Physiology & Behavior 201 (2019) 212–220

Contents lists available at ScienceDirect

Physiology & Behavior

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

Women smelling men's masked body odors show enhanced harm aversion in moral dilemmas

Cinzia Cecchetto[a,b,c,*], Elisa Lancini[a], Raffaella Ida Rumiati[a,d], Valentina Parma[a,e,f]

[a] SISSA – International School for Advanced Studies, Neuroscience Area, Via Bonomea, 265, 34136 Trieste, Italy
[b] Institute of Psychology, University of Graz, Graz, Austria
[c] BioTechMed, Graz, Austria
[d] ANVUR - Agenzia Nazionale della Valutazione del sistema Universitario e della Ricerca, Via Ippolito Nievo, 35, 00153 Roma, Italy
[e] William James Center for Research, ISPA - Instituto Universitário, Rua Jardim do Tabaco 41, 1149-041 Lisboa, Portugal
[f] Department of Clinical Neuroscience, Karolinska Institutet, Nobels väg 9, 17177, Stockholm, Sweden

ARTICLE INFO

Keywords:
Moral decision-making
Moral dilemmas
Chemosignals
Body odors
Olfaction
Social context

ABSTRACT

Among the most unnoticeable stimuli providing social information, body odors are powerful social tools that can modulate behavioral and neural processing. It has recently been shown that body odors can affect moral decision-making, by increasing the activations in neural areas processing social and emotional information during the decision process. The aim of the present study was twofold: 1) to test whether body odors selectively affect decisions to real dilemmatic moral scenario (incongruent) vs. fake (congruent) dilemmas, and 2) to characterize whether the impact of masked body odors is modulated by four conceptual factors: personal force, intentionality, benefit recipient and evitability. Women chose between utilitarian (sacrificing a person's life in order to save other lives) or deontological actions (deciding against the harmful action) in 64 moral dilemmas under the exposure of a neutral fragrance (masker) or a masked male body odor. Our results showed that the masked male body odor did not specifically affect the answers to real and fake dilemmas but instead, its effect is modulating whether the agent harms the victim in a direct or indirect manner (personal force) to save herself or only other people (benefit recipient). In particular, when exposed to the masked body odor participants gave more deontological answers when the harm was indirect and only other people were saved. These data support the hypothesis that body odors induce participants to perceive the individuals described in moral dilemmas as more real, triggering harm avoidance.

1. Introduction

Individuals of all species, humans included, live in environments highly characterized by the presence of social stimuli, including those expressed via chemical signals. Human body odors (or chemosignals) are stimuli able to communicate a variety of pieces of social information, including an individual's identity (e.g., age, gender, ethnicity, health status, sexual availability and personal predisposition; [1–3]) and emotional status [4,5]. Decoding such social messages manifests both at the behavioral and neural levels in receivers [6,7], even when body odors are not consciously perceived, as when they are masked by fragranced products [8,9].

So far, the effects of body odors have been mostly focused on perceptual features (e.g. intensity, pleasantness judgments) or on tasks showing how body odors donated in highly emotional situations simulate in the receiver the same (i.e. anxiety body odor induce in the receiver fear-specific brain activity [5,9–11]) or a complementary emotion (aggression body odor induce anxiety responses, [12]). However, little attention has been given to whether human body odors can have some effects also on high-level cognitive functions such as moral decision-making.

Moral decision-making is typically investigated through the presentation of moral dilemmas, hypothetical short stories that offer two morally conflicting alternatives among which a decision maker is expected to choose [13]. According to the most influential theory, the dual-process model, moral decisions are driven by the interaction of two competing processing systems, mediated by partially dissociable neural networks: a fast, automatic emotional system, and a slow, controlled cognitive system [14,15]. In this view, cognitive processes drive utilitarian choices, which lead to violation of societal norms and values (harming other people) for what the agent thinks is a greater good, whereas emotional processes prompt deontological (non-utilitarian)

* Corresponding author at: Institut für Psychologie, Karl-Franzens-Universität Graz, Universitätsplatz 2, A-8010 Graz, Austria.
E-mail address: cinzia.cecchetto@uni-graz.at (C. Cecchetto).

https://doi.org/10.1016/j.physbeh.2019.01.007
Received 29 October 2018; Received in revised form 9 January 2019; Accepted 9 January 2019
Available online 11 January 2019
0031-9384/

choices, which instead are based on the idea that an individual's moral principle should not be infringed, even when the welfare of a greater number of people is at stake. In the deontological perspective, aversive emotional reactions motivate pro-social behaviour and the aversion of harming other people [16–19].

As recently demonstrated by an fMRI study (Cecchetto et al., under review [20]), neutral and unconsciously perceived body odors with no clear emotional content (i.e., human axillary odors collected for 12 h during which donors were asked to avoid strenuous physical activities or stressful events) can influence moral decision-making, by increasing the activation in neural areas processing social and emotional information during the moral decision process. In line with the Relationship Regulation theory (RR) – a theory positing that people build moral rules to specifically fit a certain social context - our data suggest that perceptual signals (even when unconsciously processed) shape the way a social context is perceived and, as a result, modulate moral choices [21,22]. Considering that odors are extremely effective contextual signals [23–25], we contend that being exposed to body odors while making moral choices enhances the relevance of the social dimension encoded in the odor and influences how the choice is made. When the contextual odor is a body odor collected at rest, such smell communicates the presence of a person in the vicinity, priming people at being more prone to behave according to social rules, and avoid harmful actions (Cecchetto et al., under review [20]). Interestingly, body odors influence moral decisions only when they are made over situations that involve harming as a side-effect of the moral choice made (i.e., accidental dilemmas), but not when the moral choice involves deliberate harm (i.e., instrumental dilemmas; Cecchetto et al., under review [20]). When presented with the accidental trolley- and footbridge-like dilemmas, most people make a utilitarian decision by, for instance, pulling a lever redirecting a runaway trolley, which would kill five workers, onto a sidetrack where it will kill only one person [26]. Despite the same cost/benefit ratio, in instrumental dilemmas, most people make the deontological decision of not pushing one person off an overpass onto the tracks to stop the runaway trolley and save the five workers [15,27,28]. A possible explanation for this discrepancy lies in the fact that instrumental dilemmas trigger stronger aversive reactions [27]. We argued that adding a body odor to these scenarios would not increase the already intense emotional experience of processing instrumental dilemmas, but instead it would selectively affect the processing of accidental dilemmas, those in which the emotional response is naturally more blunted [20]. This would very well be in line with a known function of human body odors, namely to be emotional enhancers [29].

However, moral decisions, and their emotional drivers, are sensitive to multiple factors as it can be reflected in the choice of utilitarian and deontological responses beyond personal tendencies [13,30]. Beside the already mentioned distinction between accidental dilemmas (i.e. the harm is just a side effect of the action) or instrumental (i.e. the harm is deliberate and instrumentally used), each dilemma can also be described as personal, if the agent directly harms another person, or impersonal, if the agent is indirectly involved in the process that results in the harm (personal force). Furthermore, a dilemma can be defined as self-beneficial, if an agent harms another person to save herself, or other-beneficial, if the benefits of the choice are extended to other people not including the agent herself (benefit-recipient). It can also be defined in terms of inevitable death, if the sacrificed life would be lost in any case, or avoidable death, if the sacrificed life could have been saved by the decision (evitability). It has been shown that personal, self-beneficial and avoidable death dilemmas elicit stronger emotional responses compared to impersonal, other-beneficial and inevitable dilemmas [17,26,31].

Even though the effects of human body odors have been investigated so far only in relation to one conceptual factor (intentionality; Cecchetto et al., under review [20]), there is evidence showing that the four conceptual factors differentially interact with the exposure to common odors to modulate moral choices. As showed in Cecchetto and colleagues [23], the presence of a neutral odor, i.e. cedarwood oil, either consciously or unconsciously perceived, increased the frequency of deontological answers for dilemmas described as instrumental, impersonal, avoidable or other-benefit [23]. In other words, when exposed to a common odor, instrumental and impersonal dilemmas received more deontological responses, probably because the odor drew attention to the harm and the person. Concurrently, the same common odor made participants less attentive to the benefits of the harmful action and increased the deontological responses to other-benefit dilemmas [23]. This evidence based on common odor [23] prompted us to hypothesize that the four conceptual factors might influence also the effects of the human body odor on moral choices.

In order to deepen the characterization of the effects of body odors on moral choices, we replicated our previous study [20] in a behavioral setting including the four conceptual factors so far known (personal force, intentionality, benefit recipient and evitability). Participants were asked to answer to 64 moral dilemmas during the presentation of a fragrance neutral in pleasantness (mask) or to a body odor masked by the same fragrance (masked body odor). In the present study, only men's human body odors were used because of the greater intensity of men's body odor axillary secretions [3] and only women were recruited as participants because of the their greater ability in extracting information from social emotional stimuli [32,33]. The type of moral choice was the dependent variable, that could be either utilitarian, if participants decided to sacrifice one person to save more people, or deontological, if participants decided not to sacrifice one person, even if it is meant for a greater good [14,30].

Our first research question was whether men's human body odor, masked by a neutral odor (and therefore, subliminally perceived), affects only the processing of real dilemmatic moral scenarios or also of non-dilemmatic moral scenarios. To answer this question, we analyzed the proportion of utilitarian answers to two types of moral scenarios: “real” moral dilemmas and “fake” moral dilemmas using the method proposed by Conway and Gawronski [34]. In the “real” moral dilemmas (called incongruent in the terminology used by Conway and Gawronski [34]) cognitive and emotional processes generating utilitarian and deontological answers diverge. In the “fake” moral dilemmas (called congruent by Conway and Gawronski; [34]), cognitive and emotional processes converged to produce deontological actions and therefore resulted in easier (less dilemmatic) choices. For example, the action of pulling a lever redirecting a runaway trolley onto a sidetrack where it will kill one person could be chosen if that action would save five workmen (incongruent dilemma) but not if it would prevent a construction yard to be destroyed (congruent dilemma).

Our second research question related to whether the effects of masked male human body odors on the moral decisions are modulated by the four conceptual moral factors. To answer this question, we performed an exploratory analysis on the proportion of utilitarian answers with the four conceptual factors as independent variables.

Two main predictions were formulated: 1) according to the results of the previous fMRI study (Cecchetto et al., under review [20]), we expected that the masked body odor would influence only the “real” incongruent dilemmas. Since it has been shown that in incongruent (compared to congruent) dilemmas participants tend to give more utilitarian answers, we foresee such trend to be reduced in the presence of the masked body odor; 2) based on previous evidence on the effects of common odors on moral choices [23], we expected that the body odor would significantly modulate the responses to some conceptual factors. In particular, we hypothesized that the body odor would make the impersonal dilemmas perceived as more personal, increasing the frequency of deontological choices. Moreover, we expected that the body odor would intensify the emotional reactions due to the deliberate harm and avoidable deaths, increasing the deontological answers of instrumental and avoidable death dilemmas. Finally, we predicted that the body odor would increase the empathy for the victim as reflected in

boosting the deontological responses for both self and other benefit dilemmas.

2. Materials and methods

2.1. Donors

In virtue of their more intense axillary secretions [3], we included as body odor donors four healthy, heterosexual men, who donated their axillary sweat on three different days (Age: M = 26.35 years old; SD = 1.38; range = 28–24 years old). The inclusion criteria were to be a non-smoker [35] and not to have health issues or undergoing drug treatment known to be related to olfactory alterations. Donors provided their written consent and agreed to comply to behavioral (no stress events, no sport activities), nutritional (i.e., no alcohol, smoking, food altering the natural body odor) and hygienic instructions throughout the collection session (adapted from [36–39]). T-shirts, previously washed with an odorless detergent and equipped with sterilized cotton pads, attached in the armpit zone, were used to collect the body odor. Donors wore a separate t-shirt for each day of the collection period for 12 consecutive hours, right after having taken a shower using fragrance-free body wash and having dried themselves with towels washed with the same odor-free detergent used to pre-wash the t-shirts. Once not in use, each t-shirt was put in an odorless plastic bag provided by the experimenters [36,37]. To assess for odor detectability and possible odor contamination from exogenous odors (e.g., alcohol, smoke, fragrance, food), one experimenter smelled the samples. All samples were then stored in a − 80 °C freezer to prevent chemical deterioration [40] and to prevent contamination, each pad was always touched by the experiments with disposable, odorless surgical gloves.

2.2. Participants

A sample of 29 women was originally recruited with the following exclusion criteria: being pregnant, not taking hormonal contraceptives, no irregular menstrual cycle, cardiovascular, neurological or psychiatric disease, diseases of the central nervous system and diseases affecting brain metabolism; drug and nicotine consumption [35]; presence of olfactory dysfunction; previous head trauma leading to unconsciousness; chronic rhinosinusitis; being not heterosexual [41,42]; score below 10 at the 16-item odor identification subtest of the Sniffin' Sticks Extended test [43]. Only women were recruited as participants because they show greater responsiveness to social emotional stimuli [32], also when presented in olfactory form [33]. One participant was removed for technical problems and five were removed because they scored above 50 at the State and Trait Anxiety Inventory (STAI; [44]), which means that they had clinically relevant anxiety, a criterion known to interact with both olfactory perception and morality [45,46]. No depression or heightened sensitivity to disgust (Disgust Scale; [47]) was revealed. The final sample included 23 healthy, heterosexual, right-handed women between the ages of 19 and 31 (M = 21.78, SD = 2.62), who were normosmic (M = 12.96, SD = 1.37, range = 10–16), and whose STAI trait (STAI-T) score was within the normal range (M = 36.83, SD = 6.84, range = 20–48). Participants were instructed to not eat or drink anything but water one hour before the test, and to not wear any scented products on the day of testing. All aspects of the experiment were approved by the SISSA Ethics Committee and are compliant with the Declaration of Helsinki. Informed written consent was obtained from each participant.

2.3. General procedure

Experimental procedures were similar to our previous study (Cecchetto et al., under review [20]). Participants were seated in a quiet room, they were instructed about the experiment and they were asked to complete three self-report questionnaires: Disgust Scale, DS

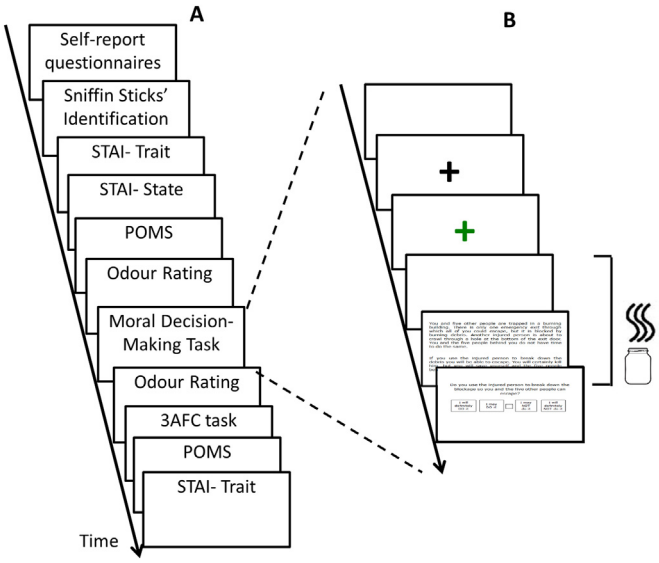

Fig. 1. (A) Summary of the general procedure. (B) Stimulus presentation during the moral decision-making task.

[47]; the Autism-Spectrum Quotient, AQ [48] and the Odor Awareness Scale, OAS [49]. These self-report questionnaires have been included because previous literature showed that moral decisions are also modulated by individual variability in sensitivity to disgust [50] and autistic traits [51,52], while the attention that people address to odors could bias the effects that odors might have on moral choices [49]. Then, participants performed the odor identification test [43]. Afterwards, participants sat in front of a computer screen and completed the State–Trait Anxiety Inventory (STAI-S and STAI-S [44]) and the Profile of Mood States (POMS [53]). These two questionnaires were included to investigate whether anxiety and mood would change after the performance of the moral decision-making task. Later, a rating odor task was proposed, followed by the moral decision-making task. After the moral decision-making task STAI-S, POMS and rating odor task were repeated to assess the effects of the moral decision-making task on anxiety, mood and odor perception. At the end of the experimental session participants performed a three-alternative forced choice (3AFC) on the odor stimuli presented (see Fig. 1 for an overview of the study procedure). Each dilemma was presented to the participants at the center of a 17″ monitor (15.16° visual angle), upon a white background. Two consecutively fixation crosses, were presented. A central black fixation cross which changed to green (0.2° visual angle) to signal the release of the odor. Odor and visual presentations, as well as response collection, were regulated via E-Prime Professional 2.0 (Psychological Software Tools. Sharpsburg. PA).

2.4. Odor stimuli

Participants were exposed within-subjects to two odor conditions: a neutral, unfamiliar common odor (200uL of cedarwood oil, Sigma-Aldrich, as in Cecchetto et al., submitted) - that we will identify as mask - and a body odor, masked with the mask odor. The body odor consisted in what is called a super-donor stimulus, which here was made of four quadrants of pads, each of which was taken from the four different donors [42]. Each participant smelled the samples collected from the same four donors, but to reduce the similarity across stimuli [39], the combination varied in terms of the axilla the sample came from and the day at which it was collected. Odors were presented bi-rhinally (total flow rate: 1.0 L/m, 0.5 L/m per nostril) in a temporally-precise, square-shaped manner using a computer-automated olfactometer [54]. Each odor was presented for approximately 1.6 (± 0.2) sec with a low flow rate to prevent irritation of the nasal mucosa over time [54,55]. To

minimize odor residuals, clean air was delivered after each odor presentation until the participant provided their response on how to act in the moral scenario [56].

2.5. Odor rating task

The odor rating task was designed to assess whether the two odor conditions were perceptually different between them and from clean air. Each odor presentation was preceded by a green fixation cross on the screen for 0.5 s followed by a black screen while an odor was presented for 4 s; a white screen followed for an average inter-stimulus interval of 6 s (± 0.12 s). Subsequently, three questions were asked in succession and in a random order, namely "How intense was the odor you just smelled?", "How pleasant was the odor you just smelled?", and "How familiar was the odor you just smelled?". Perceptual ratings for odor intensity, pleasantness, and familiarity were collected on a 100-point computerized VAS ranging from "not at all" to "very much". Participants were instructed to answer even if they did not perceive any odor.

2.6. 3AFC task

The 3AFC task was introduced to assess whether the masked body odor was consciously discriminable from the mask alone [37]. Each trial was composed by the presentation of the masked body odor and by two presentations of the mask odor in consecutive and random order, for a total of nine trials. Each odor was presented for 1.7 s it was followed by 2 s of clean air. At the end of the trial participants had to answer to the question "Which odor was different?".

2.7. Moral decision-making task

A total of 64 moral dilemmas, based on the 4CONFiDe moral set [13], was presented to each participant. In the 4CONFiDe moral set, dilemmas have been revised following the guidelines proposed by Christensen et al. (2014) [31] and Lotto et al. (2014; [26] e.g., word count, type of moral transgression, the decision maker's perspective and the type of question). Each dilemma is characterized by four conceptual factors: personal force, intentionality, benefit recipient and evitability. In the 4CONFiDe moral set, all dilemmas are designed in order that cognitive and emotional processes diverge in utilitarian and deontological answers (incongruent dilemmas). For the present study, 32 original dilemmas were selected and re-shaped in order to create other 32 dilemmas in which the cognitive and emotional processes converged in deontological actions (congruent dilemmas). Thirty-two dilemmas were presented with the mask and 32 dilemmas, equivalent for congruency, personal force, intentionality, benefit recipient and evitability, were presented with the masked body odor.

Each dilemma was presented on two subsequent screens. The first screen described the scenario, in which a danger threatens to kill a group of people (for instance, "You are an engineer on the international space station ISS. A fire breaks out in the cargo bay. The automatic fire safety system would open the outer door of the cargo bay, letting the oxygen out and putting out the fire. It only works when the inner portal is sealed, but one mechanic is still in the cargo bay. He doesn't have the time to take off the bulky space suit, which will get him stuck in the inner portal, causing the fire to spread and to kill you all."), plus a hypothetical action that would save these people but harm others ("If you manually close the portal the emergency system will be activated and it will put out the fire. This will suck the mechanic into space and you kill him, but you will save yourself and the other ten astronauts."). The second screen presented the question ("Do you put out the fire by manually sealing the inner portal, which will suck the mechanic into space, so the fire won't reach you and the ten astronauts?"). Participants had to choose between four options referred to the question in the first screen: "I certainly do it", "I do it", "I do not do it", and "I certainly do not do it". The first two answer options were considered to be utilitarian, as they maximize overall utility (i.e., saving more lives), whereas the second two choices were considered to be deontological. Participants had 6 s max to answer. Before starting the moral decision-making task, participants performed two practice trials. The instructions were similar to the ones proposed in previous studies [13]. Each trial began with a white screen presented for 10 s followed by a black cross that was displayed for 5 s (jittered randomly ± 0.294 s). Then, a green cross was presented for 4 s and the odor started to be delivered. Successively the scenario was presented for 25 s. The scenario presentation was combined with the odor presentation. Dilemmas were presented in four blocks of 16 trials. Participants were allowed to take a short break at the end of each block. During each block, 16 trails balanced for moral dilemmas types and odor conditions, were presented in randomized order, to exclude any presentation order effects on moral decision-making.

2.8. Data analysis

Data were analyzed with linear mixed-effects models (LMMs) in R (version 2.10.1; http://www.r-project.org/) and in particular using *lme* function (*nlme* package; https://cran.r-project.org/web/packages/nlme/nlme.pdf) for continuous variables and the *glmer* function for categorical variables (*lme4* package; http://cran.r-project.org/web/packages/lme4/index.html). To account for individual differences, participants were included in the models as a *random* effect. To avoid a warning of non-convergence, an optimizer (bobyqa) was applied [57]. Results with and without the optimizer are not significantly different (https://github.com/lme4/lme4/blob/master/misc/notes/release_notes.md). Estimates on the choice between utilitarian and deontological responses were based on an adaptive Gaussian Hermite approximation of the likelihood with 10 integration points. For odor ratings, models with odor factor and session were tested. For the analyses of moral choice, two models were performed: the first included odor, as the main factor of interest of our analysis, and congruency to test whether body odors have a selective effect on incongruent (real) moral dilemmas. The second model included odor and the four conceptual factors (intentionality, personal force, benefit recipient and evitability), and it was performed, considering only the incongruent dilemmas, as exploratory analysis to assess the role of the four conceptual factors on the body odor effect. For both models, at the beginning, all self-report questionnaires were included as fixed effects [58-60] and then they were progressively removed stepwise until the deletion of any additional effect caused a significant loss of fit to the model (as tested by a likelihood ratio tests using the generic *anova* function). Post-doc contrasts were performed with the *lsmeans* function. Final models are described in detail in the results sections. No outliers [61] were identified with respect to reaction times leaving a final sample of 1470 trials. Finally, in order to investigate the effect of body odor on the degree of certainty, a frequency analysis was performed on the four distinctive options to see whether the number of each option changed based on odor condition.

3. Results

3.1. The mask only and the masked body odor are perceptually similar

The LMM on intensity ratings (Clean air: M = 17.72, SD = 1.62; Mask only: M = 55.17, SD = 2.07; Masked Body odor: M = 48.56, SD = 2.44; Fig. 2A) revealed that both the mask odor and the masked body odor were perceived as significantly more intense than clean air ($p < .001$; reference factor: clean air), but no significant differences were found between the mask and the masked body odor ($p = .15$; reference factor: mask only). Moreover, no significant differences were found between ratings before and after the moral decision-making task ($p = .35$).

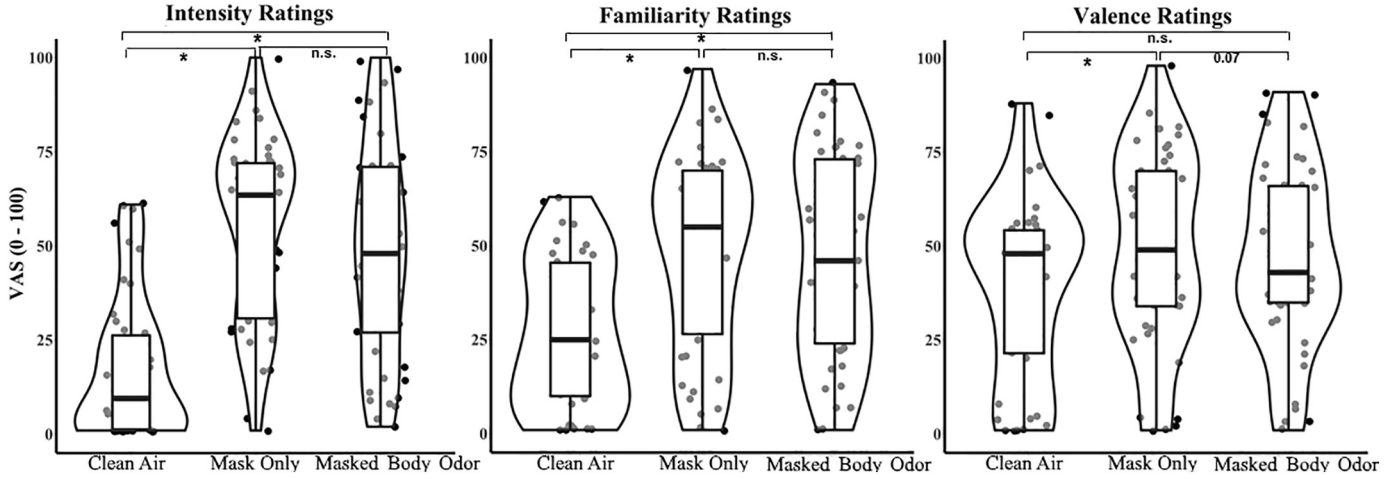

Fig. 2. Distribution of participants' odor ratings. The black dots represent single data points, whereas the box-plot represents the interquartile range of each distribution, with the thick black horizontal bar corresponding to the median. Each box-plot is surrounded by a violin plot representing the smoothed distribution of data. Significant differences ($p < .05$) are indicated with a star.

The LMM on familiarity ratings (Clean air: M = 26.79, SD = 1.77; Mask only: M = 47.56, SD = 2.33; Masked Body odor: M = 47.88, SD = 2.46; Fig. 2B) showed that both the mask odor and the masked body odor were perceived as significantly more familiar than clean air ($p < .001$; reference factor: clean air), but no significant differences were found between the mask odor and the masked body odor ($p = .89$; reference factor: mask only). No significant differences were found before and after the moral decision-making task ($p = .35$).

The LMM on valence ratings (Clean air: M = 38.62, SD = 2.15; Mask only: M = 48.70, SD = 2.26; Masked Body odor: M = 46.80, SD = 2.12; Fig. 2C) showed that the mask odor condition was perceived as more pleasant than clean air ($p = .03$) while the masked body odor tends to be perceived as more pleasant than clean air ($p = .07$; reference factor: clean air), but no significant differences were found between the mask only and the masked body odor ($p = .72$; reference factor: mask only). Moreover, a main effect of session was found: the three odor conditions were considered less pleasant after the moral decision-making task (post moral decision-making task: M = 37.90, SD = 2.37) compared to the session performed before the task (pre moral decision-making task: M = 51.61, SD = 1.84; $p < .001$; see Table 1 for descriptive data of single parameters).

3.2. Masked body odor cannot be consciously discriminated from the mask only

The results of the 3AFC test indicate that only 1 out 23 participants was able to discriminate the presence of the body odor among two mask samples in a percentage of cases significantly higher than chance. Following the binomial distribution, chance is set at 67% (6/9 correct discriminations). The participants' accuracy ranged from 0% to 89%. Using a binomial distribution, 20 participants performed below chance level, two performed at chance level, and one above chance level. In other words, all participants except one were not able to consciously discriminate the masked body odor from the mask. Given that the moral choices of the participants better able to smell the difference between mask and masked body odor superiorly than or at chance level (N = 3) were not significantly different from those of the group who could not discriminate the masked body odor, we included them in the final analyses.

3.3. Post task, anxiety is increased, but mood is stable

A Wilcoxon test (V = 148,801, $p < .0001$) determined that participants' state anxiety was increased at the end of the task (M = 35.48, SD = 8.08, range = 20–54) as compared to its beginning (M = 31.39, SD = 5.91, range = 20–44). The Wilcoxon test on POMS (V = 83.5, $p = .273$) showed that participants mood overall did not change at the end of the task.

Table 1
Summary of linear mixed effects model on intensity, familiarity and valence odor ratings.

Intensity Ratings	β	SE	t value	p value	95%CI	
Fixed effects					Lower	Upper
Intercept	56.93	4.29	13.27	< **0.001**	48.525	65.339
Clean Air	−37.38	4.66	−8.02	< **0.001**	−46.519	−28.241
Masked body odor	−6.79	4.69	−1.45	0.151	−15.992	2.394
Session (Post)	−3.52	3.82	−0.92	0.359	−11.009	3.977
Familiarity Ratings	**β**	**SE**	**t value**	**p value**	**95%CI**	
Fixed effects					Lower	Upper
Intercept	53.33	6.80	7.84	< **0.001**	39.994	66.673
Clean Air	−20.86	4.42	−4.72	< **0.001**	−29.519	−12.195
Masked body odor	−0.57	4.32	−0.13	0.895	−9. 041	7.901
Session (Post)	−3.38	3.57	−0.95	0.346	−10.384	3.621
Valence Ratings	**β**	**SE**	**t value**	**p value**	**95%CI**	
Fixed effects					Lower	Upper
Intercept	55.19	4.35	12.69	< **0.001**	46.667	63.706
Clean Air	−9.89	4.59	−2.15	**0.033**	−18.898	−0.890
Masked body odor	−1.56	4.45	−0.35	0.726	−10.278	7.157
Session (Post)	−14.09	3.71	−3.80	< **0.001**	−21.367	−6.829

Note: β = estimate; SE = standard error; 95% CI = confidence interval. Significant p values are reported in bold. Table shows model with the odor condition "Mask" set as reference.

3.4. Exposure to the masked body odor equally affects the processing of real and fake dilemmas

First, the model including odor conditions, congruency and the interaction between them was performed (see Table 2 for descriptive data of single parameters). Scores on disgust sensitivity were included since they reduce the fit of the model. A significant effect of congruency on moral choice was found ($z = 9.80$, $p < .001$): the likelihood of choosing the utilitarian option increased when dilemmas were

Table 2
Summary of the linear mixed effects model on moral choices with odor, congruency and sensitivity for disgust as fixed factors.

Moral choices	β	SE	z value	p value	βexp	95%CI	
Fixed effects						Lower	Upper
Intercept	−0.16	0.48	−0.34	0.73	0.84	0.33	2.17
Masked body odor	−0.11	0.19	−0.59	0.55	0.89	0.61	1.30
Incongruency (Incongruent)	1.71	0.17	9.80	< **0.001**	5.53	3.93	7.77
Disgust sensitivity	−0.07	0.03	−2.86	**0.004**	0.93	0.88	0.97
Masked body odor * Incongruency (Incongruent)	0.01	0.24	0.05	0.96	1.01	0.62	1.64

incongruent. Moreover, there was a significant effect of the disgust sensitivity ($z = -2.85$, $p = .004$): the likelihood of choosing the deontological option increased with higher scores in the sensitivity for disgust. No significant effect of odor condition was retrieved, neither as a main effect ($z = -0.59$, $p = .55$) or as an interaction ($z = 0.05$, $p = .96$).

3.5. Exposure to the masked body odor increases deontological answers for impersonal and other-benefit real dilemmas

Considering the results of the previous model, an exploratory analysis was performed using the model with the effects of odor conditions, the four conceptual factors and the interaction between each of them in incongruent dilemmas only (see Table 3 for descriptive data of single parameters). The scores on disgust sensitivity were included as they significantly decrease the fit of the model. The analysis revealed no main effect of odor on moral choice ($z = 0.77$, $p = .44$). However, the odor significantly interacted with the personal force factor and with the benefit recipient factor. For personal force ($z = 0.33$, $p = .03$), the post-hoc analysis showed that, in impersonal dilemmas, the likelihood of choosing deontological option increased in the masked body odor condition compared with the mask condition ($p = .017$, see Fig. 3A). For benefit recipient ($z = 0.33$, $p = .03$), the post-doc analysis showed that, in other-benefit dilemmas, the likelihood of choosing the deontological option increased in the masked body odor condition compared with the mask condition ($p = .026$, see Fig. 3B). Furthermore, the other main effects showed that: the likelihood of choosing the deontological option increased when dilemmas were personal (vs. impersonal; $z = 5.31$, $p < .001$) or instrumental (harm was intentional vs. accidental; $z = -4.08$, $p < .001$), and in individuals with higher disgust sensitivity (i.e., greater DS scores; $z = -1.98$, $p = .048$).

3.6. Exposure to the masked body odor decreases extreme utilitarian answers

A frequency analysis confirms that participants are more prone to answer in a deontological manner ($X(1) = 102.41$, $p < .0001$) and that they prefer using the central options (both deontological and utilitarian) rather than the extremes (respectively; $X(1) = 43.49$, $p < .0001$; $X(1) = 349.77$, $p < .0001$), as expected. Interestingly, the frequency analysis on the four options related to odor condition shows that during the exposure to the masked social odor condition participants gave less extreme utilitarian answers ($X(1) = 6.81$, $p = .009$) compared to the mask condition.

4. Discussion

Despite the increasing number of studies that have investigated the effects of human body odors [6,7,9,62], little attention has been given to the effects the body odor could have on decision-making. In a recent fMRI study, we have shown that male body odors collected from resting participants, and masked with a neutral odor, modulates the outcome of moral decisions by increasing the neural activation in areas involved in social information and emotional processing (Cecchetto et al., under review [20]). The present study aimed at better characterizing the effects of male body odors on moral choices at the behavioral level in female participants. First, we investigated whether body odors affect the processing of only real dilemmas (incongruent moral dilemmas [34]) or also "fake" dilemmas (congruent moral dilemmas [34]). Second, we explored how the four conceptual factors (personal force, intentionality, benefit recipient and evitability) influence the effects of body odor in incongruent moral dilemmas. Results showed that the exposure to the masked body odor: a) did not show a specific effect on incongruent or congruent dilemmas; and b) in incongruent moral dilemmas, the presence of the masked body odor increased the deontological responses in impersonal and other-benefit dilemmas.

The analysis of the body odor effects on incongruent and congruent dilemmas did not reveal any significant main effect of the masked body odor. However, since our previous fMRI analysis (Cecchetto et al., under review [20]) showed that at neural level the body odor specifically modulates the neural basis of incongruent but not of congruent dilemmas, the conceptual factors were investigated only in the incongruent dilemmas. The second analysis showed that the exposure to body odor increased deontological answers only for impersonal and other-benefit dilemmas. A differential interpretation can be proposed to explain these results. First, the body odor is identified with the victim of the harm: in this view, the masked body odor induces participants to take the victim's perspective and to avoid causing harm [16]. This hypothesis is supported by the evidence that the body odor is effective only for those dilemmas in which the victim is normally perceived as distant. Impersonal dilemmas are those in which the agent is only

Table 3
Summary of the linear mixed effects model on moral choices with odor, the four conceptual factors and sensitiviy for disgust as fixed factors.

Moral choices	β	SE	z value	p value	βexp	95%CI	
Fixed effects						Lower	Upper
Intercept	1.34	0.68	1.98	**0.05**	3.84	1.01	14.56
Masked body odor	0.28	0.36	0.77	0.44	1.32	0.65	2.69
Personal force (Impersonal)	1.28	0.24	5.32	< **0.001**	3.57	2.23	5.71
Intentionality (Instrumental)	−0.97	0.24	−4.09	< **0.001**	0.37	0.23	0.60
Benefit recipient (Self)	−0.44	0.24	−1.86	0.06	0.64	0.40	1.02
Evitability (Inevitable)	0.44	0.24	1.86	0.06	1.55	0.97	2.47
Disgust sensitivity	−0.06	0.03	−1.98	**0.05**	0.93	0.87	0.99
Masked body odor * Personal force (Impersonal)	−0.71	0.33	−2.15	**0.03**	0.49	0.25	0.93
Masked body odor * Intentionality (Instrumental)	−0.42	0.33	−1.27	0.20	0.65	0.34	1.26
Masked body odor * Benefit recipient (Self)	0.79	0.33	2.39	**0.02**	2.21	1.16	4.24
Masked body odor * Evitability (Inevitable)	−0.46	0.33	−1.39	0.16	0.63	0.33	1.21

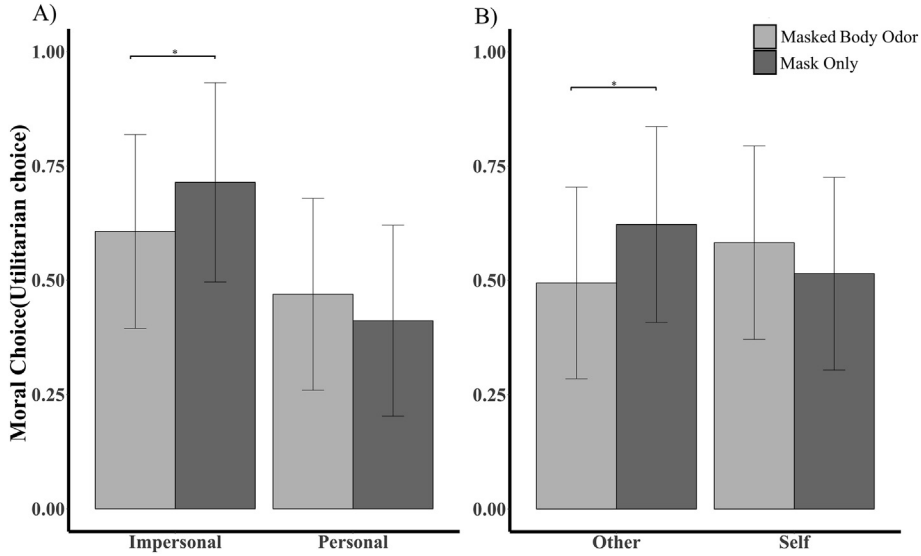

Fig. 3. A) Effect plot of the interaction between odor and personal force; B) effect plot of the interaction between odor and benefit recipient. Error bars are the Standard Error estimates of the parameter estimates of the model.

indirectly involved in the process that results in the harm, so the participant is not in direct contact with the victim [31]. Other-benefit dilemmas are those in which other people and not the participant will be saved by the harmful action, so participants present empathic feelings for the people that have to be saved but not for the victim [16]. This mechanism is similar to the one seen in dilemmas proposed in virtual reality environments. Virtual reality is a method that may be used to simulate life-threatening situations, in a safe though contextually rich environment [63], which can preserve ecological validity [63-65]. Patil et al. [64] showed that participants give more utilitarian answers for the virtual-reality dilemmas compared to textual descriptions of the same dilemmas even though the dilemmas in virtual reality are perceived as more emotionally arousing. The authors explained this result, which was unexpected and controversial since increased emotional processing is usually related to an increase in deontological answers [15,66], with an outcome-based value representation: participants in virtual reality could have been more sensitive to outcomes because they perceived as more real the virtual people involved in the dilemmas. Likewise, we contend, that in our study, the presence of body odors allowed participants to perceived the individuals described in the dilemma as more real (after all, when we can smell the odor of a person, they usually are in our vicinities) and as a result, the choices reflected a prioritization of non-harming behaviors, in tune with the social norms of the participants.

Our second interpretation proposes that the body odors might induce participants to perceive unconsciously all individuals described in the moral dilemmas as more real. In this way, the body odor gave to the moral dilemma a more salient social context incrementing the dilemmatic and emotional nature of the question and making the differences between personal and impersonal dilemmas (and self- other-benefit dilemmas) less noteworthy. This interpretation is supported by the imaging results of our previous study (Cecchetto et al., under review) which shows that the masked body odor increases the activations of the angular gyrus, which has been associated with visual attention toward salient features [67]. The angular gyrus is argued to allocate attention by employing a bottom-up strategy which draws on the area's ability to attend the retrieved memories [67]. As we have previously proposed for the instrumental dilemmas, the body odor does not increase the emotional content of personal and self-benefit dilemmas as they are already perceived as highly emotional [13,26]. Interestingly, the frequency analysis on the four choices, for both congruent and incongruent dilemmas, reports that during the exposure to the masked social odor participants gave less extreme utilitarian answers “I certainly do it” compared to the mask condition. This might indicate that participants were less confident with the decision of harming someone in the presence of a socially relevant, but masked, odor cue. Again, this result seems to support the hypothesis that the body odor is unconsciously perceived as related to the person that is going to be harm: participants might be less confident when they decide to harm someone when they perceive the presence of a real person. As confirmed by the higher level of anxiety, measured by the STAI questionnaire, at the end of the task compared to the beginning, the moral decision-making task was a real dilemmatic task. However, it is unlikely that effect on the personal and other-benefit dilemmas is due to a modulation in the participants' mood since the POMS questionnaire evidenced no changes between the beginning and the end of the task, confirming that the effect is only related to the presence of the body odor.

As the analysis of odor ratings reveals, the mask odor and the masked body odor were perceptually equivalent for intensity, valence and familiarity, indicating that the masking procedure succeeded. Therefore, the differential effects of the odor factor on moral choice should not be attributed to perceptual differences across conditions. Furthermore, the results from the 3AFC task, showing that participants performed this task below chance probability, strengthens the idea that the two odor conditions were not consciously discriminable. This is an important aspect, since it supports the hypothesis that human body odors modulate behavior even when they are subliminally perceived. Therefore, in our daily social life, even if masked by fragrances body product, body odor can still affect our behavior. Based on the notion that social chemosignal communication is based primarily on unconscious processes [7], and considering that in everyday life our natural body odors are often masked by fragranced products, we evaluated here the effects of masked body odor on moral decision making. However, if an unmasked, natural body odor would be tested with the same paradigm, we hypothesize that comparable effects on moral decision making would emerge. A different hypothesis can be advanced if participants were told that the odor stimuli are human body odors. In this case, disgust and avoidance reactions may be triggered and overtly influence the moral answers [68,69].

Taken together, our results support the Relationship Regulation theory proposed by Rai and Fiske [22] which argues that moral rules are determined by social relationship and shaped for specific social context. This view tries to go beyond the dual process model [e.g. 63,64] according to which moral choices are driven by the interaction

between two opposing processing systems: a fast, automatic, emotional system, which plays a key role in producing deontological choices - based on the idea that the moral principle of avoiding harm should never be infringed - and a slow cognitive (executive) system, which supports the production of utilitarian responses - grounded on a cost–benefit analysis aimed at reducing the overall harm [27,70]. Our results advocate for the mediating role of social relationships in moral decisions: indeed, in the present study, body odors were a means for triggering the social context and for making the social norms more salient even when the perceiver cannot appreciate the presence of the body odor. Moreover, we showed that the masked body odor reveals effects only when certain conceptual factors (impersonal and other-benefit dilemmas) are considered, suggesting that its effect is specifically related to the situation that the participant needs to face. Since the present study was exploratory, further research is needed to replicate this finding.

The present study considers the theory proposed by Rai and Fiske [22] in a narrow way, presenting via body odors the presence of a person stranger to the smeller. However, although it provides new insights into the mechanisms of moral decision-making and the effects of human body odors, the present study also poses some questions. In the present study, we tested only women smelling men's body odors. Based on the gender differences that have recently been highlighted in body odor literature [,71], these results may not be fully generalized to the overall population. Would the effects of body odors be different if we had women or men smelling women's body odors or men smelling men's body odors? Additionally, considering the role that familiarity plays in modulating body odors responses, would presenting the odor of a familiar person change the nature of the moral decisions, as it does for neural and psychophysiological responses [12,36,15]? Would the odor from people belonging to cultures different from the receivers have an impact on the moral decision? Future studies will have to clarify these aspects.

To conclude, this study showed that a social context, even when presented through a masked body odor, plays a role in shaping moral decisions [21,22]. Future studies should consider the social context in addition to the cognitive and emotional components, which have been deeply investigated in previous moral literature, to clarify how moral decision are made.

Competing interests

The authors declare that they have no competing interests.

References

[1] M.K. McClintock, S. Bullivant, S. Jacob, N. Spencer, B. Zelano, C. Ober, Human body scents: conscious perceptions and biological effects, Chem. Senses 30 (2005) i135–i137, https://doi.org/10.1093/chemse/bjh151.

[2] T.D. Wyatt, Pheromones and Animal Behavior: Chemical Signals and Signatures, Cambridge University Press, Cambridge, 2014.

[3] K.A. Prokop-Prigge, K. Greene, L. Varallo, C.J. Wysocki, G. Preti, The effect of ethnicity on human axillary odorant production, J. Chem. Ecol. 42 (2016) 33–39, https://doi.org/10.1007/s10886-015-0657-8.

[4] J.H.B. de Groot, G.R. Semin, M.A.M. Smeets, On the communicative function of body odors: a theoretical integration and review, Perspect. Psychol. Sci. (2017), https://doi.org/10.1177/1745691616676599.

[5] O.A. Wudarczyk, N. Kohn, R. Bergs, K.S. Goerlich, R.E. Gur, B. Turetsky, F. Schneider, U. Habel, Chemosensory anxiety cues enhance the perception of fearful faces - An fMRI study, NeuroImage 143 (2016) 214–222, https://doi.org/10.1016/j.neuroimage.2016.09.002.

[6] J.N. Lundström, M.J. Olsson, Functional neuronal processing of human body odors, Vitam. Horm. 83 (2010) 1–23, https://doi.org/10.1016/S0083-6729(10)83001-8.

[7] V. Parma, A.R. Gordon, C. Cecchetto, A. Cavazzana, J.N. Lundström, M.J. Olsson, Processing of human body odors, Springer Handb. Odor, Springer International Publishing, Cham, 2017, pp. 127–128, , https://doi.org/10.1007/978-3-319-26932-0_51.

[8] C. Cecchetto, A. Cavazzana, A.R. Gordon, V. Rebeschini, V. Parma, J.N. Lundstrom, Chemosensory threat signals: the case of strangers' body odor, Chem. Senses, Oxford Univ Press Great Clarendon ST, Oxford OX2 6DP, England, 2016, pp. E39–E40.

[9] P.B. Singh, A. Young, S. Lind, M.C. Leegaard, A. Capuozzo, V. Parma, Smelling anxiety chemosignals impairs clinical performance of dental students, Chem. Senses 43 (2018) 411–417, https://doi.org/10.1093/chemse/bjy028.

[10] J.H.B. de Groot, M.A.M. Smeets, Human fear chemosignaling: evidence from a meta-analysis, Chem. Senses 42 (2017) 663–673, https://doi.org/10.1093/chemse/bjx049.

[11] L.R. Mujica-Parodi, H.H. Strey, B. Frederick, R. Savoy, D. Cox, Y. Botanov, D. Tolkunov, D. Rubin, J. Weber, Chemosensory cues to conspecific emotional stress activate amygdala in humans, PLoS One 4 (2009) e6415, https://doi.org/10.1371/journal.pone.0006415.

[12] S. Mutic, V. Parma, Y.F. Brünner, J. Freiherr, You smell dangerous: communicating fight responses through human chemosignals of aggression, Chem. Senses 00 (2015) bjv058, https://doi.org/10.1093/chemse/bjv058.

[13] C. Cecchetto, R.I. Rumiati, V. Parma, Promoting cross-culture research on moral decision-making with standardized, culturally- equivalent dilemmas: the 4CONFiDe set, J. Heal. Soc. Sci. 22 (2017) 173–194, https://doi.org/10.19204/2017/prmt5.

[14] J.D. Greene, L.E. Nystrom, A.D. Engell, J.M. Darley, J.D. Cohen, The neural bases of cognitive conflict and control in moral judgment, Neuron 44 (2004) 389–400, https://doi.org/10.1016/j.neuron.2004.09.027.

[15] J.D. Greene, R.B. Sommerville, L.E. Nystrom, J.M. Darley, J.D. Cohen, An fMRI investigation of emotional engagement in moral judgment, Science 293 (2001) 2105–2108, https://doi.org/10.1126/science.1062872.

[16] M. Sarlo, lorella Lotto, R. Rumiati, D. Palomba, If it makes you feel bad, don't do it! Egoistic rather than altruistic empathy modulates neural and behavioral responses in moral dilemmas, Physiol. Behav. 130 (2014) 127–134, https://doi.org/10.1016/J.PHYSBEH.2014.04.002.

[17] C. Cecchetto, S. Korb, R.I. Rumiati, M. Aiello, Emotional reactions in moral decision-making are influenced by empathy and alexithymia, Soc. Neurosci. 13 (2017) 226–240, https://doi.org/10.1080/17470919.2017.1288656.

[18] I. Patil, G. Silani, Reduced empathic concern leads to utilitarian moral judgments in trait alexithymia, Front. Psychol. 5 (2014) 501, https://doi.org/10.3389/fpsyg.2014.00501.

[19] M.J. Crockett, L. Clark, M.D. Hauser, T.W. Robbins, Serotonin selectively influences moral judgment and behavior through effects on harm aversion, Proc. Natl. Acad. Sci. 107 (2010) 17433–17438, https://doi.org/10.1073/pnas.1009396107.

[20] C. Cecchetto, E. Lancini, D. Bueti, R.I. Rumiati, V. Parma, Social odors (even when masked) make you more emotional: behavioral and neural insights, Retrieved from Osf.Io/Q3gh2 (2018).

[21] M. Cikara, R.A. Farnsworth, L.T. Harris, S.T. Fiske, On the wrong side of the trolley track: neural correlates of relative social valuation, Soc. Cogn. Affect. Neurosci. 5 (2010) 404–413, https://doi.org/10.1093/scan/nsq011.

[22] T.S. Rai, A.P. Fiske, Moral psychology is relationship regulation: moral motives for unity, hierarchy, equality, and proportionality, Psychol. Rev. 118 (2011) 57–75, https://doi.org/10.1037/a0021867.

[23] C. Cecchetto, R.I. Rumiati, V. Parma, Relative contribution of odour intensity and valence to moral decisions, Perception 46 (2017) 447–474, https://doi.org/10.1177/0301006616689279.

[24] J.-C. Chebat, R. Michon, Impact of ambient odors on mall shoppers' emotions, cognition, and spending: a test of competitive causal theories, J. Bus. Res. 56 (2003) 529–539, https://doi.org/10.1016/S0148-2963(01)00247-8.

[25] M. Larsson, A. Arshamian, C. Kärnekull, Odor-based context dependent memory, Handb. Odor, 2017, pp. 821–826.

[26] L. Lotto, A. Manfrinati, M. Sarlo, A new set of moral dilemmas: norms for moral acceptability, decision times, and emotional salience, J. Behav. Decis. Mak. 27 (2014) 57–65, https://doi.org/10.1002/bdm.1782.

[27] M. Sarlo, L. Lotto, A. Manfrinati, R. Rumiati, G. Gallicchio, D. Palomba, Temporal dynamics of cognitive–emotional interplay in moral decision-making, J. Cogn. Neurosci. 24 (2012) 1018–1029, https://doi.org/10.1162/jocn_a_00146.

[28] L. Young, M. Koenigs, Investigating emotion in moral cognition: a review of evidence from functional neuroimaging and neuropsychology, (2007), pp. 69–79, https://doi.org/10.1093/bmb/ldm031.

[29] J.H.B. De Groot, G.R. Semin, M.A.M. Smeets, I can see, hear, and smell your fear: Comparing olfactory and audiovisual media in fear communication, J. Exp. Psychol. Gen. 143 (2014) 825.

[30] J.F. Christensen, A. Gomila, Moral dilemmas in cognitive neuroscience of moral decision-making: a principled review, Neurosci. Biobehav. Rev. 36 (2012) 1249–1264, https://doi.org/10.1016/J.NEUBIOREV.2012.02.008.

[31] J.F. Christensen, A. Flexas, M. Calabrese, N.K. Gut, A. Gomila, Moral judgment reloaded: a moral dilemma validation study, Front. Psychol. 5 (2014) 607, https://doi.org/10.3389/fpsyg.2014.00607.

[32] A.M. Proverbio, A. Zani, R. Adorni, Neural markers of a greater female responsiveness to social stimuli, BMC Neurosci. 9 (2008) 56, https://doi.org/10.1186/1471-2202-9-56.

[33] B.M. Pause, K. Lübke, J.H. Laudien, R. Ferstl, C. Murphy, Intensified neuronal investment in the processing of chemosensory anxiety signals in non-socially anxious and socially anxious individuals, PLoS One 5 (2010) e10342, , https://doi.org/10.1371/journal.pone.0010342.

[34] P. Conway, B. Gawronski, Deontological and utilitarian inclinations in moral decision making: a process dissociation approach, J. Pers. Soc. Psychol. 104 (2013) 216–235, https://doi.org/10.1037/a0031021.

[35] S. Boesveldt, S.T. Lindau, M.K. McClintock, T. Hummel, J.N. Lundstrom, J.N. Lindstrom, Gustatory and olfactory dysfunction in older adults: a national probability study, Rhinology 49 (2011) 324–330, https://doi.org/10.4193/Rhino10.155.

[36] J.N. Lundström, J.A. Boyle, R.J. Zatorre, M. Jones-Gotman, Functional neuronal processing of body odors differs from that of similar common odors, Cereb. Cortex 18 (2008) 1466–1474, https://doi.org/10.1093/cercor/bhm178.

[37] J.N. Lundström, J.A. Boyle, R.J. Zatorre, M. Jones-Gotman, The neuronal substrates of human olfactory based kin recognition, Hum. Brain Mapp. 30 (2009) 2571–2580, https://doi.org/10.1002/hbm.20686.
[38] J.N. Lundström, M. Jones-Gotman, Romantic love modulates women's identification of men's body odors, Horm. Behav. 55 (2009) 280–284, https://doi.org/10.1016/j.yhbeh.2008.11.009.
[39] S. Mitro, A.R. Gordon, M.J. Olsson, J.N. Lundström, A. Vainius, The smell of age: perception and discrimination of body odors of different ages, PLoS One 7 (2012) e38110, https://doi.org/10.1371/journal.pone.0038110.
[40] P. Lenochova, S.C. Roberts, J. Havlicek, Methods of human body odor sampling: the effect of freezing, Chem. Senses 34 (2008) 127–138, https://doi.org/10.1093/chemse/bjn067.
[41] J. Krajnik, K. Kollndorfer, K.H. Nenning, J.N. Lundström, V. Schöpf, Gender effects and sexual-orientation impact on androstadienone-evoked behavior and neural processing, Front. Neurosci. 8 (2014) 1–7, https://doi.org/10.3389/fnins.2014.00195.
[42] Y. Martins, G. Preti, C.R. Crabtree, T. Runyan, A.A. Vainius, C.J. Wysocki, Preference for human body odors is influenced by gender and sexual orientation, Psychol. Sci. 16 (2005) 694–701, https://doi.org/10.1111/j.1467-9280.2005.01598.x.
[43] T. Hummel, B. Sekinger, S.R. Wolf, E. Pauli, G. Kobal, "Sniffin" sticks': olfactory performance assessed by the combined testing of odor identification, odor discrimination and olfactory threshold, Chem. Senses 22 (1997) 39–52, https://doi.org/10.1093/chemse/22.1.39.
[44] C. Spielberger, The State-trait Anxiety Inventory (STAI): Test Manual for Form X, (1968).
[45] K. Starcke, C. Polzer, O.T. Wolf, M. Brand, Does stress alter everyday moral decision-making? Psychoneuroendocrinology 36 (2011) 210–219, https://doi.org/10.1016/j.psyneuen.2010.07.010.
[46] T. Takahashi, H. Itoh, Y. Nishikawa, Y. Higuchi, M. Nakamura, D. Sasabayashi, S. Nishiyama, Y. Mizukami, Y. Masaoka, M. Suzuki, Possible relation between olfaction and anxiety in healthy subjects, Psychiatry Clin. Neurosci. 69 (2015) 431–438, https://doi.org/10.1111/pcn.12277.
[47] P. Rozin, J. Haidt, C. McCauley, L. Dunlop, M. Ashmore, Individual differences in disgust sensitivity: comparisons and evaluations of paper-and-pencil versus behavioral measures, J. Res. Pers. 33 (1999) 330–351, https://doi.org/10.1006/JRPE.1999.2251.
[48] S. Baron-Cohen, S. Wheelwright, R. Skinner, J. Martin, E. Clubley, The autism-spectrum quotient (AQ): evidence from asperger syndrome/high-functioning autism, malesand females, scientists and mathematicians, J. Autism Dev. Disord. 31 (2001) 5–17, https://doi.org/10.1023/A:1005653411471.
[49] M.A.M. Smeets, H.N.J. Schifferstein, S.R. Boelema, G. Lensvelt-Mulders, The odor awareness scale: a new scale for measuring positive and negative odor awareness, Chem. Senses 33 (2008) 725–734, https://doi.org/10.1093/chemse/bjn038.
[50] S. Schnall, J. Haidt, G.L. Clore, A.H. Jordan, Disgust as embodied moral judgment, Personal. Soc. Psychol. Bull. 34 (2008) 1096–1109, https://doi.org/10.1177/0146167208317771.
[51] J.M. Moran, L.L. Young, R. Saxe, S.M. Lee, D. O'Young, P.L. Mavros, J.D. Gabrieli, Impaired theory of mind for moral judgment in high-functioning autism, Proc. Natl. Acad. Sci. 108 (2011), http://www.pnas.org/content/108/7/2688.short accessed September 18, 2018.
[52] M. Buon, E. Dupoux, P. Jacob, P. Chaste, M. Leboyer, T. Zalla, The role of causal and intentional judgments in moral reasoning in individuals with high functioning autism, J. Autism Dev. Disord. 43 (2013) 458–470, https://doi.org/10.1007/s10803-012-1588-7.
[53] D.M. McNair, M. Lorr, L.F. Droppleman, Profile of mood states—revised, Calif. Educ. Institutional Test. Serv, San Diego, 1992.
[54] J.N. Lundström, A.R. Gordon, E.C. Alden, S. Boesveldt, Methods for building an inexepensive computer-controlled olfactometer for temporally-precise experiments, 78 (2010), pp. 179–189, https://doi.org/10.1016/j.ijpsycho.2010.07.007.Methods.
[55] J. Lötsch, G. Ahne, J. Kunder, G. Kobal, T. Hummel, Factors affecting pain intensity in a pain model based upon tonic intranasal stimulation in humans, Inflamm. Res. 47 (1998) 446–450, https://doi.org/10.1007/s000110050359.
[56] J. Seubert, K.M. Gregory, J. Chamberland, J.-M. Dessirier, J.N. Lundström, Odor valence linearly modulates attractiveness, but not age assessment, of invariant facial features in a memory-based rating task, PLoS One 9 (2014) e98347, https://doi.org/10.1371/journal.pone.0098347.
[57] M.J.D. Powell, The BOBYQA algorithm for bound constrained optimization without derivatives, Cambridge NA Rep. NA2009/06, Univ, Cambridge, Cambridge, 2009, pp. 26–46.
[58] D. Crepaldi, W.-C. Che, I.-F. Su, C. Luzzatti, Lexical-semantic variables affecting picture and word naming in Chinese: a mixed logit model study in aphasia, Behav. Neurol. 25 (2012) 165–184, https://doi.org/10.3233/BEN-2012-119002.
[59] R.A. McLean, W.L. Sanders, W.W. Stroup, A unified approach to mixed linear models, Am. Stat. 45 (1991) 54–64, https://doi.org/10.1080/00031305.1991.10475767.
[60] E.I. Wehling, D. Wollschlaeger, S. Nordin, A.J. Lundervold, Longitudinal changes in odor identification performance and neuropsychological measures in aging individuals, Neuropsychology 30 (2016) 87–97 http://psycnet.apa.org/buy/2015-26453-001 (accessed March 8, 2018).
[61] D.C. Hoaglin, B. Iglewicz, J.W. Tukey, Performance of some resistant rules for outlier labeling, J. Am. Stat. Assoc. 81 (1986) 991–999.
[62] O.A. Wudarczyk, N. Kohn, R. Bergs, R.E. Gur, B. Turetsky, F. Schneider, U. Habel, Chemosensory anxiety cues moderate the experience of social exclusion – an fMRI investigation with Cyberball, Front. Psychol. 6 (2015) 1475, https://doi.org/10.3389/fpsyg.2015.01475.
[63] M. Zanon, G. Novembre, N. Zangrando, L. Chittaro, G. Silani, Brain activity and prosocial behavior in a simulated life-threatening situation, NeuroImage 98 (2014) 134–146, https://doi.org/10.1016/J.NEUROIMAGE.2014.04.053.
[64] I. Patil, C. Cogoni, N. Zangrando, L. Chittaro, G. Silani, Affective basis of judgment-behavior discrepancy in virtual experiences of moral dilemmas, Soc. Neurosci. 9 (2014) 94–107, https://doi.org/10.1080/17470919.2013.870091.
[65] M.M. McDonald, A.M. Defever, C.D. Navarrete, Killing for the greater good: Action aversion and the emotional inhibition of harm in moral dilemmas, Evol. Hum. Behav. 38 (2017) 770–778, https://doi.org/10.1016/J.EVOLHUMBEHAV.2017.06.001.
[66] P. Valdesolo, D. DeSteno, Manipulations of emotional context shape moral judgment, Psychol. Sci. 17 (2006) 476.
[67] M.L. Seghier, The angular gyrus, Neuroscience 19 (2013) 43–61, https://doi.org/10.1177/1073858412440596.
[68] J.F. Landy, G.P. Goodwin, Does incidental disgust amplify moral judgment? A meta-analytic review of experimental evidence, Perspect. Psychol. Sci. 10 (2015) 518–536, https://doi.org/10.1177/1745691615583128.
[69] M.T. Liuzza, T. Lindholm, C.B. Hawley, M.G. Sendén, I. Ekström, M.J. Olsson, J.K. Olofsson, Body odour disgust sensitivity predicts authoritarian attitudes, R. Soc. Open Sci. 5 (2018) 171091, https://doi.org/10.1098/rsos.171091.
[70] A. Shenhav, J.D. Greene, Integrative moral judgment: dissociating the roles of the amygdala and ventromedial prefrontal cortex, J. Neurosci. 34 (2014), http://www.jneurosci.org/content/34/13/4741.short accessed June 8, 2018.
[71] S. Mutic, V. Parma, Y.F. Brünner, J. Freiherr, You smell dangerous: communicating fight responses through human chemosignals of aggression, Chem. Senses 41 (2016) 35–43, https://doi.org/10.1093/chemse/bjv058.