Journal of Obsessive-Compulsive and Related Disorders xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Journal of Obsessive-Compulsive and Related Disorders

journal homepage: www.elsevier.com/locate/jocrd

I obsessively clean because deontological guilt makes me feel physiologically disgusted!

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ARTICLE INFO

Keywords:
Obsessive-compulsive disorder
Heart rate variability
Disgust
Deontological guilt
Altruistic guilt

ABSTRACT

The emotions of guilt and disgust play a pivotal role in obsessive-compulsive disorder (OCD). The present study hypothesized the existence of a distinctive relation between deontological (but not altruistic) guilt and subjective and physiological correlates of disgust. Moreover, we aimed at testing whether the evoked emotion of disgust may activate OCD-like washing behaviors. Gender-matched healthy participants were randomly assigned to altruistic (n = 31) or deontological guilt (n = 30) inductions followed by a cleaning task, while their electrocardiogram was continuously recorded to derive vagally-mediated heart rate variability (HRV). At baseline and after each experimental condition, participants' momentary emotional state was assessed by visual analog scales (VAS). Compared to altruistic guilt, deontological guilt had the effect of: a) enhancing the physiological correlate of disgust (i.e. augmented HRV); b) increasing OCD-like washing behaviors (e.g. checking). In both groups, washing behaviors had the effect to reduce the physiological correlate of disgust. These effects were stronger in participants with higher OC tendencies, as indicated by scores on the dispositional questionnaires. Results support previous reports on a distinctive relation between deontological guilt and both disgust and OCD symptoms.

1. Introduction

The emotions of guilt and disgust play a key role in the development and maintenance of obsessive-compulsive disorder (OCD) (Power & Dalgleish, 2008). The present study utilizes an experimental approach to examine: (1) the notion that altruistic and deontological guilt can be considered mutually exclusive constructs and (2) the relationship between deontological (as opposed to altruistic) guilt, disgust and OCD-like washing behaviors.

1.1. Deontological and altruistic guilt

In moral psychology, the core relational theme for guilt can be described as "someone I am concerned about has been harmed and I have responsibility for that in virtue of what I have done or failed to do" (Prinz & Nichols, 2010, p. 134). Prinz and Nichols postulate that the prototype of guilt, at least in today's Western culture, implies that one has both caused harm to others by action or omission and violated a moral norm. However, these two assumptions may also occur independently. One might feel the emotion of guilt based on empathic/altruistic principles without the transgression of moral norms (i.e. altruistic guilt) or based on the transgression of moral norms without the presence of actual victims (i.e. deontological guilt) (Mancini & Gangemi, 2017).

An example of altruistic guilt, occurring without the transgression of moral norms is the following: *I suffered serious symptoms and was admitted to hospital. During this time I shared a room with another person and we became friends. After ten days doctor informed me that all was well and that I could go home. I was packing my bag when my friend came into the room. He was very distressed: the doctor had diagnosed him with cancer. Even today I can't stand the idea that I was able to resume my life and his became an ordeal. I feel guilty at not having shared his fate.* "The phenomenon of survivor guilt […] makes clear that people can feel guilty without having done anything wrong or, indeed, having done much of

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https://doi.org/10.1016/j.jocrd.2018.01.004
Received 28 July 2017; Received in revised form 17 January 2018; Accepted 19 January 2018

anything at all" (Baumeister, Stillwell, & Heatherton, 1994, p. 251). Altruistic guilt is characterized by feelings of sorrow, even of anguish for the victim. Altruistic guilt is more easily activated by the closeness of friendship, and implies compassion and the tendency to alleviate the suffering of the victim at the expense of one's own (O'Connor, Berry, Weiss, Schweitzer, & Sevier, 2000; Tangney, Stuewig, & Mashek, 2007).

In comparison, an example of deontological guilt is: *I had just graduated in medicine. One evening, when I arrived for night duty, I found that a patient with terminal cancer had gone into a coma. Even in the torpor of his coma the patient complained of the pain. The head physician instructed me to give him massive doses of morphine, which would have soothed his pain but above all, would have speeded up his death. I was just going to inject the morphine when the thought crossed my mind "Who am I to decide on this person's life or death? Who authorizes me to play God? It is not morally correct, I cannot do that." This thought stopped me from acting.* Deontological guilt is triggered by the assumption of having violated one's own moral rules. It implies feeling of unworthiness, and expectations of punishment, and it might be alleviated through confession or penance (Basile & Mancini, 2011; Haidt, Koller, & Dias, 1993). Whereas in altruistic guilt there is always a victim and the assumption of not having been altruistic, in the case of deontological guilt one might feel guilty even if she/he had acted for the good of the victim, as in the case of euthanasia, where in order to reduce the victim's suffering, the moral norm of "Not Playing God" needs to be violated (Mancini, 2008). In the case of deontological guilt, the assumption of having violated a moral rule is necessary and sufficient.

In the last decade, empirical evidence supporting the distinction between the two types of guilt has been accumulated. First, Basile and Mancini (2011) found that it is possible to distinctly activate altruistic or deontological guilt by using a combination of facial expressions and sentences aimed at mimicking the participants' internal dialogue. The same stimuli have been used in a subsequent study using functional magnetic resonance imaging (fMRI), in which these two types of guilt emerged to be associated with different brain networks (Basile et al., 2011). Here, deontological guilt was associated with activation of the insula and the anterior cingulate cortex, whereas altruistic guilt elicited activation in the theory of mind network, particularly medial prefrontal brain areas.

Mancini and Mancini (2015) further showed that the induction of deontological and altruistic guilt differently affects choices at a third-party version of the ultimatum game, in which participants are asked to decide on behalf of others to accept or reject economic offers with several degrees of fairness. Participants who underwent induction of deontological guilt were more likely to accept moderately unfair offers and followed the "Do not play God" principle, which limited their decisional autonomy, not allowing them to decide on behalf of others (Mancini & Mancini, 2015).

Using the trolley dilemma, Mancini and Gangemi (2015) suggested that whereas participants undergoing the induction of deontological guilt are more likely to opt for deontological choices (i.e. omission options of not turning the trolley implying the "Do not play God" principle), the induction of altruistic guilt leads to more consequentialist choices (i.e. turn the trolley to kill one person and save many more) (Mancini and Gangemi, 2015). In a different study, two different versions of the trolley dilemma were used: an authority version, where a moral authority such as a judge was close to the protagonist, and a closeness/altruistic version, where the protagonist was close to the five potential victims. Consistent with the hypotheses, the authority version leads to a preference for the omission option, presumably in order to prevent deontological guilt, while the closeness version leads individuals to a preference for the consequentialist option, presumably in order to prevent altruistic guilt (Gangemi & Mancini, 2013).

To sum up, although deontological and altruistic guilt usually co-occur in our everyday life, the reviewed evidence suggests that they can also be elicited and occur separately. Thus, the first aim of the present study is to empirically support the notion that altruistic and deontological guilt can be considered mutually exclusive constructs.

1.2. The relationship between guilt and disgust

The relationship between guilt and disgust is well documented (Lee & Schwarz, 2011; Schnall & Haidt, 2008; Schnall, Benton et al., 2008). Zhong and Liljenquist (2006) showed that activation of threat to moral purity was related to increased mental accessibility of words related to cleansing and increased likelihood of choosing cleansing products (the "Lady Macbeth effect"). They concluded that "physical cleansing alleviates the upsetting consequences of unethical behavior and reduces threats to one's moral self-image" (Zhong & Liljenquist, 2006, p. 1451). On the other hand, feelings of dirtiness and the urge to wash can be enhanced by increasing elements of betrayal in a moral context (the "perpetrator effect"), and contamination-related behavioral tendencies can be triggered by threatening participants' moral self-perceptions (Doron, Sar-El, & Mikulincer, 2012; Rachman, Radomsky, Elliot, & Zysk, 2012). More generally, the sensation of dirtiness elicits a stronger tendency to judge oneself more negatively from a moral point of view (Tobia, 2015).

Despite accumulating evidence on the association between guilt and disgust, a series of studies using the same methodology of the seminal study by Zhong and Liljenquist failed to replicate the so-called Lady Macbeth effect (Earp, Everett, Madva, & Hamlin, 2014). Given that the neural substrate underlying deontological guilt comprises brain regions strictly implicated in the emotion of disgust (i.e. the insulae), whereas altruistic guilt elicits activation in areas involved in the representation of others' intentions and in experiencing empathy and compassion (i.e. medial prefrontal areas), we hypothesize that disgust and consequently the Lady Macbeth effect would be more strongly associated with deontological rather than altruistic guilt (Basile et al., 2011). If this was the case, then the failure to replicate the Lady Macbeth effect could be due to the fact that previous studies did not take into account the distinction between these two types of guilt.

This hypothesized distinctive association between deontological guilt and disgust is supported by the work of D'Olimpio and Mancini (2014), who found that the induction of deontological guilt –but not that of altruistic guilt- elicits the Lady Macbeth effect. More specifically, the induction of deontological guilt triggered more washing behaviors compared to the induction of altruistic guilt. In the deontological guilt condition, self-reported happiness increased after the washing task, but this increase in positive emotion after washing was not observed in the altruistic guilt condition (D'Olimpio & Mancini, 2014).

The second aim of the present study is to explore the relationship between deontological guilt and disgust and deontological guilt and OCD-like washing behaviors. The present study uses the same methodology as D'Olimpio and Mancini (2014) to test the hypothesis that -compared to the induction of altruistic guilt- the induction of deontological guilt would increase the subjective and physiological correlates of disgust. Moreover, we expected that washing behaviors would result in diminished levels of disgust, both subjectively and physiologically. From a physiological viewpoint, disgust is generally characterized by parasympathetic nervous system dominance, which can be associated or not with sympathetic nervous system activation depending on the induction context (e.g. Comtesse & Stemmler, 2016). Heart beat slowing, as well as disgust-related functions such as monitoring of tastes, rejection of inedible foods, nausea and vomiting are achieved by activation of vagus nerve parasympathetic drive to the heart via brainstem nuclei (Babic & Browning, 2014). Such parasympathetic nervous system modulation can be noninvasively indexed by vagally-mediated HR variability (HRV) (Task Force, 1996). The topography of HR response is distinct for general stress or fear and disgust, which suggests that HRV response is a useful indicator to examine the relative contribution of disgust and fear (Cisler, Olatunji, & Lohr, 2009; Davey, 2011). In fact, the physiological response to stress is

phasic HRV suppression representing the withdrawal of cardiac vagal control and the activation of the defensive systems (e.g., Park, Vasey, Van Bavel, & Thayer, 2014), whereas during disgust, HRV increases, due to baroreceptor activation and parasympathetic dominance (Ekman, Levenson, & Friesen, 1983; Schlegel et al., 2001). Therefore, HRV can be reliably used to distinguish disgust from fear/general stress. In light of the reviewed evidence, in the present study the physiological concomitant of disgust was assessed using vagally-mediated heart rate variability (HRV) as a proxy for parasympathetic activation (see also Rohrmann & Hopp, 2008).

1.3. The relationship between deontological guilt and OCD

Our second hypothesis was that the induction of deontological guilt would elicit more OCD-like washing behaviors compared to the induction of altruistic guilt. Following a dimensional approach to psychopathology, we studied a sample of healthy individuals but we expect these effects to be stronger in participants with higher dispositional obsessive-compulsive tendencies.

The relevance of these considerations for OCD becomes clear if one considers that the emotion of guilt plays a crucial role in the genesis and maintenance of the disorder. In their review of existing literature, Shapiro and Stewart (2011) illustrate that guilt leads to OC-like symptoms in healthy participants (Gangemi, Mancini, & van den Hout, 2007; Mancini, Gangemi, Perdighe, & Marini, 2008), a guilt-state leads to brain activation in regions proximal to OCD-affected regions (Shin et al., 2000; Takahashi et al., 2004). Indeed, an increase of responsibility and fear of guilt also in non-symptomatic domains, implies a greater increase in checking in all OCD subtypes than in anxious and non-clinical samples (Arntz, Voncken, & Goosen, 2007). In particular, Reuven, Liberman, and Dar (2014) found a higher Lady Macbeth effect in patients with OCD compared to healthy controls, showing that a higher sensitivity to guilt accounts for washing symptoms in these patients (see also Rachman et al, 2012). What kinds of guilt do patients with OCD want to prevent? The question arises from a number of clinical observations and from empirical data. Patients' concern over a harmful event, for instance a gas explosion, is drastically reduced if responsibility for the event is not their own but someone else's, even if the event can happen all the same (Lopatka & Rachman, 1995). This suggests that OC patients' concern is not for any possible victims of the explosion but for being responsible and guilty for it. Moreover, OC patients are frequently concerned about sins of a religious or sexual nature, even though no harm is caused to anyone and are frequently concerned more about their performance than about the outcome. For example, patient M.M. would spend hours repeating good-luck rituals aimed at preventing the crashing of the aircrafts in which his parents often traveled, rather than finding out which airlines were safer, or convincing his parents to travel less (Mancini, 2016). In this case, there is the involvement of a guilt, for whom neither the worry for, nor the presence of a victim, are necessary.

Evidence suggests that deontological rather than altruistic guilt plays a role in the genesis and maintenance of OCD. For example D'Olimpio and Mancini (2016) demonstrated that a stronger dispositional tendency to obsessions and compulsions is associated with an increased number of deontological choices (i.e. omission) at the trolley dilemma. Similarly, in Mancini and Gangemi (2015) patients with OCD were more likely to opt for deontological choices at the trolley dilemma compared to patients with anxiety and mood disorders who opted for more consequentialist choices (i.e., the altruistic choice to save the highest number of people). Moreover, Kang, Rowatt, and Fergus (2016) examined which moral domains represented in moral foundations theory clustered most strongly with obsessive-compulsive symptoms and found that purity/sanctity is the moral domain most relevant to obsessive-compulsive symptoms. Lastly, several studies using fMRI suggest that tasks aimed at eliciting symptoms in patients with OCD activate the same areas that are involved when non-pathological individuals are experiencing deontological guilt, in particular, the anterior cingulate cortex and the insulae (Basile et al., 2011; Mataix-Cols, Rosario-Campos, & Leckman, 2005; Rauch et al., 1998). This overlap between brain areas involved in deontological guilt and OC brains may suggest that during symptom provocation patients are experiencing deontological guilt, an assumption consistent with the fact OC patients and controls show different brain response patterns only when processing deontological guilt stimuli, and not when processing stimuli associated with altruistic guilt, anger or sadness (Basile, Mancini, Macaluso, Caltagirone, & Bozzali, 2014).

2. Material and methods

2.1. Participants

The sample comprised 61 healthy subjects (30 females and 31 males; mean age = 27.1 $\pm$ 5.5 years; range 18 – 44 years). Participants were recruited from the general population by word of mouth; the sample was mostly composed of university and postgraduate students who were naive to the objectives and predictions of the experiment.

Exclusionary criteria were: diagnosis of heart disease or any other serious illness, diagnosis of psychiatric disorder, obesity (body mass index (BMI) > 30 kg/m^2), menopause, pregnancy or child birth within the last 12 months, and use of drug or medicine that might influence HRV.

The protocol was approved by the Bioethical Committee of S. Lucia Foundation, Rome, Italy.

2.2. Procedure

After giving written informed consent, participants were assigned to one of two conditions by the use of block randomization: altruistic (AGG, n = 31) or deontological guilt (DGG, n = 30); groups were equally divided in gender. Then, all of them filled out a series of sociodemographic and psychological questionnaires followed by the first visual analog scale (VAS; detailed in Section 2.5.2.) to evaluate their momentary emotional state. Next, the electrocardiogram (ECG) electrodes were attached to the subject's chest, and the experimenter provided them with the following instruction:

> *"In a moment, I will start the video recorder and leave the room. You have to wear the headphones and follow the instructions that you will see on the computer screen. I will be in the room next to this one. When you have finished, please call me".*

The experimental protocol started with a 5-min 'vanilla' baseline (Jennings, Kamarck, Stewart, Eddy, & Johnson, 1992), during which participants read a neutral (gardening) magazine. Second, they listened to a 4-min story meant to induce either deontological guilt or altruistic guilt. Then, they completed the second VAS, which was followed by the cleaning task. When they felt that the task was completed, participants filled out the third VAS.

At the end of the experimental session, participants were fully acquainted about the experiment and compensated for their time (€ 15).

2.3. Experimental manipulation

The experimental protocol was developed and delivered on a personal computer using the E-Prime software (Schneider, Eschman, & Zuccolotto, 2002).

Each participant was required to listen to one of a series of prerecorded stories that have been previously derived and used to successfully induce altruistic and deontological guilt (see D'Olimpio & Mancini, 2014 for details on the methodological procedure followed to obtain the stories used in the present study). For each type of guilt, different stories were used for men and women, for a total of 4 stories of the same duration of about 4 min. The reason for using different stories

for males and females is cultural and based on results of the preliminary validation study (D'Olimpio & Mancini, 2014). The second-person was used in all the audio scripts (e.g. "You are"), and participants were asked to immerse themselves in the situation. The scripts consisted in a vivid description of one of the following scenes: the participant is responsible for (a) betraying her beloved boyfriend and lying to him about it (deontological guilt, female version); (b) taking his father's car against his will and lying to him about it (deontological guilt, male version); (c) witnessing an old woman being stolen of her pension without doing anything to prevent it (altruistic guilt, male and female versions). An English translation of the scripts used in this study (in Italian language in the original version) can be obtained by contacting the corresponding author.

2.4. Cleaning task

As in D'Olimpio and Mancini (2014), the task required the subjects to clean a 20 × 20 cm cube of Plexiglas that had six different faces with six different colors (blue, orange, yellow, red, azure, black). The cube was placed in front of the participant on the table. A basket containing cleaning products (gloves, Kleenexes, leather cloth, sponges, etc.) was placed close to the cube. Participants were required to clean the cube without any constraint regarding the time and the products to use. Participants' behavior was videotaped.

The entire set of videotapes were coded by two independent judges assessing: (a) number of faces washed; (b) checking, defined as the number of times the participant went back to clean the same face of the cube; (c) number of times the participant used the spray; (d) the time before beginning the cleaning task, that is a time for planning behavior and; (e) an accuracy score of the cleaning task for each participant, defined on a 9 Likert scale. As standard practice (Hallgren, 2012), inter-rater agreement of these variables was computed on a subsample of observations (about 44% of randomly selected videos), yielding high levels of reliability (κ = .91).

2.5. Measures

2.5.1. Questionnaires

First, participants completed a series of questions about socio-demographic (e.g., years of school, work, marital status) and lifestyle (e.g., nicotine, alcohol and caffeine consumption, physical exercise) information, and then they filled out the following standardized questionnaires.

The Self-Report Altruism Scale (SRA; Rushton, Chrisjohn, & Fekken, 1981) is a self-report questionnaire consisting of 20 items concerning altruistic behaviors. Respondents are asked to indicate the frequency at which they have engaged in such behaviors using a 5-point Likert scale, from 1 (Never) to 5 (Very often). Scores range from 14 to 70 and higher scores indicate more altruistic behavior. Cronbach's alpha in the present study was .78.

The Penn Inventory of Scrupulosity-Revised (PIOS-R; Olatunji, Abramowitz et al., 2007) is a 15-item self-report scale evaluating the degree of scrupulosity-related symptomatology in the lifetime. Items are scored on a 5-point scale ranging from 0 (Never) to 4 (Constantly). The PIOS-R consists of two subscales: one measuring fears of having committed a religious sin (fear of sin; "I worry that I might have dishonest thoughts"), and the other measuring the fears of punishment from God (fear of God; "I am afraid my thoughts are unacceptable to God"). If present, participants are also asked to report their religious affiliation and the strength of religious devotion (from 1 = Not at all devoted to 5 = Very strongly devoted). In the present study, the total score and scores on the subscales had Cronbach's alphas greater than .90.

The Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996; Italian version by Sica & Ghisi, 2007) consists of 21 items requiring participants to respond how they have felt during the previous 2 weeks on a 4-point scale ranging from 0 to 3. A total score of 0–13 is considered minimal, 14–19 mild, 20–28 moderate, and 29–63 severe depression. Cronbach's alpha was .90 in the present study.

The Disgust Scale-Revised (DS-R; Olatunji & Williams, 2007; Italian version by Melli, Chiorri, & Smurra, 2013) is a 27-item self-report questionnaire concerning the individual's proneness to respond with disgust across three domains of disgust elicitors (core, animal reminder, and contamination-based disgust). All items are rated on a 5-point Likert scale from 0 (Not at all) to 4 (Very true). In the present study, Cronbach's alpha for the total score was .79.

The Guilt Inventory (GI; Kugler & Jones, 1992) investigates three domains of guilt (state, trait guilty, and adhesion to moral standard). Participants indicate the degree of agreement with 45 items (e.g. "Guilt and remorse have been part for as long as I can recall") using a 5-point Likert scale from 1 (Completely agree) to 5 (Completely disagree). In the present study, Cronbach's alpha for the 3 subscales was greater than .56.

The Obsessive-Compulsive Inventory-Revised (OCI-R; Foa et al., 2002; Italian version by Sica et al., 2009) is an 18-item questionnaire. Participants rate the degree to which they have been distressed by OCD symptoms in the past month on a 5-point scale from 0 (Not at all) to 4 (Extremely). The OCI-R assesses six types of obsessive-compulsive symptoms: Washing concerns, Checking/Doubting, Obsessing, Neutralizing, Ordering, and Hoarding. In the present study, Cronbach's alphas for the total score and the subscales were greater than .49.

The State-Trait Anxiety Inventory (STAI; Spielberger, 1970; Italian translation by Pedrabissi & Santinello, 1989) consists of 20 items assessing levels of state and trait anxiety. In the present study the only the trait version has been used. Respondents indicate how they generally feel ("I am a steady person") using a four-point Likert scale, from 1 (Almost never) to 4 (Almost always). In the present study, Cronbach's alpha was .92.

2.5.2. Visual analog scales (VAS)

Participants were asked to rate their current levels of happiness, shame, fear, sadness, disgust, anger, pity, altruistic guilt, and deontological guilt on separate 100-point VAS (D'Olimpio & Mancini, 2014). Altruistic and deontological guilt were investigated as follows:

Altruistic guilt, sorrow, and remorse for the suffering or unwarranted harm of another person, accompanied by the awareness that you did not want to or could not help him/her; desire to sacrifice yourself to help or comfort him; "Poor him/her, I could have helped him/her, I had the chance to do it!"

Deontological guilt, the feeling of having transgressed moral standards accompanied by remorse; repentance and desire, but sometimes also fear, to confess, to ask forgiveness and to do penance; "Oh God! What did I do! How could I!"

There were pragmatic reasons for using such long descriptions of altruistic and deontological guilt: first, the same assessment was used by D'Olimpio and Mancini (2014) and the present study aims at replicating and extending their findings; second, these types of guilt complex emotions, as suggested by Basile and Mancini (2011).

The VASs were administered: (1) at the beginning of the experimental session, to evaluate the momentary emotional state; (2) after the induction, as a manipulation check; and (3) after cleaning task completion, to verify the emotional state after cleaning behaviors.

2.5.3. Psychophysiological assessment

HR was recorded as beat-to-beat intervals in ms with the Bodyguard 2 (Firstbeat) device. HRV was assessed by computing the root mean square of successive beat-to-beat interval differences (RMSSD), which reflects vagal regulation of HR (Task Force, 1996). Outlier and artifact detection as well as HRV analyses were performed using Kubios HRV software (Tarvainen, Niskanen, Lipponen, Ranta-Aho, & Karjalainen, 2014). From now on, we will use HRV to refer to RMSSD.

Table 1
Pre-existing differences between the deontological guilt group and the altruistic guilt group in socio-demographic, dispositional, and physiological variables.

	Deontological Guilt (n = 30)	Altruistic Guilt (n = 31)	t/χ^2
Age (years)	26.3 ± 3.9	27.8 ± 6.7	1.1
Gender	15 M, 15 F	16 M, 15 F	.02
BMI (Kg/m^2)	22.4 ± 3.5	22.2 ± 2.7	.22
Education	0 C; 12 D; 13 G; 5 P	3 C; 10 D; 15 G; 3 P	3.8
HRV (ms)	39.6 ± 23.7	42.7 ± 23.2	.51
BDI	8.1 ± 6.3	9.5 ± 4.9	.95
STAI trait	40.9 ± 9.5	41.9 ± 10.6	.38
DS-R	47.9 ± 11.3	56.8 ± 12.2	2.9*
PIOS-R	7.9 ± 9.7	7.8 ± 6.5	.01
PIOS-R (God fear)	1.7 ± 3.7	1.6 ± 2.6	.11
PIOS-R (Sin fear)	6.1 ± 6.8	6.2 ± 5.3	.06
SRA	28.4 ± 9.2	26.4 ± 8.5	.89
GI state	27.1 ± 5.7	26.4 ± 4.8	.50
GI trait	51.1 ± 7.9	53 ± 10.8	.80
GI moral standards	44.2 ± 5	44.8 ± 6.1	.47
OCI-R	8.3 ± 5.9	10.5 ± 6.9	1.3
OCI-R Hoarding	1.5 ± 1.4	2.2 ± 1.9	1.8
OCI-R Checking	1.6 ± 1.5	2.1 ± 1.9	1.2
OCI-R Ordering	2.1 ± 1.7	3.1 ± 3.2	1.5
OCI-R Neutralizing	.77 ± 1.5	.37 ± .76	1.3
OCI-R Washing	1.2 ± 1.6	1.2 ± 1.7	.08
OCI-R Obsessing	1.2 ± 1.7	1.5 ± 2.1	.61

Note. * $p < .05$. M = Males; F = Females; BMI = Body Mass Index; C, College; D, Diploma; G, Graduate; P, Postgraduate; HRV = Heart Rate Variability; SRA = Self-Report Altruism Scale; PIOS-R = Penn Inventory of Scrupulosity-Revised; BDI = Beck Depression Inventory; DS-R = Disgust Scale-Revised; GI = Guilt Inventory; OCI-R = Obsessive-Compulsive Inventory-Revised.

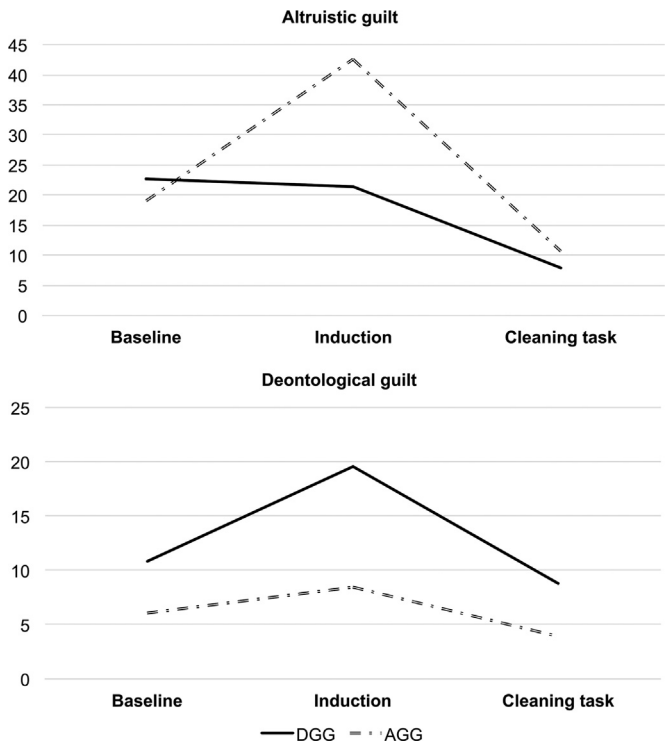

Fig. 1. Manipulation check. *Note.* VAS = Visual Analog Scale; DGG = Deontological Guilt Group; AGG = Altruistic Guilt Group.

3. Data analysis and results

Differences at $p \leq .05$ were regarded as significant. Data processing was performed with SPSS 23 (IBM), with the exception of mixed-effects models that were performed with the R software (R version 3.3.2, R Team, 2016). Skewed distributions were log-transformed if normality could not be approached.

First, the two groups were tested for pre-existing differences on the key variables of the study by *t*-tests and χ^2 tests. As shown in Table 1, significant pre-existing group differences emerged for levels of disgust sensitivity; therefore, this variable has been included as a covariate in all the subsequent analyses.

3.1. Manipulation check

As a manipulation check, a 2 (Group: DGG vs AGG, between-subject factor) X 3 (Time: Baseline, Induction, Cleaning Task, within subject factor) X 2 (Type of guilt: altruistic vs deontological, between subject factor) Mixed Analysis of Variance (ANOVA) on self-reported levels of deontological and altruistic guilt was performed on VAS scores, with Disgust Sensitivity as a covariate.

A significant Group X Time X Type of guilt interaction emerged, $F(2,112) = 7.92$, $p = .001$; $\eta_p^2 = .12$. Post-hoc analyses showed that AGG participants reported higher levels of altruistic guilt after induction compared to baseline ($p < .05$ for all contrasts) and to DGG; levels of altruistic guilt then diminished from induction to the cleaning task.

Similarly, results for self-reported level of Deontological guilt were in the expected direction, with a significant increase from baseline (10.8) to induction (19.6) and a decrease from induction to the period following the cleaning task (8.8) in DGG compared to the AGG (see Fig. 1).

3.2. Effects of induction on self-reported affective state

A further check for manipulation was conducted on self-reported affective state. We investigated if induction of deontological guilt elicits the activation of a different emotional state compared the induction of altruistic guilt. To this aim, a series of 2 (Group; DGG vs AGG, between-subject factor) X 3 (Time; Baseline, Induction, Cleaning task, within-subject factor) mixed ANOVAs, with disgust sensitivity as a covariate, were performed on self-reported levels of shame, fear, sadness, disgust, anger, pity, and happiness.

Table 2 illustrates levels of self-reported affective state (VAS) at baseline, following the induction, and after the cleaning task in the two groups. We found a significant main effect of Group for shame ($F(1,58) = 4.45$, $p = .04$; $\eta_p^2 = .07$), with higher levels of shame in DGG, but no Time ($F(2,116) = 2.45$, $p = .09$; $\eta_p^2 = .04$) or Group X Time interaction ($F(2,116) = 3.28$, $p = .08$; $\eta_p^2 = .05$) effects. As to fear, no effects of Time ($F(2,116) = .36$, $p = .70$; $\eta_p^2 < .01$), Group ($F(1,58) = 2.48$, $p = .12$; $\eta_p^2 = .04$) or Group X Time interaction ($F(2,116) = 1.78$, $p = .17$; $\eta_p^2 = .03$) were found. The analysis on disgust did not yield any significant effect (Time: $F(2,116) = .30$, $p = .74$; $\eta_p^2 < .01$; Group: $F(1,58) = .04$, $p = .83$; $\eta_p^2 < .01$; Group X Time: $F(2,116) = .38$, $p = .69$; $\eta_p^2 < .01$). The same pattern emerged for sadness, with no significant effects of Time ($F(2,116) = .86$, $p = .43$; $\eta_p^2 = .01$), Group ($F(1,58) = .78$, $p = .38$; $\eta_p^2 = .01$), or their interaction ($F(2,116) = .81$, $p = .45$; $\eta_p^2 = .01$). As to anger, a significant main effect of Time emerged ($F(2,116) = 3.07$, $p = .05$; $\eta_p^2 = .05$). Post-hoc comparisons showed that anger significantly decreased after the cleaning task in both groups. A significant effect of Group ($F(1,58) = 4.88$, $p = .03$; $\eta_p^2 = .08$) also emerged, with AGG reporting higher levels of anger than DGG. No significant effect of Group X Time was found ($F(2,116) = 2.83$, $p = .06$; $\eta_p^2 = .05$) for anger. As to pity, a significant Group X Time interaction was found ($F(2,116) = 4.05$, $p = .02$; $\eta_p^2 = .06$). Post-hoc comparisons showed that pity significantly increased only in AGG after emotion induction and decreased after task completion. Pity did not change in DGG. No main effect of Time ($F(2,116) = .36$, $p = .70$; $\eta_p^2 < .01$) or Group ($F(1,58) = .04$, $p = .83$; $\eta_p^2 < .01$) was found for pity.

As to Happiness, only a main effect of Time emerged when controlling for disgust sensitivity ($F(2,110) = 3.71$, $p < .03$; $\eta_p^2 = .06$).

Table 2
Levels of self-reported affective state (VAS) at baseline, following the induction, and after the cleaning task in the two groups.

	Deontological (n = 30)			Altruistic (n = 31)		
	Baseline	Induction	Cleaning task	Baseline	Induction	Cleaning task
VAS (0–100)						
Happiness	52.9 ± 34.2[a]	24.6 ± 35.4[b]	36.8 ± 35.9[c]	52.5 ± 30.5[a]	24.6 ± 27.9[b]	35.4 ± 31.8[c]
Shame	8.0 ± 13.8[a]	24.4 ± 29[a]	8.8 ± 14.5[a]	5.1 ± 8.9[b]	9.8 ± 16.7[b]	5.2 ± 7.2[b]
Fear	10.7 ± 17.6	19.4 ± 26.9	4.3 ± 8	8.7 ± 16.8	8.5 ± 13.8	3.7 ± 4.5
Sadness	9.9 ± 10.7	20.0 ± 25.3	6.5 ± 12.1	18.3 ± 27	21.3 ± 27.6	7.3 ± 10.5
Disgust	3.9 ± 6.8	9.6 ± 14.2	3.7 ± 5.2	6.2 ± 16.8	8.7 ± 17.2	3.9 ± 5.3
Anger	10.2 ± 19.3[a]	10.7 ± 19.5[a]	4.2 ± 7.3[b]	18.9 ± 24.4[c]	27.7 ± 30.2[c]	7.1 ± 11.2[d]
Pity	29.7 ± 34.6[a]	33.2 ± 30.6[a]	18.8 ± 28.8[a]	28 ± 29.9[a]	47.6 ± 34.1[b]	10.2 ± 15.7[c]

Note. VAS = Visual Analog Scale. [a, b, c] Means with different superscripts are significantly different from each other ($p < .05$).

Post-hoc analyses confirmed a significant decrease in levels of self-reported happiness after induction in both groups and a significant increase after cleaning task, ($p < .05$). No effect of Group ($F(1,55) = .01$, $p < .94$; $\eta_p^2 < .01$) or Group X Time interaction ($F(2,110) = .02$, $p = .98$; $\eta_p^2 < .01$) emerged.

3.3. Effects of induction on washing behavior

To test for the capacity of deontological guilt to induce more OCD-like washing behaviors compared to altruistic guilt, a between-subject MANOVA including disgust sensitivity as covariate was performed on number of faces washed, checking behavior, number of times the participant used the spray, time before washing, and accuracy.

The analysis yielded a significant main effect of Group (Lambda = .78, $F(5,50) = 2.86$, $p = .02$; $\eta_p^2 = .22$). Univariate analyses showed that DGG participants washed more faces ($F(1,54) = 6.45$, $p < .02$; $\eta_p^2 = .10$; DGG: 10.32, AGG: 8.34), and went back to clean the same face more times than participants in AGG ($F(1,54) = 15.24$, $p < .001$; $\eta_p^2 = .22$; DGG: 2.11, AGG: .62). No differences emerged in terms of number of times the participant used the spray, time before washing, and accuracy.

3.4. Effects of induction on parasympathetic response

The hypothesis that the induction of deontological –but not altruistic- guilt would elicit disgust at a physiological level was tested using a mixed-effects model by the lmer program of the lme4 package (Bates, Mächler, Bolker, & Walker, 2015). Mixed-effects models are a powerful procedure for the analysis of repeated-measures data because the non-independence of observations and individual heterogeneity (random effects) are considered. We used mixed-effects models to study group (i.e., deontological and altruistic) differences in HRV during time conditions (i.e., baseline, induction, and cleaning task). Our hypothesis was modeled considering HRV as dependent variable; Group, Time, and their interaction as fixed factors; and Participants as random factor. The Akaike Information Criterion (AIC decreases with goodness of fit; R package: stats. Bolker et al., 2009; Wagenmakers & Farrell, 2004) was used to compare our model with other eight plausible models (see Appendix) and the best fitting data was selected. Due to the difficulty in degrees of freedom estimation and consequent p-values absence in mixed models, maximum likelihood method to study the contribution of the model's parameters was also obtained. The maximum likelihood method creates a likelihood ratio, known to approximate a chi-square distribution that is used to assess if a first model is significantly different from a second model that does not contain one of the parameters.

As illustrated in Table 3, nine plausible mixed models were considered starting from simple (the null model, Formula: *Dependent Variable ~ (1|Individual)*) to more complex (model01, Formula: *Dependent Variable ~ group*Time + Disgust scoring + (1|Individual)*), to control for baseline group differences in disgust sensitivity (see Appendix). The best-fitting models are reported in terms of likelihood (by AIC).

Table 3
Models comparison method by Akaike Information Criterion (AIC).

HRV	df	AIC
m01	9	1445.69
m02	6	1446.75
m05	8	1446.90
m06	5	1447.82
m04	7	1448.56
m08	6	1449.77
null.model	3	1492.26
m03	5	1492.99
m07	4	1494.20

Note. HRV = Heart Rate Variability; m = model; df = degree of freedom.

Considering HRV as dependent variable, m01 (Formula: *RMSSD ~ Time*Group + Disg + (1| Individual)*) resulted the preferred model. Specifically, Log-likelihood ratio test set our modeled hypothesis as the best to describe the data. M01 assumed group differences in HRV during time conditions. Assessing the AIC weight of evidence in favor of m01 and the other candidate models, the best-fitting m01 was 3.5 times more likely to be the best model than the next-bests. First, the effect of Time was tested ($F = 31.59$). A chi-square test of goodness-of-fit and AIC weight were performed to determine whether adding this predictor improved the fit of the model (AIC weight = .99, $X^2(2, N = 12) = 48.44$, $p < .001$). The inclusion of Group as a predictor ($F = .56$), did not improve the fit of the model. However, an improvement in the fit of the model (AIC weight = .81, $X^2(2, N = 16) = 6.87$, $p = .03$) emerged when testing Group by Time interaction ($F = 3.53$).

Effects of m01 are depicted in Fig. 2. Only the deontological group

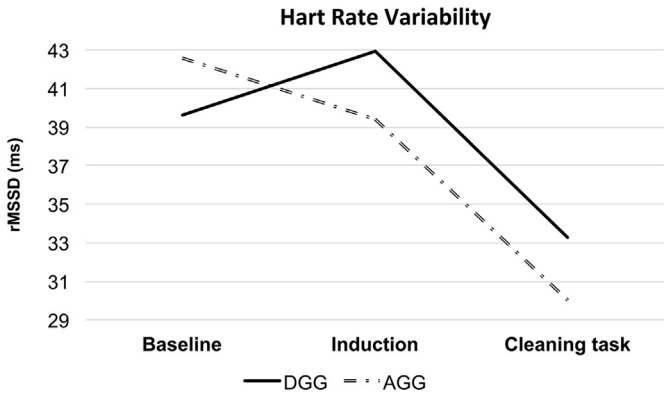

Fig. 2. Differences in heart rate variability (HRV) at baseline, during the induction, and during the cleaning task between the deontological guilt and the altruistic guilt groups. *Note.* rMSSD = root mean square of successive beat-to-beat interval differences; DGG = Deontological Guilt Group; AGG = Altruistic Guilt Group.

was characterized by a significant increase in HRV from pre- to post-induction (39.6 ± 23.7 vs 42.9 ± 24.6, respectively). However, in both groups the cleaning task had the effect to decrease HRV (33.3 ± 25.1 for the deontological group and 30 ± 20.8 for the altruistic group) compared to both baseline (39.6 ± 23.7 for the deontological group and 42.5 ± 23.6 for the altruistic group) and induction (42.9 ± 24.6 for the deontological group and 39.4 ± 18.9 for the altruistic group).

3.5. Intercorrelations between the examined variables

Lastly, partial correlations (controlling for disgust sensitivity) were performed to test for associations between physiological responses to the induction (ΔHRV = induction minus baseline) and OCD characteristics in the two groups (OCI-R total score, sin fear, adhesion to moral standard, state guilt). As participants underwent different experimental conditions, these partial correlations regarding HRV in response to the induction, were performed separately in the two groups.

Larger HRV increases (change score from baseline) after deontological guilt induction were associated with higher scores on the OCI-R ($r = .49$; $p = .02$), and marginally correlated with the sin fear subscale of the PIOS ($r = .40$; $p = .07$).

To understand if cleaning behaviors were associated with diminished sensations of disgust, partial correlations (controlling for disgust sensitivity) were also performed on HRV during the cleaning task and the cleaning variables. In the entire sample, reduced HRV during the cleaning task (indicating diminished feelings of disgust) was associated with higher checking and washing (number of faces washed) behaviors ($r = -.34$; $p = .01$ for both), underlying the role of cleaning behavior in reducing disgust.

4. Discussion

The present study has two central hypotheses: the first is that induction of deontological guilt induces subjective and physiological correlates of disgust, whereas this is not the case for induction of altruistic guilt. Before examining the core results, it is important to note that by using the same induction of D'Olimpio and Mancini (2014) we were able to replicate the expected two senses of guilt, corroborating the hypothesis of a substantial difference between them.

The main result of the present study is that the induction of deontological guilt triggered the activation of physiological (i.e. increased parasympathetic response) but not of subjective correlates of the emotion of disgust. Although this result is not completely in line with our hypothesis, it has to be noted that a better capacity of physiological measures to detect subtle changes in levels of disgust compared to subjective reports is not uncommon (Ottaviani, Mancini, Petrocchi, Medea, & Couyoumdjian, 2013; Shenhav & Mendes, 2014). Such discrepancy between physiological response and subjective feelings has been thoroughly documented in patients with OCD, who appear to have attenuated access to internal states and emotional experiences (Lazarov, Dar, Liberman, & Oded, 2012; Lazarov, Liberman, Hermesh, & Dar, 2014; see also Robinson & Freeston, 2014 for a review). In line with our hypothesis, the induction of altruistic guilt did not elicit disgust neither at a subjective nor at a physiological level.

These results suggest that the two senses of guilt differ as to their association with disgust, as already emerged in the imaging study by Basile et al. (2011) and as suggested by D'Olimpio and Mancini (2014). Present results also provide a plausible explanation for the reason why the Lady Macbeth effect has not been consistently found: existing studies did not take into account the distinction between deontological and altruistic guilt and did not include the assessment of the physiological correlates of disgust. Moreover, distinctive emotional states in terms of shame, pity, and anger were evoked by the two types of guilt, similar to what has been found in previous investigations using the same (D'Olimpio & Mancini, 2014) or different experimental induction (i.e., faces and sentences; Basile & Mancini, 2011).

Our first hypothesis had two corollaries. The first is that compared to induction of altruistic guilt, induction of deontological guilt would imply more OCD-like cleaning behaviors during the task and this was indeed the case replicating findings by D'Olimpio and Mancini (2014). The second corollary is that the execution of a cleaning task would reduce deontological more than altruistic guilt or would enhance positive emotions or reduce negative emotions more in deontological than in the altruistic group. As expected, the cleaning task had the effect to reduce not only the physiological correlate of disgust but also guilt, supporting the view that physical cleansing alleviates the upsetting consequences of unethical behavior (Zhong & Liljenquist, 2006). Similarly, Schnal and colleagues showed that participants found certain moral actions to be less wrong when the cognitive concept of cleanliness was activated or when participants physically cleaned themselves after experiencing disgust (Schnall, Benton et al., 2008). However, contrary to our hypothesis, both HRV and negative affect diminished as a consequence of cleaning in both groups. Unfortunately, a limitation of our study is the absence of a non-cleaning control task, which prevents us from excluding that the relieving effects of cleaning are simply due to the fact that participants are "distracted" from the effects of induction.

4.1. New insights

What can we infer from present data that would significantly contribute to the understanding of OCD? The most significant finding is the replication of results by D'Olimpio and Mancini (2014), that is the induction of deontological rather than altruistic guilt induces the execution of a cleaning task in a OCD-like manner (i.e. with more checking behaviors and more washing in general). Moreover, the present study found greater parasympathetic responses to the induction of deontological guilt in participants with higher obsessive-compulsive tendencies (i.e. higher scores on the OCI-R). If we consider this result together with results of a previous study in which induction of moral disgust (i.e. a script describing an incest) significantly increased HRV only in participants with higher scores on the OCI-R (Ottaviani et al., 2013), it seems that in subclinical participants –and presumably in patients with OCD- the association between guilt and disgust is stronger than in other individuals and this would be due on one side to a sensitivity to deontological guilt (Basile et al., 2014; Mancini F, 2015), and on the other to a stronger sensitivity to moral disgust that appears to be non-metaphoric in OCD (see the concept of Mental Contamination by Rachman, 2006). It is possible to synthetize this concept by saying that in individuals with clinical or sub-clinical OC manifestations, the sense of guilt that plays a role, i.e. deontological guilt, is dirtier and more contaminating compared to the other sense of guilt, i.e. the altruistic and that the disgust that plays a role in this process has a stronger moral valence compared to what happens in non-pathological individuals. In other words, when facing an event that makes them feel guilty, patients with OCD focus more on the deontological rather than the altruistic facet of guilt; when facing a contaminating event, they focus on the moral and particularly deontological and therefore dismissing facet, and that cleaning rituals would not be finalized at pushing away the contaminating agent but rather at purifying the self. Patients with OCD feel so dramatically and easily threatened by moral dirtiness, i.e. the deontological one, that they do not tolerate to feel physically dirty because for them these two types of dirtiness tend to sum up and result in self-unworthiness. The link between guilt and disgust in OCD may be more subtle than the association which goes through responsibility: to protect oneself from contamination would not only have the implication to prevent the guilt of a contagion for oneself or the beloved ones, but it would have the sense of safeguarding the self from moral degradation.

4.2. Challenges faced and solutions

Several limitations need to be acknowledged, the first of which has

already been mentioned and regards the absence of a non-cleaning distraction condition. The second limitation is the use of a between-subject design. Although we did our best to assess potential confounders (e.g. religious beliefs), the two groups may have different for other overlooked variables that are relevant for the domain of morality. Third, by chance the group assigned to the altruistic guilt induction had higher levels of disgust sensitivity. However, we can exclude that our results are due to this bias because a) the bias is against the hypothesis of the study; b) we have statistically controlled for scores on the disgust sensitivity scale in all the statistical analyses and this may have contributed to reduce some of the statistical differences between the two groups. Fourth, a single physiological measure was used as a proxy for disgust (i.e. HRV). Even if the inclusion of other indices such as the electromyographic activity of the musculus levator labii would have enhanced the reliability of present findings, we can exclude that the reported changes in HRV represent a mere response to stress (Ekman et al., 1983). Lastly, given that our hypotheses are relevant to OCD, it would have been desirable to recruit participants with and without OCD symptoms. In line with a dimensional view of psychopathology, we believe that the hypothesized association between guilt and disgust exists not only in OCD patients but also –although to a lesser extent- in non-pathological participants. We therefore tested the hypothesis in healthy individuals first, in order to have preliminary supportive data to justify the application of the same paradigm in patients. We have decided to take these steps also in light of ethical considerations, that is, to avoid the burden of a guilt induction to patients with OCD in the absence of preliminary data. If confirmed by future studies on patients, present data would suggest the need to target deontological guilt in therapeutic approaches for OCD. Indeed, therapeutic interventions on inflated responsibility (Vos, Huibers, & Arntz, 2012), or on acceptance of guilt, even in non-symptomatic domains, have been shown to significantly lower OC symptoms of all sub-types (Cosentino et al., 2012). In light of present results, future studies need to test if therapeutic approaches targeting deontological guilt are more effective compared to previously used approaches targeting responsibility in general.

Acknowledgments

The authors are grateful to Frances Meeten for her valuable input on an earlier version of the manuscript.

Funding

Supported by the Italian Ministry of Health (GR-2011–02348232).

Appendix. R code

```
m01 < -lmer (Psycophy ~ Time*Group + Disg + (1| Individual), data = Mydata, REML = FALSE)
m02 < -lmer(Psycophy ~ Time + Disg + (1|Individual), data = Mydata, REML = FALSE)
m03 < -lmer(Psycophy ~ Group + Disg + (1| Individual), data = Mydata, REML = FALSE)
m04 < -lmer(Psycophy ~ Time + Disg + Group + (1| Individual), data = Mydata, REML = FALSE)
m05 < - lmer(Psycophy ~ Time *Group + (1| Individual), data = Mydata, REML = FALSE)
m06 < - lmer(Psycophy ~ Time + (1| Individual), data = Mydata, REML = FALSE)
m07 < - lmer(Psycophy ~ Group + (1| Individual), data = Mydata, REML = FALSE)
m08 < - lmer(Psycophy ~ Time + Group + (1| Individual), data = Mydata, REML = FALSE)
null.model < - lmer(Psycophy ~ (1| Individual), data = Mydata, REML = FALSE)
```

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