Internovi) and visually displayed with forest plots. Effect sizes of *g* equal to 0.20, 0.50, and 0.80 were considered small, medium, and large, respectively (Cohen, 1988).

In experimental studies, *g* represented the difference between responses to a moral threat (Study 1) or a disgust induction (Study 2) and responses to a control condition. For state measures, effect sizes were assigned a positive sign when 1) there were larger increases in disgust levels associated with a moral threat (e.g., moral violations) compared to a control condition (Study 1), and 2) there were larger increases in the severity of moral judgments and moral attitudes (e.g., toward outgroup, politics, homosexuals) associated with increased disgust levels compared to a control condition (Study 2). For trait measures, effect sizes were positive when the high-disgust sensitivity group exhibited more severe moral judgments/attitudes compared to the low-disgust sensitivity group. For correlational studies, the *r* coefficient was converted to Hedges' *g* (Lipsey & Wilson, 2001).

Effect size calculations were based on means, standard deviations, difference in mean scores, *p* values, and sample sizes. When only standard errors (SE) were reported, standard deviations were calculated using the formula $SD = SE * \sqrt{n}$ (Higgins & Green, 2011). For studies that did not provide raw data but instead reported statistics (e.g., *t*-values), transformation formulas were applied to convert these statistics to Hedges'*g* (Lipsey & Wilson, 2001). When *p*-values were reported as $p < .05$ or $p < .001$, we computed Hedges' *g* using *p* values of 0.045 and 0.00095, respectively, assuming a one-tailed test, which likely provided a conservative estimate of the effect size.

The *Q* statistic was employed to determine the presence ($p < .05$) or absence of heterogeneity which quantifies the degree to which the effect sizes (e.g., treatment effects) vary between the included studies. Assessing heterogeneity provides insights into whether differences in study design, population, or other factors may be influencing effect sizes, with implications for the interpretation of results (Higgins et al., 2003). I^2 was used to estimate the proportion of variance in study estimates due to heterogeneity, with values of 0.25, 0.50, and 0.75 corresponding to low, moderate, and high between-study heterogeneity, respectively. Random-effects models were used in the analyses to account for both within-study variability and between-study variability (heterogeneity).

Publication bias, the tendency of journals and authors to publish studies with positive results over those with negative or nonsignificant results, was assessed in three ways. First, a funnel plot of effect size against standard error was used to check for asymmetry. Second, Begg and Mazumdar's rank correlations was computed to evaluate the correlation between the ranks of effect sizes and their variance (Kendall's *Tau*) (Begg & Mazumdar, 1994). Third, Egger's regression intercept test was used to assess the degree of funnel plot asymmetry, with the test output including the intercept (and its confidence interval) as well as of the results of a *t*-test (Egger et al., 1997).

All analyses were initially conducted on the entire set of studies, followed by a second round excluding potential outliers, specifically studies with statistically significant standardized residuals (Ellis, 2010).

2.4. Moderator analysis

Continuous moderators were evaluated using meta-regression, where the outcome variable is the effect estimate. Subgroup analyses were employed to assess the influence of categorical moderators on effect size in each meta-analysis. Scatter plots and funnel plots were employed to examine the relationships between moderators and effect sizes, providing a visual representation of potential trends and patterns within the data. In the following results section, the moderators of primary interest for the two meta-analyses are presented. Additional analysis and discussion of other moderators can be found in the Supplemental Material.

In Study 1, we examined how the size of the effect of moral threat/violation on disgust varied as a function of factors such as age, country, sex (% of women), ethnicity, type of morally threatening object (sexuality, social issues, religion), moral orientation (self-oriented vs. other-oriented), moral domain (purity, authority, fairness, loyalty, harm), type of morality (deontological vs. altruistic), disgust measurement (physiological/sensory, implicit, self-report, behavioral), and study design (i.e., between-subject, within-subject, correlational).

In Study 2, for each outcome, we analyzed how the size of the effect of disgust manipulation on moral judgment/attitude varied according to factors such as age, country, sex (% of women), ethnicity, trait vs. state disgust, disgust manipulation (sensory stimuli, cleanliness/dirtiness-related objects, physical cleansing, environment-related), disgust orientation (self-oriented vs. externally oriented), object of moral judgment (religion-related issues, sexuality, social issues), moral domain (authority, fairness, harm, purity), type of morality (deontological vs. altruistic), and study design (experimental/control condition, correlational).

A minimum of four studies per subgroup was required for the moderation analysis. To ensure a comparable number of studies in each subgroup and reliably detect moderators' effects, some moderators were recoded (see the Supplemental Material for more details). Due to the limited number of studies available, the two meta-analyses were unable to test person-related moderators of interest, such as political or religious preferences.

3. Results: do moral transgressions elicit disgust? (study 1)

As shown in Fig. 2, a significant effect of moral violations on disgust was observed across 78 studies with a total of 10,617 participants ($g = 0.55$, 95 % *CI* [0.41, 0.68], $p < .001$). This effect was medium in size and exhibited significant heterogeneity ($Q = 1271.04$, $p < .001$; $I^2 = 93.94$). Kendall's tau indicated a marginally significant publication bias, which was also supported by Begg and Mazumdar's rank correlation test ($Z = 1.66$; $p = .097$), though not by Egger's linear regression test (intercep $t = 0.06$, $t = 0.06$, $p = .951$) (Fig. 3 for the funnel plot).

Excluding outliers (see Table S1) did not affect the effect size or heterogeneity ($g = 0.56$, 95 % *CI* [0.47, 0.65], $p < .001$; $Q = 447.03$, $p < .001$; $I^2 = 84.12$), but it did eliminate the publication bias ($Z = 1.36$; $p = .173$; intercept $= -0.27$, $t = -0.42$, $p = .676$).

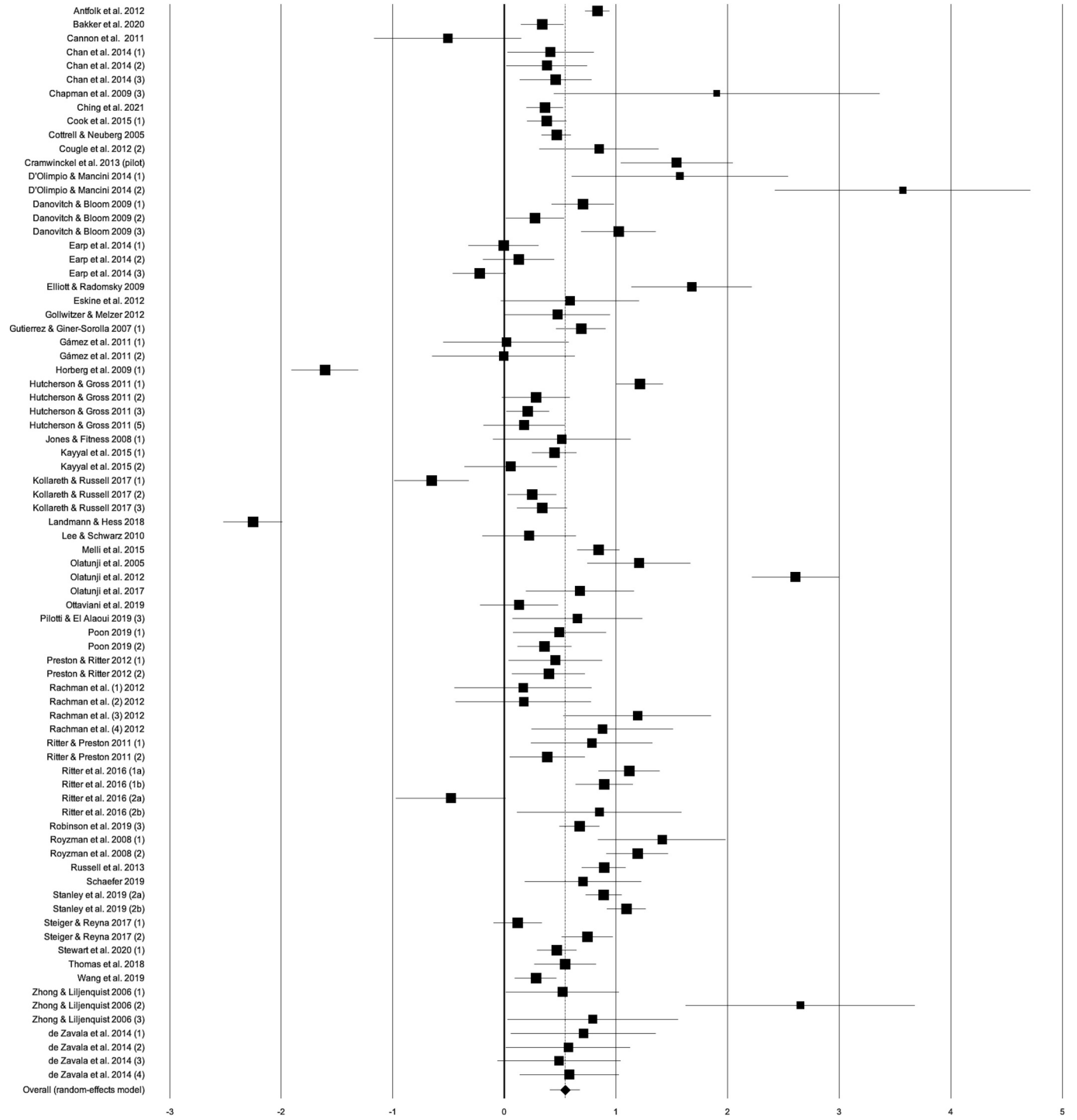

Fig. 2. Forest plots from the meta-analysis illustrating the effects of moral transgressions on feelings of disgust (Study 1) (Antfolk et al., 2012; Bakker et al., 2020; Cannon et al., 2011; Chan et al., 2014; Chapman et al., 2009; Ching et al., 2021; Cook et al., 2015; Cottrell & Neuberg, 2005; Cougle et al., 2012; Cramwinckel et al., 2013; D'Olimpio & Mancini, 2014; Danovitch & Bloom, 2009; Earp et al., 2014; Elliott & Radomsky, 2009; Eskine et al., 2012; Gollwitzer & Melzer, 2012; Gutierrez & Giner-Sorolla, 2007; Gámez et al., 2011; Horberg et al., 2009; Hutcherson & Gross, 2011; Jones & Fitness, 2008; Kayyal et al., 2015; Kollareth & Russell, 2017; Landmann & Hess, 2018; Lee & Schwarz, 2010; Melli et al., 2015; Olatunji et al., 2005; Olatunji et al., 2012; Olatunji et al., 2017; Ottaviani et al., 2019; Pilotti and El Alaoui, 2019; Poon, 2019; Preston & Ritter, 2012; Rachman et al., 2012; Ritter and Preston, 2011; Ritter et al., 2016; Robinson et al., 2019; Royzman et al., 2008; Russell et al., 2013; Schaefer, 2019; Stanley et al., 2019; Steiger & Reyna, 2017; Stewart et al., 2020; Thomas et al., 2018; Wang et al., 2019; de Zavala et al., 2014; Zhong & Liljenquist, 2006).

3.1. Moderation analysis: person-related characteristics

3.1.1. Age

Out of the 78 studies examined, only 61 provided data on age, with participants ranging from approximately 7 years old (Danovitch & Bloom, 2009) to around 40 years old (Melli et al., 2015). Meta-regression analysis showed no significant effect of age on the association between moral violations and disgust both before ($k = 61$; intercept $= 0.82$; $p = .492$) and after ($k = 57$; intercept $= 0.58$; $p = .826$) removing outliers (Fig. S1).

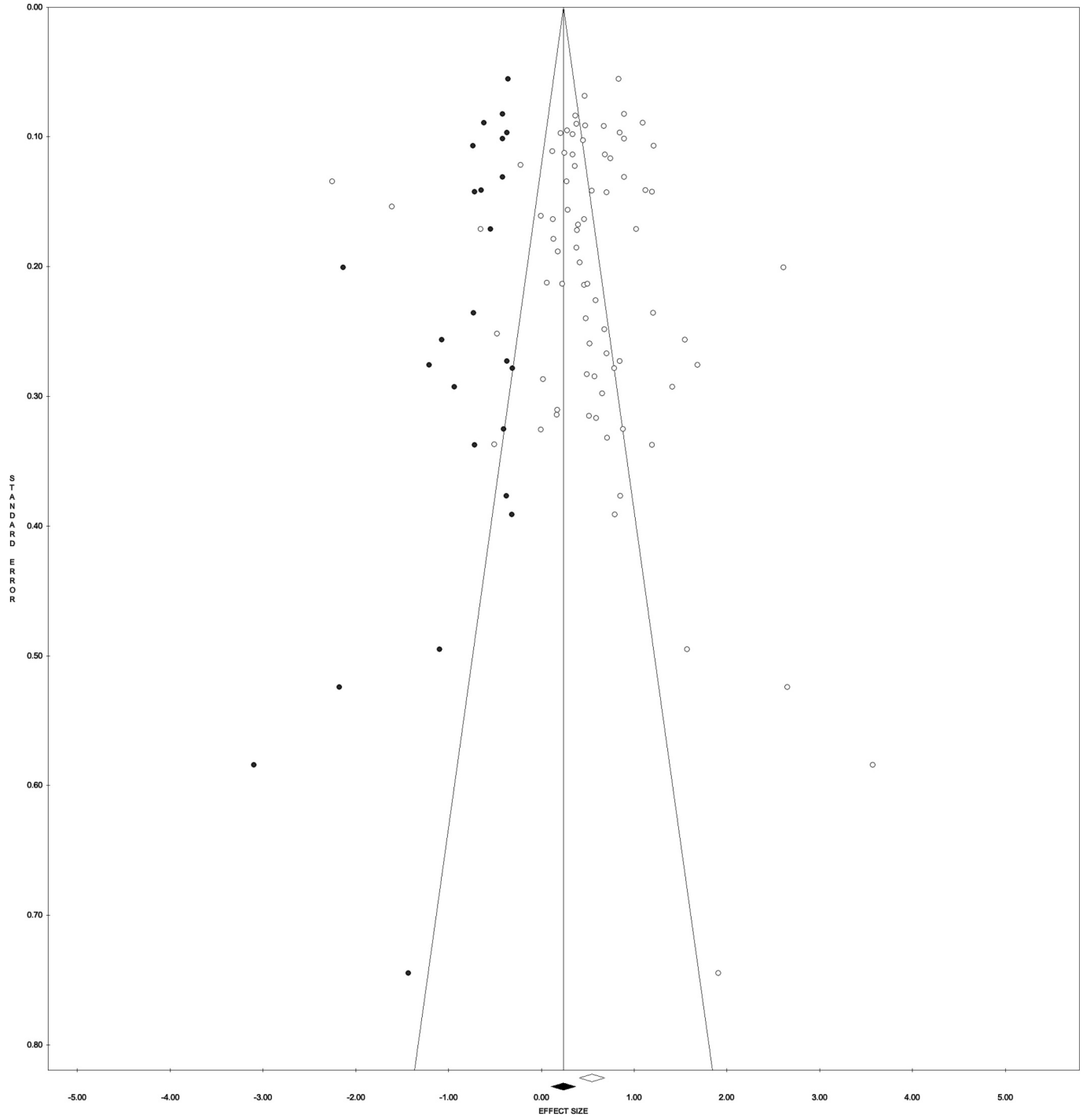

Fig. 3. Funnel plot for visual inspection of publication bias in the meta-analysis illustrating the effects of moral transgressions on feelings of disgust (Study 1).

3.1.2. Sex (% of females)

Sex data was available for 65 of the 78 studies. The meta-regression analysis indicated no effect of the percentage of female participants on the association between moral violations and disgust both before (k = 65; intercept = 0.47; p = .792) and after (k = 60; intercept = 0.64; p = .689) removing outliers (Fig. S2).

3.1.3. Country

Country of origin significantly moderated the effect of moral violations on disgust (Q = 9.59, p = .048). Only participants from Western countries (Canada, Europe, USA, UK/Australia) showed significant disgust responses to moral violations (Canada: g = 0.83, k = 5, n = 229, p = .007; USA: g = 0.62, k = 43, n = 6332, p < .001; Europe: g = 0.57, k = 15, n = 1795, p = .027; UK/Australia: g = 0.30, k = 5, n = 363, p = .184) compared to participants from Asian countries, including China, India, Saudi Arabia, Turkey, and United Arab Emirates (g = 0.19, k = 8, n = 1263, p = .140) (Fig. S3). Substantial heterogeneity was observed within all subgroups (Canada: Q = 19.57, p = .001; I^2 = 79.56; USA: Q = 581.46, p < .001; I^2 = 92.78; Europe: Q = 528.97, p < .001; I^2 = 97.35; UK/Australia: Q = 20.92, p < .001; I^2 = 80.88; Asia: Q = 49.37, p < .001; I^2 = 85.82). After the removal of outliers, this moderator remained marginally significant (Q = 8.88, p = .064), with heterogeneity remaining unchanged.

3.1.4. Ethnicity

Ethnicity was a significant moderator ($Q = 6.14$, $p = .013$; Fig. S4 for the forest plot). Studies with a majority of Caucasian/White participants showed a larger effect of moral violations on disgust ($g = 0.57$, $k = 14$, $n = 2399$, $p < .001$), compared to those with a majority of Asian participants ($g = -0.07$, $k = 8$, $n = 1313$, $p = .752$). Both groups exhibited substantial heterogeneity ($Q = 138.63$, $p < .001$; $I^2 = 90.62$ and $Q = 169.49$, $p < .001$; $I^2 = 95.87$, respectively). After the removal of potential outliers, this moderator was no longer significant.

3.2. Moderation analysis: measurement-related characteristics

3.2.1. Morally threatening behavior

The type of behavior perceived as a moral threat (e.g., sexual behavior, religion-related issues, social issues) emerged as significant moderator ($Q = 11.68$, $p = .003$). Sexuality-related threats elicited a stronger disgust response ($g = 0.80$, $k = 18$, $n = 2662$, $p < .001$) compared to religious-related threats ($g = 0.67$, $k = 10$, $n = 1742$, $p < .001$) and social issues ($g = 0.43$, $k = 6$, $n = 468$, $p < .001$) (Fig. S5 for the forest plot). Significant heterogeneity was observed for sexuality and religion ($Q = 115.61$, $p < .001$, $I^2 = 85.29$ and $Q = 37.59$, $p < .001$; $I^2 = 76.06$). The exclusion of extreme outliers did not affect the impact of this moderator or the heterogeneity within subgroups.

3.2.2. Disgust measurement

We examined whether the method used to assess disgust influenced the outcomes when evaluating the effect of moral threats on disgust responses. This moderator was categorized into physiological/sensorial responses (i.e., autonomic response, facial muscular activity, oral inhibition, sensory stimulus rating), behavioral responses (e.g., washing behaviors), implicit measures, and self-reports (Fig. S7 for the forest plot). This variable did not moderate the association between moral violations and disgust ($Q = 0.79$, $p = .851$; after outliers' removal: $Q = 4.00$, $p = .261$).

3.2.3. Type of morality

A comparison between studies using moral violations associated with deontological morality and those involving altruistic violations revealed a marginally significant difference ($Q = 2.99$, $p = .084$). Deontological transgressions elicited stronger disgust responses ($g = 0.55$, $k = 26$, $n = 4058$, $p < .001$) compared to altruistic transgressions ($g = 0.15$, $k = 5$, $n = 494$, $p = .393$) (Fig. S10). Both subgroups exhibited significant heterogeneity ($Q = 930.87$, $p < .001$; $I^2 = 97.31$ and $Q = 11.24$, $p = .024$; $I^2 = 64.40$, respectively). The exclusion of outliers increased the moderating effect ($Q = 9.15$, $p = .002$) with deontological violations having an even greater impact on disgust responses ($g = 0.72$, $k = 22$, $n = 3697$, $p < .001$) compared to altruistic violations ($g = 0.15$, $k = 5$, $n = 494$, $p = .393$), without affecting heterogeneity.

4. Results: does disgust increase moral severity? (study 2)

This meta-analysis identified significant effects of disgust induction on the severity of moral judgments and attitudes (101 studies; 18,180 participants; $g = 0.40$, 95 % *CI* [0.30, 0.49], $p < .001$), revealing a small-to-medium effect size (Fig. 4) with significant heterogeneity ($Q = 956.94$, $p < .001$; $I^2 = 89.55$).

There was no evidence of publication bias (intercept = 0.14 $t = 0.19$, $p = .853$; $Z = 0.63$; $p = .530$; Fig. 5 for the funnel plot). However, after excluding extreme outliers (see Table S1), a marginally significant *Z*-value was observed ($Z = 1.75$, $p = .080$) with the Egger's test remaining non-significant (intercept = 0.45, $t = 0.69$, $p = .494$). The exclusion of outliers did not affect the effect size or heterogeneity ($g = 0.43$, 95 % *CI* [0.35, 0.50], $p < .001$; $Q = 433.05$, $p < .001$; $I^2 = 80.60$).

4.1. Moderation analysis: person-related characteristics

4.1.1. Age

Out of the 101 studies examined, 82 included age data, ranging from 18 (Petrescu & Parkinson, 2014) to 43 years (Huangfu et al., 2017). Meta-regression analysis indicated that age significantly moderated the effects of disgust on moral judgments both before ($k = 82$; intercept = −0.18; $p = .046$) and after the removal of outliers ($k = 70$; intercept = −0.04; $p = .006$) (Fig. S12).

4.1.2. Sex (% of females)

Of the 101 studies, 95 included data on the percentage of female participants. Meta-regression analysis revealed no moderating effect of sex on the relationship between disgust and moral judgments ($k = 95$; intercept = 0.47; $p = .806$; Fig. S13).

4.1.3. Country

To ensure a comparable number of studies for this sub-group analysis, the country of origin was re-coded into Western (Europe, UK, USA, Canada) and Eastern (China, Singapore, Taiwan) categories. A significant difference emerged between studies form Western countries and those from Eastern countries ($Q = 4.93$, $p = .026$). Specifically, Western populations exhibited a stronger effect of disgust on moral judgments ($g = 0.43$, $k = 80$, $n = 15{,}064$, $p < .001$) compared to Eastern populations ($g = 0.06$, $k = 16$, $n = 1560$, $p = .696$) (Fig. S14). This effect was further amplified after removing outliers ($Q = 8.58$, $p = .003$). Both subgroups showed substantial heterogeneity (Western: $Q = 623.28$, $p < .001$; $I^2 = 87.33$; Eastern: $Q = 160.42$, $p < .001$; $I^2 = 90.65$), which remained significant after removal of outliers ($Q = 302.96$, $p < .001$; $I^2 = 76.89$ and $Q = 25.48$, $p = .002$; $I^2 = 64.67$, respectively).

4.1.4. Ethnicity

No moderating effect of ethnicity was initially detected ($Q = 0.99$, $p = .319$). However, after removing outliers, this moderator became significant ($Q = 4.32$, $p = .038$). Studies with a majority of Caucasians/Whites showed a stronger effect of moral violations on disgust ($g = 0.36$, $k = 17$, $n = 4650$, $p < .001$) compared to those with a majority of Asian participants ($g = 0.11$, $k = 8$, $n = 1013$, $p = .328$) (Fig. S15). Heterogeneity was substantial in both subgroups of studies before (Caucasian: $Q = 42.06$, $p < .001$; $I^2 = 61.96$; Asian: $Q = 207.28$, $p < .001$; $I^2 = 93.25$) and after outliers' removal (Caucasian: $Q = 42.06$, $p < .001$; $I^2 = 61.96$; Asian: $Q = 22.47$, $p = .002$; $I^2 = 68.85$).

4.2. Moderation analysis: measurement-related characteristics

4.2.1. Trait versus state disgust

A significant difference was observed when contrasting studies that assessed disgust sensitivity with those that assessed incidental disgust ($Q = 6.75$, $p = .009$; Fig. S16). Trait disgust had a stronger effect on morality ($g = 0.54$, $k = 40$, $n = 11{,}148$, $p < .001$) than state disgust ($g = 0.30$, $k = 61$, $n = 7032$, $p < .001$). Both subgroups exhibited significant heterogeneity ($Q = 242.41$, $p < .001$; $I^2 = 83.91$ and $Q = 607.32$, $p < .001$; $I^2 = 90.12$, respectively). The exclusion of extreme outliers did not impact the overall effect of this moderator, or the observed heterogeneity.

4.2.2. Disgust manipulation

To maintain a comparable number of studies for this analysis, the type of disgust manipulation was recoded into three subgroups: cleansing-related tasks (e.g., physical cleansing, cleanliness-dirtiness reminders), disgusting/polluted environment (e.g., experimental setting), and sensory stimuli (e.g., gustatory, olfactory, tactile, visual, auditory). This variable marginally moderated the effects of disgust on moral judgment ($Q = 4.92$, $p = .085$; Fig. S17), with sensory manipulations producing a greater effects on morality ($g = 0.41$, $k = 17$, $n = 1770$, $p = .009$) compared to other manipulations (environmental: $g =$

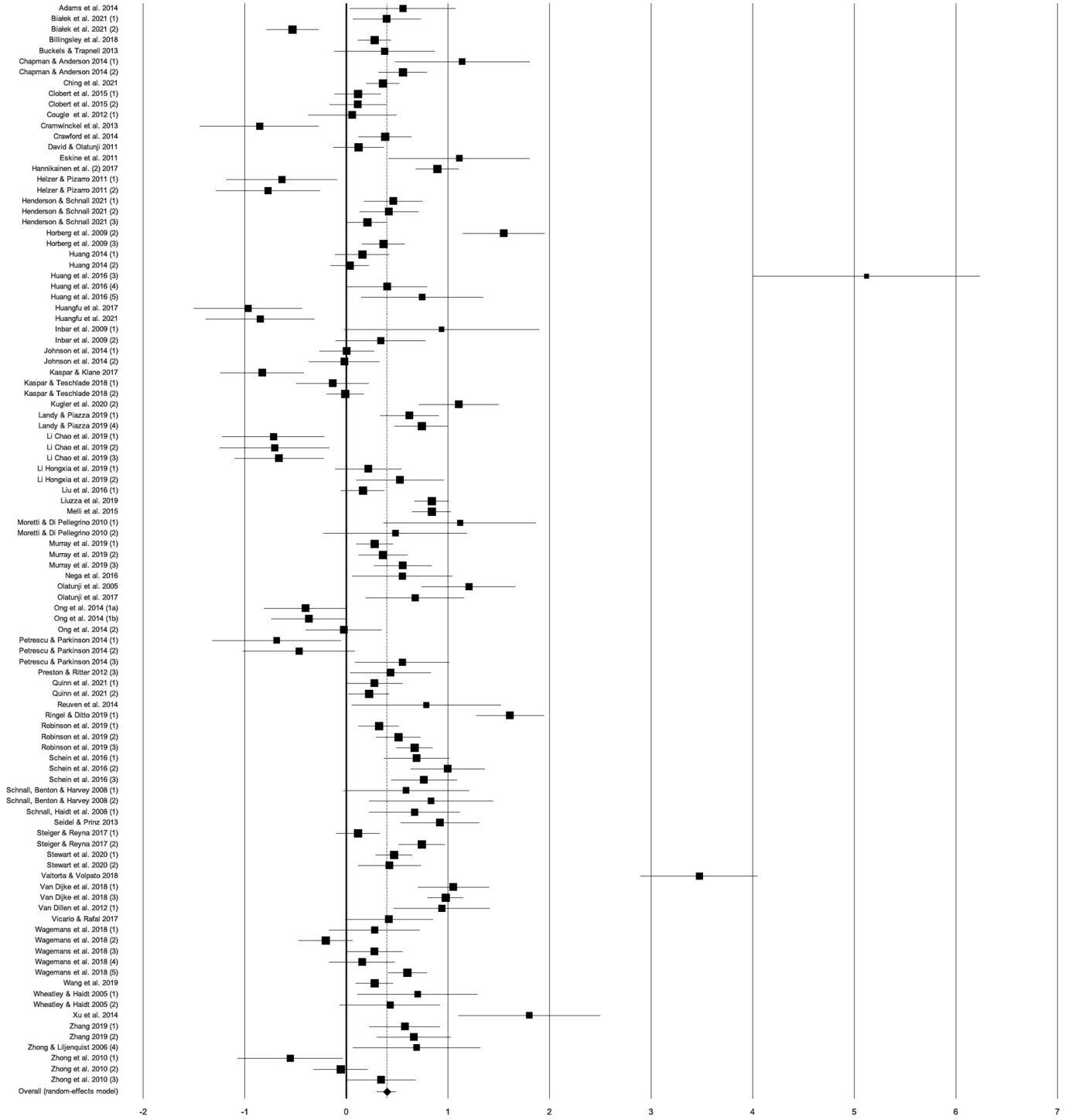

Fig. 4. Forest plots from the meta-analysis illustrating the effects of disgust on perceived moral severity (Study 2) (Adams et al., 2014; Białek et al., 2021; Billingsley et al., 2018; Buckels & Trapnell, 2013; Chapman & Anderson, 2014; Ching et al., 2021; Clobert et al., 2015; Cougle et al., 2012; Cramwinckel et al., 2013; Crawford et al., 2014; David & Olatunji, 2011; Eskine et al., 2011; Hannikainen et al., 2017; Helzer & Pizarro, 2011; Henderson & Schnall, 2021; Horberg et al., 2009; Huang, 2014; Huang et al., 2016; Huangfu et al., 2017; Huangfu et al., 2021; Inbar et al., 2009; Johnson et al., 2014; Kaspar & Klane, 2017; Kaspar & Teschlade, 2018; Kugler et al., 2020; Landy & Piazza, 2019; Li, Liu et al., 2019; Li, Wang, et al., 2019; Liu et al., 2016; Liuzza et al., 2019; Melli et al., 2015; Moretti & Di Pellegrino, 2010; Murray et al., 2019; Nega et al., 2016; Olatunji et al., 2005; Olatunji et al., 2017; Ong et al., 2014; Petrescu & Parkinson, 2014; Preston & Ritter, 2012; Quinn et al., 2021; Reuven et al., 2014; Ringel & Ditto, 2019; Robinson et al., 2019; Schein et al., 2016; Schnall, Benton, et al., 2008; Schnall, Haidt, et al., 2008; Seidel & Prinz, 2013; Steiger & Reyna, 2017; Stewart et al., 2020; Valtorta & Volpato, 2018; van Dijke et al., 2018; Van Dillen et al., 2012; Vicario & Rafal, 2017; Wagemans et al., 2018; Wang et al., 2019; Wheatley & Haidt, 2005; Xu et al., 2014; Zhang, 2019; Zhong & Liljenquist, 2006; Zhong et al., 2010).

0.05, $k = 7$, $n = 1273$, $p = .778$; cleansing-related: $g = 0.00$, $k = 21$, $n = 2307$, $p = .995$). Outliers' removal did not alter this outcome ($Q = 8.96$, $p = .011$).

Substantial heterogeneity was present in all subgroups (sensory stimuli: $Q = 149.73$, $p < .001$, $I^2 = 89.31$; cleansing-related: $Q = 112.26$, $p < .001$; $I^2 = 82.18$; environmental: $Q = 39.61$, $p < .001$; $I^2 = 84.85$),

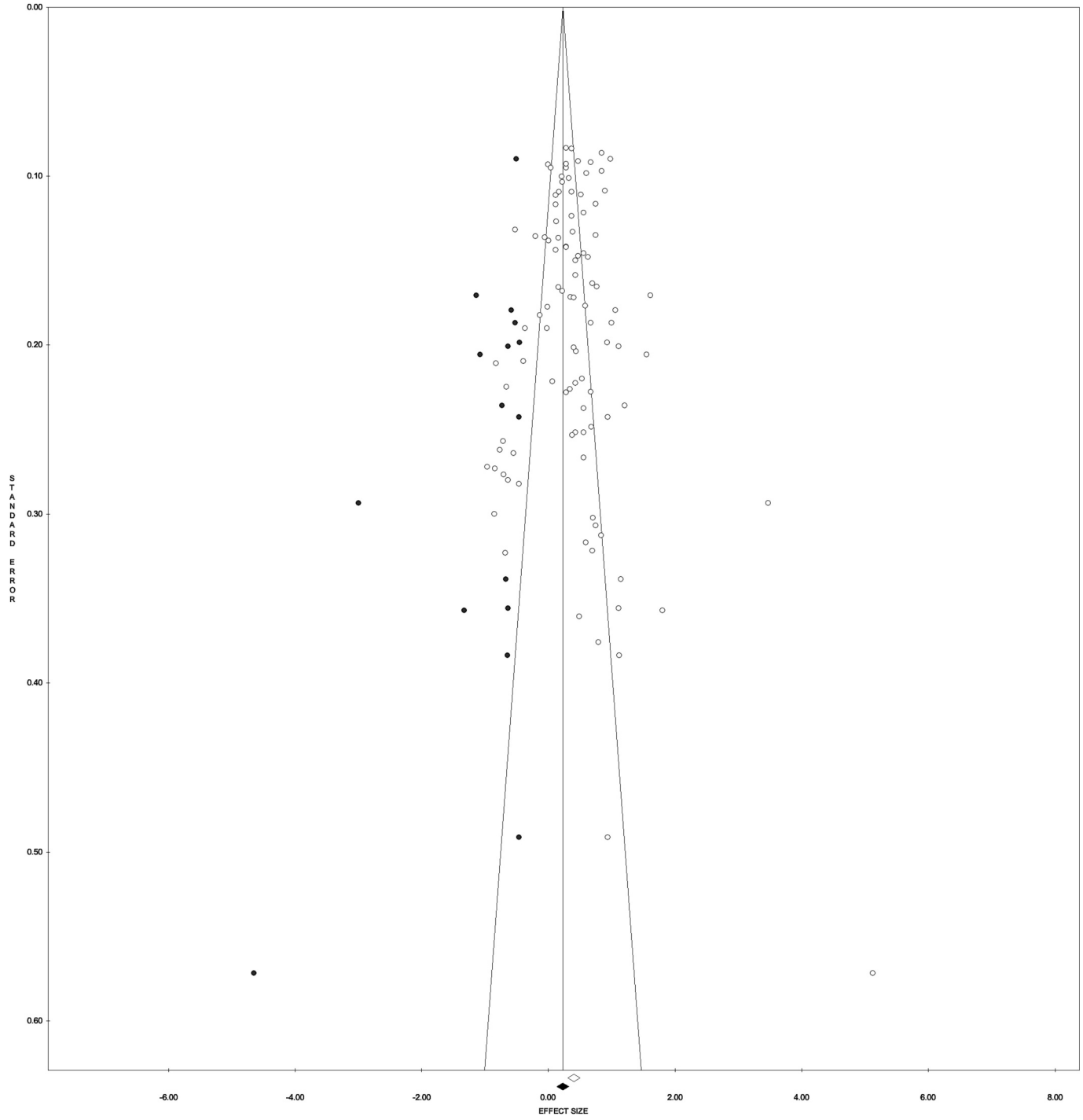

Fig. 5. Funnel plot for visual inspection of publication bias in the meta-analysis illustrating the effects of disgust on perceived moral severity (Study 2).

although it remained significant only for sensory and cleansing-related manipulations after outliers' removal.

4.2.3. Moral issue

The moral issue investigated (e.g., sexuality, social issues, religion-related) was a significant moderator ($Q = 8.86$, $p = .012$; Fig. S20). Disgust induction had stronger effect on religious values ($g = 0.68$, $k = 5$, $n = 1015$, $p < .001$) compared to sexuality ($g = 0.38$, $k = 12$, $n = 2007$, $p < .001$) and social issues ($g = 0.06$, $k = 22$, $n = 2539$, $p = .706$). All subgroups exhibited significant heterogeneity (religion: $Q = 14.99$, $p = .005$, $I^2 = 73.31$; sexuality: $Q = 30.92$, $p = .001$; $I^2 = 64.42$; social: $Q = 254.93$, $p < .001$; $I^2 = 91.76$). However, this moderator did not remain significant after excluding extreme outliers.

4.2.4. Interaction between disgust target and moral type

We further analyzed the interaction between the direction of disgust and moral judgments, as theorized by Tobia (2014). We identified four categories of interactions: undirected disgust vs. other-directed morality, other-directed disgust vs. other-directed morality, self-directed disgust vs. other-directed morality, and self-directed disgust vs self-directed morality (see Supplemental Material for details). This variable significantly moderated the effects of disgust on moral judgment ($Q = 14.64$, $p = .002$; Fig. S22), with other-directed disgust vs. other-directed morality and self-directed disgust vs self-directed morality

having the strongest effects ($g = 0.68$, $k = 12$, $n = 1273$, $p < .001$ and $g = 0.38$, $k = 7$, $n = 964$, $p = .029$, respectively). In contrast, other interactions showed weaker or negative effects (undirected disgust vs. other-directed morality: $g = -0.03$, $k = 8$, $n = 1315$, $p = .882$; self-directed disgust vs other-directed morality: $g = -0.21$, $k = 7$, $n = 668$, $p = .421$). After removing outliers, the significance of this moderator became marginal ($Q = 7.49$, $p = .087$).

Substantial heterogeneity was observed across all subgroups (other-directed disgust vs. other-directed morality: $Q = 64.79$, $p < .001$, $I^2 = 83.02$; self-directed disgust vs self-directed morality: $Q = 33.02$, $p < .001$; $I^2 = 81.83$; undirected disgust vs. other-directed morality: $Q = 56.19$, $p < .001$; $I^2 = 87.54$; self-directed disgust vs. other-directed morality: $Q = 62.92$, $p < .001$; $I^2 = 90.46$), with the exception of the undirected disgust vs. other-directed morality category, which no longer showed significant heterogeneity after outliers' removal.

4.2.5. Type of morality

Significant differences emerged when comparing studies investigating deontological versus altruistic morality as dependent variables ($Q = 11.75$, $p = .001$; Fig. S25). Disgust induction had a stronger impact on deontological morality ($g = 0.43$, $k = 29$, $n = 7135$, $p < .001$) than on altruistic morality ($g = -0.20$, $k = 5$, $n = 411$, $p = .234$). Both sets of studies demonstrated significant heterogeneity (deontological: $Q = 265.31$, $p < .001$; $I^2 = 89.45$; altruistic: $Q = 15.86$, $p = .003$; $I^2 = 74.77$). The removal of potential outliers did not affect the effect size or the heterogeneity within the subgroups.

5. Discussion

The data supported the hypotheses that moral transgressions elevate levels of disgust (*elicitation hypothesis*) and that manipulating disgust influences the perceived severity of moral violations (*amplification hypothesis*), both with small-to-medium effect sizes. Additionally, several variables were found to moderate these effects, underscoring the influence of both biological and cultural factors.

5.1. The moderating role of age

Among the person-related characteristics investigated, the fact that disgustful reactions to moral transgressions remained consistent across different ages has intriguing implications, particularly when considering evolutionary models of morality, such as social intuitionist theories, or "neural reuse" theories. Haidt and Joseph (2008) propose that, just as people instinctively react with disgust to certain foods, children quickly recognize and respond to moral situations because they possess «bits of mental structure that connect the perception of specific patterns in the social world to evaluations and emotions» (p. 381). Lee and Schwarz (2011) suggest that responses to moral transgressions may be scaffolded on the evolutionary precursor of the disgust response. This aligns with the neural reuse theory (Anderson, 2010), which posits that evolution builds new functions on pre-existing mechanisms, and with the grounded cognition perspective, which argues that human reasoning about abstract domains is guided by concrete domains with which we have direct sensory experience (Barsalou, 2008).

While Study 1 indicated stability in disgust reactions across age, Study 2 suggests age-related variability in the relationship between disgust and moral judgments. This implies that as individuals age, their moral judgment processes may become more influenced by disgust. This aligns with evidence suggesting that greater sensitivity to disgust is associated with harsher moral judgments, and that this effect is enhanced with age (Aguiar et al., 2022). However, other studies have found that older adults reported less intense negative emotions, including disgust, suggesting they are less aroused by immoral acts (Lu & Fung, 2019). Together, these findings challenge the evolutionary perspective by suggesting that the impact of disgust on moral judgments may evolve or change over the lifespan.

5.2. Sex differences in the interrelationships between disgust and morality

Sex differences did not influence the relationship between morality and disgust in either Study 1 or Study 2. However, closer examination suggests that men and women might react differently to specific moral topics, which could mitigate the overall effect. For example, Russell et al. (2013) found that women, more than men, were disgusted by divinity violations, while men were more disgusted by community violations. Men also expressed stronger negative feelings and avoidance of/aggression toward individuals with same-sex sexual orientation (Ching et al., 2021), whereas women hold more positive attitudes toward gay people (Kite & Whitley, 1996). Additionally, women appear to be more disgusted by incest than men (Antfolk et al., 2012), a finding consistent with evolutionary theories concerning inbreeding avoidance.

5.3. Ethnicity and country of origin: the importance of cultural factors

In both Study 1 and Study 2, ethnicity and country of origin emerged as significant moderators, with White/Caucasian and Western individuals showing a more significant and bidirectional relationship between disgust and morality than Asian and Eastern individuals. This could be attributed to cultural differences in emotional expressions. For instance, display rules (Ekman, 2003) specify who can show which emotion to whom and when. Cultures also vary in the specific events that are likely to elicit emotions (Ekman, 2003). Another possible explanation could be the differing religious background. In monotheistic religions, which predominantly characterize Western and Caucasian cultures, a singular, omnipotent deity establishes a moral code with well-defined doctrines and commandments, creating a binary moral landscape that might amplify emotional responses like disgust when moral norms, perceived as divinely ordained, are violated. The concept of sin in these religions, often linked with feelings of guilt and contamination, could further reinforce the connection between moral transgressions and disgust. In contrast, polytheist religions, more prevalent in Asian and Eastern cultures, feature multiple deities with distinct characteristics and domains of influence. This plurality may lead to a more nuanced and less absolute moral framework, potentially resulting in a less intense or more differentiated emotional response to moral violations. Although religious affiliation was not included as a moderator in our meta-analysis due to an insufficient number of studies collecting this demographic variable, this speculation suggests that religious background may play a role in shaping emotional responses to moral violations (Graham & Haidt, 2012; Haidt, 2012; Haidt et al., 1993; Mancini & Gangemi, 2021; Rozin et al., 1999; Sunstein, 2005).

5.4. Sexuality

In both meta-analyses, sexuality significantly moderated the relationship between morality and disgust. Previous research has shown that negative moral judgments of sexual activities are informed by both disgust and anger, with sexual immorality predicting disgust independent of anger (Giner-Sorolla et al., 2012). Among the sexual behaviors examined in our meta-analysis, homosexuality frequently emerged as a major moral issue, with disgust being associated with prejudice toward homosexuals (Crawford et al., 2014; Inbar et al., 2009; Nega et al., 2016; Olatunji et al., 2017; Quinn et al., 2021; Schein et al., 2016). Additionally, individuals with high disgust sensitivity appeared to hold negative attitudes toward homosexuality, and this relationship seems to be mediated by moral foundations, particularly the concept of sanctity (Wang et al., 2019). Religious beliefs often play a significant role in shaping views on sexual behavior (Baker et al., 2020; Runkel, 1998).

5.5. Religious values

Religion also emerged as a crucial factor in shaping moral attitudes and structuring their relationship with disgust. In many religions, sin is

thought to corrupt the soul, and rituals of body washing are used to cleanse the conscience. From a clinical perspective, patients with OCD often experience concerns about sins of a religious and sexual nature, even when no harm is caused to others. Particularly in some cultures, the link between morality and religion has deep roots. For example, the ethic of divinity functions to protect and glorify God, and the foundation of purity often shares religiously laden values (Shweder et al., 1997). From a dualistic perspective (Mancini & Gangemi, 2021), the connection between religion and morality is especially profound when considering deontological values, such as norms of authority and sanctity/purity. Examples of deontological norms include the first three commandments of the Bible, which explicitly regulate the relationship with the divine rather than relationships with other people. There are also internalized moral norms that prohibit sexual conducts without the intent to harm others, such as consensual incest between adults and masturbation.

5.6. Type of morality

Analyzing the relationship between deontological morality and disgust was one of the primary objectives of both Study 1 and 2. Across the studies, effect sizes consistently showed a significant and stronger link between disgust and deontological morality compared to the link between disgust and altruistic morality, confirming the selective relationship between deontological morality and disgust, as supported by existing literature (Basile et al., 2011; D'Olimpio & Mancini, 2014; Ottaviani et al., 2018; Ottaviani et al., 2019; Robinson et al., 2019; Salvo et al., 2022). This association is particularly relevant in the context of OCD, where guilt and disgust are pivotal emotions, with OCD patients showing heightened sensitivity to deontological guilt, often involving religious or sexual transgressions (e.g., Mancini et al., 2022).

The absence of a clear relationship between altruistic morality and disgust may be due to the inherently other-oriented nature of altruistic concerns, which emerge when negative consequences for others are implied. In contrast, disgust is self-oriented, motivating individuals to avoid contamination and initiate self-purification. As Mancini and Gangemi (2021) speculate, the strong relationship between deontological morality and disgust could be linked to aspects of moral education, emphasizing respect for authority, prohibitions, and norms. Since disgust is more easily induced than fear, requiring only simple suggestions and showing greater resistance to extinction (Olatunji et al., 2009), it could serve as an effective tool for instilling adherence to norms, offering advantages over fear in reducing stress within both the nurturer-nurtured relationship and the social group context (Mancini & Gangemi, 2021). Furthermore, inducing disgust directly engages individuals' self-perception, minimizing costs for educators and reducing the risk of rebellion by learners (Chapman & Anderson, 2013; Ohtsuki et al., 2009). Unlike fear which protects against explicit dangers (e.g., a predator, an earthquake), the core function of disgust is to protect against subtle, non-obvious dangers, such as food that appears appetizing but may be poisonous. The "defense" function against subtle dangers might have been socially *re-used* to protect against traitors, cheaters, swindlers – those within a social group who do not respect its rules (Mancini & Gangemi, 2021).

5.7. Experimental paradigms

In both meta-analyses, we paid particular attention to variables concerning the experimental methods used. We found that moral transgressions affect the level of disgust regardless of how disgust is measured. This finding contributes to the ongoing debate about whether moral transgressions elicit true (i.e., physical) disgust or if moral disgust is largely a linguistic artifact (Landy & Goodwin, 2015; Mancini & Gangemi, 2021). This debate is particularly relevant for studies using verbal self-reported measures to rate momentary emotional state in response to moral transgressions, often considered less reliable indicators of disgust. However, our results indicate that studies measuring disgust through physiological/sensory responses, behavioral responses, implicit measures, or self-reports were all similarly affected by moral violations.

5.8. State versus trait disgust

We contrasted studies assessing trait disgust with those exploring the effects of incidental disgust on moral attitudes, finding that trait disgust had a more substantial influence on moral judgments. This suggests that individual differences in dispositional traits, such as disgust sensitivity, may play a more significant role in moral evaluations than temporary increases in disgust. This finding may help explain the moral rigidity observed in patients with OCD, as several studies have demonstrated a link between disgust sensitivity and obsessive symptoms (Mancini, 2018).

Among the studies investigating the impact of incidental disgust on morality, we categorized the types of disgust manipulations into three groups: sensory stimuli, cleansing-related tasks, and disgust induced by a polluted/dirty environment. Disgust induced by sensory stimuli had the strongest effect on moral judgments, followed by the other two categories. As noted by Tobia (2014), cleanliness can influence moral judgments in varying ways, with several factors potentially mediating its impact.

5.9. Importance of directional congruence between disgust and morality

In addition to analyzing disgust and morality independently, we also examined the interaction between their directionalities. Tobia (2014) emphasized the importance of considering the "Target" and "Type" of experimental manipulations. Our analysis revealed that other-directed disgust had a stronger influence on other-directed morality, and self-directed disgust had greater impact on self-directed morality. This "congruence effect" suggests that the alignment of disgust and moral judgment directions enhances their interrelationship. Conversely, undirected disgust and self-directed disgust had minimal effects on other-directed morality, underscoring the significance of directional congruence in moral reasoning. This nuanced understanding highlights the need to consider both the source and the target of moral judgments and emotional responses in moral psychology research (Mancini & Gangemi, 2021; Tobia, 2014).

6. Limitations and conclusions

While comprehensive, the current study has limitations that warrant careful interpretation. First, the analysis was restricted to studies published in English, which may limit its generalizability. Second, we did not include unpublished studies, introducing the possibility of publication bias, given the tendency to publish studies with positive findings. The presence of extreme outliers, which sometimes altered the significance of moderators when removed, indicates potential sensitivity in the findings and raises questions about their robustness. Additionally, there was considerable heterogeneity across studies, which suggests that the studies being analyzed might not be entirely comparable mainly due to differences in study design, populations, and outcome measurements. Although we addressed this issue by using random-effects model, substantial heterogeneity can undermine the generalizability of our findings (Higgins & Thompson, 2002).

There are likely other important moderators that were not examined. The moderator analysis was constrained by the limited number of studies addressing specific variables of interest. For instance, political orientation was not considered, although research suggests that disgust is more strongly associated with conservative than liberal orientations (Billingsley et al., 2018), though this is not always the case (Petrescu & Parkinson, 2014). Religious affiliation is another potential moderator that could influence the relationship between morality and disgust

across different cultural contexts.

Methodologically, the inclusion of studies with varied designs, ranging from experimental to correlational, introduces variability that could lead to conflicting conclusions. Furthermore, the studies in our meta-analysis employed diverse methods to measure disgust, including physiological, behavioral, and self-reported approaches. These methods may not equally capture the complexity of emotional responses, resulting in variable outcomes. Lastly, these meta-analyses focused on the relationship between morality and disgust in healthy individuals. While the exclusion of clinical populations might be seen as a limitation – especially given the potential role of disgust and guilt in OCD – there were insufficient studies on clinical samples to address this issue adequately. In summary, while our study provides valuable insights into the relationship between disgust and morality, its limitations underscore the need for future research to refine and expand upon these findings.

In conclusion, our study underscores the importance of considering various factors – methodological approaches, individual characteristics, and dispositional differences – in researching the complex relationship between disgust and morality. A critical methodological focus of our meta-analysis was on the orientation of both disgust and morality and the moderating effect of their interaction. The alignment of disgust's direction with the type of moral judgment (other-directed disgust vs. other-directed morality, and self-directed disgust vs. self-directed morality) was found to amplify the impact of this relationship, emphasizing the importance of congruence in these dynamics. Another crucial factor is the importance of cultural differences, particularly ethnicity and country of origin, in shaping moral disgust across different cultural and religious backgrounds. Our findings reveal how cultural context significantly influences moral judgments tied to disgust, suggesting that what is considered "morally tainted" could depend on deeply ingrained societal norms and values (such as religious beliefs). This cultural lens not only highlights the variability in moral frameworks across societies but also points to the importance of cultural sensitivity when interpreting disgust-related moral phenomena. A key methodological consideration is the impact of dispositional traits on the observed relationship between morality and disgust. The role of disgust sensitivity in shaping responses to moral violations, raises the question of how individual differences can affect the results of this kind of studies. With this regard, the moderating effects of these and other confounding factors, such as social or economic status (Schwitzgebel & Cushman, 2011; Tobia, Chapman, & Stich, 2013), should be taken into account by future research. In conclusion, while our meta-analysis provides a comprehensive overview, the presence of heterogeneity indicates that the results should be interpreted with caution, and further research is needed to explore such sources of variability.

CRediT authorship contribution statement

Giuseppe Salvo: Writing – review & editing, Writing – original draft, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Cristina Ottaviani:** Writing – review & editing, Validation, Supervision, Software, Project administration, Methodology, Conceptualization. **Francesco Mancini:** Writing – review & editing, Supervision, Project administration, Conceptualization.

Declaration of competing interest

The author(s) declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.paid.2024.113032.

Data availability

Data and coding procedures related to this meta-analysis are available from the corresponding author upon request.

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