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Contribution of perceptual and emotional skills to moral decision-making

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To my father

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It was Gandalf who roused them all from sleep. He had sat and watched all alone for about six hours, and had let the others rest. 'And in the watches I have made up my mind,' he said. 'I do not like the feel of the middle way; and I do not like the smell of the left-hand way: there is foul air down there, or I am no guide. I shall take the right-hand passage. It is time we began to climb up again.'

The fellowship of the ring
J.R.R Tolkien

OVERVIEW

Moral decision-making is the ability to choose an optimal course of action based on a system of norms and values that guides our behaviour in a community. Even though the models of moral decision-making have mainly focused on cognitive reasoning and emotions, moral decisions - like all kind of decisions - are taken within a context and in interaction with environmental factors. Therefore, the role played by such factors is critical in order to explain how a decision is reached.

In Chapter 1, after a systematic overview of the different theoretical models proposed to explain morality, I discuss the evidence in favour of the role played by sensory stimuli in moral choices, focusing on a recent meta-analysis (Landy & Goodwin, 2015a) that showed that besides vision, chemosensory stimuli play a central role in the moral decision process. Then, I explore the link between odours and morality, starting from the disgust emotion, arguing that olfactory stimuli could extend their effects to morality via mechanisms unrelated to disgust, as suggested by the shared neural underpinnings underlying olfaction and moral choices.

The following chapters (2 - 5) concern the experimental works that I undertook with the aim of exploring how olfactory perception can impact on moral decision-making, in particular the covert effects that odours exert. Approaching the existing literature, I realized that many contextual factors may highly influence moral choice, making the effect of olfactory stimuli hard to investigate. Therefore, to investigate the effects of olfactory stimuli on moral decisions, I had to dissociate such effects from those linked to other confounding aspects.

The first step for accounting for the many contextual factors that might influence moral decisions was to use a set of stimuli in Italian language that included all the four conceptual factors proposed by previous literature (Christensen, Flexas, Calabrese *et al.*, 2014). In

literature, a database in Italian language that considers more than one conceptual factor does not exist. In Chapter 2 I described the database that I created for the purpose of assessing fine-grained effects in olfactory perception. Previous moral dilemma sets were extended and adapted to create a comprehensive moral set called 4CONFiDe (4 Conceptual Factors Dilemmas). The set was evaluated for cultural effects by English-native speakers proficient in Italian, and Italian-native speakers proficient in English (Study 1). The analysis showed that moral choices were made irrespective of participants' native language and dilemmas version, suggesting that the translation was culturally-representative. In Study 2 Italian-native speakers (N=112) rated arousal, valence and familiarity levels experienced with each dilemma.

In Chapter 3 I focus on individual differences. In particular, I explored the influence of empathy and alexithymia on moral decision-making task and emotional responses while participants performed a moral decision task. Self-report (valence and arousal ratings) and physiological (skin conductance and heart rate) measures were collected during the task. Previous studies have shown that participants lacking emotional empathy and the experience (and understanding) of unpleasant emotions in response to other people's suffering are more likely to make choices that violate societal norms in favour of a greater good (utilitarian options; Patil & Silani, 2014b; Sarlo *et al.,* 2014; Gleichgerrcht *et al.,* 2013). Moreover, a higher tendency to make utilitarian choices has been described also in alexithymic individuals. However, to date, the influence of alexithymia on morality has only been investigated using moral judgment tasks (Koven, 2011; Patil & Silani, 2014b; 2014a), even though differences exist between moral decision and moral judgment tasks (Szekely & Miu, 2014; Tassy *et al.*, 2013b). Furthermore, no study has jointly investigated the influence of both empathy and alexithymia on moral decision-making. Analysis showed that empathy and alexithymia shaped emotional reactions to moral decisions, but did not bias moral choices. The more

empathic the participants, the more dilemmas were perceived as unpleasant and arousing, and the greater the increase in skin conductance, while alexithymia was characterized by a reduced physiological activation during moral decisions, but normal self-report ratings. The results of Chapter 3 seems to suggest that, even though individual differences in empathy or alexithymia might not affect moral choices, they do influence emotional reactions to moral dilemma, reinforcing the view that interactions between individual differences in emotional awareness and moral decision-making are very complex and need to be addressed further.

In Chapters 4-5, I examined the several ways in which olfactory stimuli can impact on moral decision-making. In particular, Chapter 4 was devoted to find the best olfactory stimuli for studying how odours could modulate moral choices. Through a set of three pilot studies, I tried to assess whether and how odour intensity biases moral choices (Study 1a), its psychophysiological responses (Study 1b), as well as the behavioural and psychophysiological effects of odour valence on moral choices (Study 2). Overall, the results of the three studies showed that: first, only when olfactory stimuli were presented in a sub-threshold concentration they have shown to be effective in biasing moral choices towards a deontological tendency; second, pleasant and unpleasant odours might not differentially affect moral choices. As expected, odour intensity effect was tracked by skin conductance responses, whereas no difference in cardiac activity is revealed. In conclusion, Chapter 4 suggests that olfactory stimuli affect the processes underlying moral decisions by incrementing deontological choices and that this effect goes beyond the ability of the odour to induce disgust.

Finally, since the most of moral choices are made within the framework of social contexts, in **Chapter 5** we explored, through a behavioural experiment and a functional magnetic resonance imaging (fMRI) experiment, whether human social odours, which are powerful signals to communicate social information, are able to influence people on their

moral decisions and which neural mechanisms are involved in such process. Behavioural data showed that body odours increased deontological answers when presented during impersonal dilemmas and decrease them for personal dilemmas. The same pattern was found for the evitability factor: masked social odour increases deontological answers for avoidable dilemmas and it increases them for inevitable dilemmas. Moreover, fMRI data showed that moral dilemmas processed during the masked social odour seem involve the activation of more areas included in the social brain (fusiform gyrus, caudate nucleus, anterior insula and orbitofrontal cortex) than the moral dilemmas processed during the masker odour. Overall, results indicates that social odour, when unconsciously processed, is able to make more salient the social context incrementing the dilemmatic nature of the question.

Taken together these studies support the hypothesis that the context in which the decisions are made is relevant for understanding how that decision is made.

CHAPTER 1

Introduction

Everyday, in many different situations, we ask ourselves "Which is the right thing to do?": Should I give up my seat on the bus for the old woman, even if I am really tired? Should I give back the thick wallet I found in the street, even if I desperately need money? If in some cases what is acceptable and what is unfair is easily recognized, other ambiguous and stressful situations can undoubtedly be puzzling. For instance, if you witness a child drowning, most likely you will feel compelled to rescue him. However, if saving that child has as a consequence to let three other young children die, the goodness of the act of saving one child becomes questionable. This hypothetical short story, which researchers call moral dilemma, offers two morally conflicting alternatives among which the decision maker has to choose. Many criticisms have been raised against these sacrificial types of stories (Bauman, McGraw, Bartels *et al.*, 2014; Rosas & Koenigs, 2014; Kahane, 2015). But to date, utilitarian and non-utilitarian (or deontological) scenarios have been almost the only available experimental stimuli used to shed light on the behavioural and neural bases of fundamental and opposing approaches to morality (Hauser, Cushman, Young *et al.*, 2007; Christensen & Gomila, 2012; Cushman & Greene, 2012). The moral dilemmas can widely differ, however they are often variations of the classical *Trolley* and *Footbridge* dilemmas, developed by Foot (1967) and Thomson (1976). In the *Trolley* dilemma, a runaway trolley is about to run over and kill five people. The only way to save the group of five is to hit a switch that will turn the trolley onto a side-track, an act that will cause the death of the one person, standing on that

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track. In the *Footbridge* dilemma, one can save the five by pushing a big man off an overpass onto the track below. This will kill the man, but also will prevent the trolley from killing five people. The outlined actions in the two dilemmas reflect *utilitarian choices* that will cause the death of only one person, preventing a greater number of victims. Refusing to hit the switch of the trolley or to push the man is defined as a *non-utilitarian* (or *deontological*) *choice,* which favours people's inviolable rights and duties independently of the choice's outcomes (Kant, 2005). Experimental evidence has shown that the majority of people considers morally acceptable to hit the switch to turn the trolley, but not to push the man to stop the trolley, even if the outcome is the same (i.e., one person is killed whereas five are saved). Thus, moral dilemmas force the decision maker to process multiple alternatives and select an optimal course of action by taking into account a system of norms and values that guides behaviour in social contexts.

The study of moral psychology can be traced back to Plato and Aristotle who brought systematic thinking to bear on this issue (Haidt, 2008). The first modern accounts emphasized the role of cognition (Kohlberg, 1963; 1984), while in the last decade research has focused on the role of emotional processing in human morality, suggesting its critical and even prominent role in shaping moral choices (Bargh & Chartrand, 1999; Pizarro, 2000). Lately, increasing evidence has shown that morality is a result of the interplay between cognitive and emotional processes (Greene & Haidt, 2002; Pizarro & Bloom, 2003; Koenigs, Young, Adolphs *et al.*, 2007; Greene, Morelli, Lowenberg *et al.*, 2008) and led to the definition of morality as an *"interlocking sets of values, practices, institutions, and evolved psychological mechanisms that work together to suppress or regulate selfishness and make social life possible"* (Haidt, 2008). Morality is by all means an extremely complex system. Indeed, researchers have to take on the task of carefully disentangling its intermingled aspects to fully uncover how moral decision-making is generated. Attempts have been made to separate stimulus- vs. individual-

related influences, to dissociate the processes guiding moral decisions (Conway & Gawronski, 2013), to define the interaction between model-based and model-free decision architecture (Cushman, Sheketoff, Wharton *et al.*, 2013; Crockett, 2014), and to examine moral judgment and moral behaviour in a social-relational context (Rai & Fiske, 2011). However, the majority of theories of morality are based on dual-process models, grounded on cognitive and emotional influences. Yet, all decisions - moral decisions included - are processed within a context and in interaction with environmental factors. Therefore, the role played by such factors is of interest for understanding how the decision is made.

In the next few pages, we try to provide a detailed overview of the current knowledge on how sensory stimuli can impact on formal thinking, behavioural consequences and neural underpinnings of morality. We make explicit reference to morality because the terms *moral judgment* and *moral decision-making* are not consistently used in the field. When participants are asked to evaluate the *appropriateness* or the *permissibility* of certain actions (Greene, Sommerville, Nystrom *et al.*, 2001; Greene, Nystrom, Engell *et al.*, 2004; Cushman, Young, & Hauser, 2006; Valdesolo & DeSteno, 2006; Moretto, Làdavas, Mattioli *et al.*, 2009; Fumagalli, Ferrucci, Mameli *et al.*, 2010; Ugazio, Lamm, & Singer, 2012; Youssef, Dookeeram, Basdeo *et al.*, 2012b; Pastötter, Gleixner, Neuhauser *et al.*, 2013), moral judgments are implied (Monin, Pizarro, & Beer, 2007). When participants are the main characters of a dilemma and, as such, they are responsible for the action chosen and for its moral consequences (Koenigs *et al.*, 2007; Waldmann & Dieterich, 2007; Starcke, Polzer, Wolf *et al.*, 2011; Sarlo, Lotto, Manfrinati *et al.*, 2012; Carmona-Perera, Martí-García, Pérez-García *et al.*, 2013; Szekely & Miu, 2014), the decision-making processes in which a moral choice directly interacts with its consequences are investigated (Tassy, Oullier, Mancini *et al.*, 2013b). Even if these terms have been used as synonyms in the past, it has recently been suggested that moral judgment and moral choice are likely related to different psychological constructs (Sood & Forehand, 2005; Tassy *et al.*,

2013b). Indeed, participants can choose actions they judge as being morally wrong (FeldmanHall, Mobbs, Evans *et al.*, 2012; Kurzban, DeScioli, & Fein, 2012; Tassy, Deruelle, Mancini *et al.*, 2013a) and the emotional investment of acting immorally is more long-lasting than that in judging someone else's immoral actions (Tassy *et al.*, 2013a; Szekely & Miu, 2014).

1.1 Theories of morality

Kohlberg and the rationalist view

The pioneering work of Kohlberg (Kohlberg, 1963) opened the scientific work on morality. Kohlberg describes morality as the primary result of intellectual deliberation (Kohlberg, 1984). His view is inspired by the Kantian philosophical thinking, arguing that emotions are antagonistic to cognitive processing, and by Piaget's theory of cognitive development (Piaget, 1932; 1997), Kohlberg's rationalist approach was supported by his observations that people were able to articulate sophisticate reasoning when asked to solve hypothetical dilemmas. Although the role of emotions was not actively denied, his rationalist account of morality considers cognition as the centre of morality (Kohlberg, 1963; Piaget, 1965; Kohlberg, 1984) and emotions as peripheral (Kohlberg, 1963; Piaget, 1965; Kohlberg, 1984). The rationalistic model has been increasingly challenged by findings in evolutionary psychology (Trivers, 1971) and primatology (Flack & de Waal, 2000) showing that each human individual possesses a set of emotions that promotes behaviours facilitating survival, such as kin altruism and cheating detection. These findings tilt the scales in favour of a major role of emotions in moral matters (Williams, 1973; Damasio, 1994; Pizarro, 2000). Indeed, this evidence moves away from conscious deliberations, namely slow cognitive process characterized by (mostly) explicit deductive and inductive reasoning (Allman, Watson, Tetreault *et al.*, 2005; Woodward & Allman, 2007), and suggests the presence of an implicit

and automatic form of cognition. Intuition - a plastic process whose logic remains below conscious awareness - requires processing information from a situation and the environment in order to produce an immediate response (Woodward & Allman, 2007). It is clear even from this brief description that intuition is implemented in situations that require immediate decisions, grounding heuristics on salient emotional information; in contrast, deliberation is used to control conscious thoughts and to overtly govern emotional excesses.

Moral intuitions as central player in moral choices

Haidt is one of the authors who strongly suggested that intuition (and its emotional triggers) play a central role in shaping morality. In his "*Social Intuitionist model*" (Haidt, 2001), in agreement with Hume's emotionalist vision rather than with Kantian rationalism, Haidt claims that moral choices are made conscious in an automatic and effortless way, as a result of moral intuitions. Reasoning does not cause moral choices, but it is generated by the necessity to justify them (Haidt, 2001; 2007). Haidt built his model based on psychological observations in which individuals automatically apply moral stereotypes to other people (Devine, 1989), and easily create reasons to justify their stereotypical judgments (Nisbett & Wilson, 1977; Kunda, 1990). Also, neuroimaging studies concur to support the involvement of affective processes in morality. In healthy volunteers, the presentation of different types of moral stimuli such as pictures (Moll, de Oliveira-Souza, & Eslinger, 2003; Harenski & Hamann, 2006), sentences – namely, short statement which participants are asked to judge as morally acceptable or not (Moll *et al.*, 2003) - or dilemmas (Heekeren, Wartenburger, Schmidt *et al.*, 2003; Heekeren, Wartenburger, Schmidt *et al.*, 2005) typically evoke significant increasing activations in brain areas associated with emotional processing, such as ventro-medial prefrontal cortex (vmPFC), posterior superior temporal sulcus (pSTS), orbitofrontal cortex (OFC), anterior/middle temporal gyrus and the posterior cingulate cortex (PCC) (Moll, de

Oliveira-Souza, Bramati *et al.*, 2002; Moll, de Oliveira-Souza, Eslinger *et al.*, 2002; Heekeren *et al.*, 2003; Heekeren *et al.*, 2005; Harenski & Hamann, 2006).

The dual-process theory

The "*dual-process theory*" represents an effort to overcome the dichotomy between cognition and emotion that characterizes the previous models (Greene *et al.*, 2001; Greene & Haidt, 2002; Greene *et al.*, 2004; Greene *et al.*, 2008; Shenhav & Greene, 2014). This model first proposed by Greene (Greene *et al.*, 2001), theorizes the presence of a complex - sometimes competitive - interplay between cognition and emotions in morality (Greene *et al.*, 2001; Greene & Haidt, 2002; Greene *et al.*, 2004; Greene *et al.*, 2008; Shenhav & Greene, 2014). Greene's view is based on the distinction between personal and impersonal dilemmas. Such a distinction is defined on the physical proximity between the agent and the produced harm (Greene *et al.*, 2001; Greene *et al.*, 2004). Greene and colleagues showed that personal moral dilemmas, during resolution, lead to the co-activation of brain regions associated with social and emotional processes (vmPFC, medial frontal gyrus, posterior cingulate gyrus, bilateral STS and amygdala). This would be in line with the idea that moral dilemmas with a personal involvement require more effort to be resolved. In contrast, impersonal dilemmas – considered easier to be solved, given the reduced physical proximity with the harm – are associated with increased activity in areas also involved in working memory tasks: dorsolateral prefrontal (dlPFC) and parietal areas (Greene *et al.*, 2001; Greene & Haidt, 2002; Greene *et al.*, 2004; Shenhav & Greene, 2014). Greene and his collaborators suggested that personal moral dilemmas, driven by automatic emotional responses, usually lead to deontological choices (e.g., disapproving of killing one person to save more lives), while impersonal moral dilemmas, driven by controlled cognitive processes, more often give rise to

utilitarian choices (e.g., approving of killing one person to save more lives (Greene *et al.*, 2001; Greene & Haidt, 2002; Greene *et al.*, 2004; Greene *et al.*, 2008; Paxton & Greene, 2010).

Support to the competitive interplay between cognition and emotion in morality also comes from independent neuropsychological studies including patients with emotional deficits. For instance, patients with lesion in vmPFC (Ciaramelli, Muccioli, Làdavas *et al.*, 2007; Koenigs *et al.*, 2007; Moretto *et al.*, 2009; Thomas, Croft, & Tranel, 2011) or with frontotemporal lobar degeneration (Mendez, Anderson, & Shapira, 2005) presented with moral dilemmas make significantly more utilitarian choices as compared to healthy controls (Anderson, Bechara, Damasio *et al.*, 1999; Mendez *et al.*, 2005; Ciaramelli *et al.*, 2007; Koenigs *et al.*, 2007; Moretto *et al.*, 2009; Young, Bechara, Tranel *et al.*, 2010; Thomas *et al.*, 2011). This evidence suggests that they are less prone to be conditioned by the emotional consequences of an utilitarian act. In other words, these patients seem to lack of empathic insight. This has been confirmed by a series of studies investigating the influence of empathy disposition and its emotional reactions in moral choices (Pizarro, 2000; Decety & Cowell, 2014; Patil & Silani, 2014b; Sarlo, Lotto, Rumiati *et al.*, 2014). These studies suggest that reduced emotional aversive experiences revealed when processing moral dilemmas are due to an impaired empathic response towards the victim. For instance, an increased utilitarian choice in personal dilemmas is linked to the inability to fully experience affective empathy (Choe & Min, 2011; Gleichgerrcht & Young, 2013; Patil & Silani, 2014b; Sarlo *et al.*, 2014). Along the same lines, Crockett, Clark, Hauser *et al.* (2010) showed that enhancing serotonin function in healthy volunteers reduced utilitarian choices in personal moral dilemmas: moreover this effect is stronger in participants high in trait empathy, indicating that empathy is heavily involved in modulating moral choices. Altogether, this evidence seems to suggests that the less the participants are prone to experience (or understand) unpleasant emotions related to the action of killing one person to save many, the more utilitarian moral choices they make. To

further explore this aspect, the ability of participants with psychopathy tendency to process moral dilemmas has been evaluated, confirming the widespread use of utilitarian strategies (Glenn, Koleva, Iyer *et al.*, 2010; Langdon & Delmas, 2012; Young, Koenigs, Kruepke *et al.*, 2012; Gao & Tang, 2013; Tassy *et al.*, 2013a). This particular response pattern has been explained with psychopaths being unable to understand the victims' emotional experience of the harm, and it confirms a general lack of emphatic involvement when making utilitarian moral choices (Young *et al.*, 2012).

In other studies, the experimental manipulations aimed to limit cognitive ability in healthy participants, therefore emphasizing the contribution of emotional processes in moral choices. This manipulation, which has been found to increase deontological responses, occurred by directly increasing the cognitive load of the participants (Greene *et al.*, 2008) or by reducing the time available to respond (Suter & Hertwig, 2011). Moreover, individual differences in executive control influence moral choices. Indeed, individuals with weak attentional control displayed stronger disgust responses and more severe moral choices (Van Dillen, van der Wal, & van den Bos, 2012). Likewise, individuals with greater working memory capacity found more appropriate personal dilemmas than people with reduced working memory capacity (Moore, Clark, & Kane, 2008). Moreover, the better the participants were using reappraisal strategies (an emotion-regulation strategy of attaching a positive meaning to negative events), the fewer deontological choices they made (Feinberg, Willer, Antonenko *et al.*, 2012; Szekely & Miu, 2014).

Besides the personal-impersonal distinction, it has been theorized that the intention with which a moral choice is made modulates the cognitive-emotional balance (Royzman & Baron, 2002; Hauser *et al.*, 2007; Sarlo *et al.*, 2012). According to the *principle of double effect*, it is acceptable to harm someone for the greater good only if the harm comes as a side effect of the action (Aquinas, 1947; 1965; Foot, 1967; Thomson, 1976; Fischer & Ravizza, 1992; Kamm,

1998). When moral dilemmas are such that the willingness to harm could be prevented, causing harm was found less morally acceptable than when such harm was an unforeseen consequence. Participants made a higher proportion of utilitarian choices in response to dilemmas in which the harm is a side-effect (accidental dilemmas) compared to dilemmas in which the harm is deliberate and used instrumentally (instrumental dilemmas; Royzman & Baron, 2002; Borg, Hynes, Van Horn *et al.*, 2006; Cushman *et al.*, 2006; Hauser *et al.*, 2007; Moore *et al.*, 2008; Greene, Cushman, Stewart *et al.*, 2009; Sarlo *et al.*, 2012; Cushman, 2014; but see Waldmann & Dieterich, 2007 for a negative result).

The progressive extension of the dual-system theories has also been supported by novel imaging findings, which have unveiled cortico-subcortical networks - including vmPFC, dlPFC, ACC, STS, TPJ, insula and amygdala, among others - shaping normal and abnormal cognitive and emotional modulations of moral decisions (see Table 1.1).

Table 1.1 Schematic overview of the possible brain structures involved in the processing of moral information [see (Fumagalli & Priori, 2012) for a more detailed overview]. vmPFC = *ventromedial prefrontal cortex; dlPFC = dorsolateral prefrontal cortex; ACC = anterior cingulate cortex; STS = superior temporal sulcus.*

Brain area	**Brain structure**	**Hypothesised Function**
Frontal	vmPFC	Emotional processing
	dlPFC	Cognitive control, problem solving
	ACC	Mediating the conflict between emotional and rational components
Parietal	Inferior and superior parietal lobe	Cognitive control, working memory
Temporal	STS	Emotion and social cognition
	Temporo-parietal junction	Moral intuition
Subcortical structures	Amygdala	Emotion processing, affective judgment
	Insula	Emotion processing, perception of inequity

Beyond cognition and emotion: model-based approaches and social-bounded moral decision making

Even though dual-system theories have been widely used to explain moral processes, they have recently raised some criticisms, mainly that the division between cognition and emotion is not as strict as dual-system theories suggest, particularly in light of lack in the computational power to explain how hypothetical scenarios are transformed from mental products to concrete outcomes (McGuire, Langdon, Coltheart *et al.*, 2009; Baron, Gürçay, Moore *et al.*, 2012; Kahane, Wiech, Shackel *et al.*, 2012; Moll, Oliveira-Souza, & Zahn, 2008; Kvaran & Sanfey, 2010; Nucci & Gingo, 2010; Crockett, 2013; Cushman, 2013).

To solve this issue, recent advances in neuroscience offer the opportunity to approach

moral decision-making from a perspective centered on value: on the one hand model-free learning assigns value to actions (based on previously encountered situations involving similar features), whereas model-based learning assigns value to the outcome, based on the evaluation of the action-outcome contingencies (Crockett, 2013; Cushman, 2013). Taking the perspective of the *Footbridge* dilemma, model-free learning assigns negative value to the representation of pushing someone off the bridge, leading to deontological decisions, while model-based learning assigns greater positive value to the final result (saving five people), thus leading to utilitarian decisions.

To part from a strict neurobiological view, Rai and Fiske (2011) highlight the importance of considering actions and outcomes in the context of specific social relationships. The *Relationship Regulation Theory* (RR) stresses the role of *motives* in guiding moral decisions within specific social relationships. For instance, Unity is the motive to support and care for the integrity of our own group and to provide aid and protection to the other members. The other motives identified by (Rai & Fiske, 2011) are hierarchy, equality proportionality.

Therefore, a moral transgression is defined as the failing to behave in accordance with relational prescriptions (Rai & Fiske, 2011), meaning that any action - including violence and impure acts - can be perceived as morally right depending on the social relationships in which is realized (Rai & Fiske, 2011). This theory helps also to clarify moral disagreements that cannot be simply related to different knowledge or logical reasoning. Indeed, RR proposes that moral disagreements result from different relational models applied to the same situation or from situations in which the appropriate moral motive is ambiguous (Rai & Fiske, 2011).

A similar view has been proposed also by Bussani and Infantino (2015). Indeed, they

suggested the interplay between tort law and legal cultures as an argument to better understand the variability in moral decisions. Tort law is a branch of private law whose mix of rules, institutions and procedures aims at addressing risk and assignments of responsibilities and to shift the costs of accidents from the victim to a different subject (Bussani & Infantino, 2015). In their broad comparative analysis of Western and non-Western legal traditions, Bussani and Infantino (2015) argued that tort law is at the same time the parent and the child of a given cultural and societal setting, and lives outside as much as inside the courtrooms. In a continuous and dynamic process, tort notions, ideas and perceptions exert an influence as well as they are influenced by the very cultural and societal settings in which they are embedded. While in Western tort low cultures money can replace persons, losses and pain, elsewhere, money cannot be used as a depersonalized toll for bad behaviours. The arguments put forward by Bussani and Infantino (2015) suggest that moral decisions could likewise be influenced by different cultural frameworks.

As evident from this non-exhaustive analysis, the role of sensory stimuli has been rather neglected in the context of moral decision-making, both in reference to dual-system theories, as well as model-based and socially-grounded approaches. Nevertheless, perceptual information is invariantly at the basis of all these explanations. In the next paragraphs we will argue why sensory information is critical for such decisions to be made.

1.2 Sensory information: a neglected actor in morality

So far moral decisions have been studied as if they were made in the vacuum, irrespective of the immersive experience produced by contextual sensory stimuli. However, we do know from personal experience as well as from the neuroscientific literature that we

live in a world to which all sensory modalities critically contribute. In the next sections we will address how moral choice and, in particular, moral decision-making results from the interaction of cognition, emotion and sensory information.

The foundation of moral decision-making in the sensory experience

Imagine you have really found that thick wallet we previously mentioned in the street. Are you going to give the wallet to the police, even if you desperately need money? Based on what we know about the role played by cognition and emotion in moral decision-making, we might predict that cognition would urge you to give the money back, because according to moral norms keeping something that is not yours is wrong. However, as you are also aware that nobody knows that the wallet does not belong to you, you could keep the money and use it for personal purposes. Emotion can tilt your choice towards the first or the second solution: you may feel disgusted and guilty at the idea of keeping the money; or you may feel angry at the idea of how unfair it would be to give the money back, since you too, are in need of that money. Now, imagine this scenario embedded in two real-life environments. In the first scenario, you are making your choice in a hot and sunny day, at the corner of a crossroad congested in traffic, in a street full of sweaty people and pungent odours coming from the surrounding food trucks. In the second scenario, you are walking by the beach in a breezy day, with people emanating the typical beach-sunscreen smell, the ice cream truck serving refreshing sorbets, and a nice music played in the background. Do you think your choice will be maintained across scenarios? Might the chaotic urban environment make you feel more disgusted, angry and thus facilitate a utilitarian drive to keep the wallet for yourself, whereas the relaxing beach environment may unbalance your choice towards a deontological approach? Or, might the relaxing beach environment give you more time to think as compared

to the urban environment, prompting a calmer and reasoned approach so that you will eventually select the utilitarian option?

An attempt to simulate ecological situations in the laboratory has been pursued using virtual reality, with participants making their moral decision, independently of sensory confounds (Navarrete, McDonald, Mott *et al.*, 2012; Patil, Cogoni, Zangrando *et al.*, 2014). In one study, participants were presented with a moral dilemma in a virtual reality environment or via a text format (Patil *et al.*, 2014). When in the virtual reality environment participants made more utilitarian choices as compared to when the same dilemmas were presented in textual form. This finding points out that perceptual information can strongly modulate the way we think and experience emotions, and subsequently change our decisions and behaviour. The complex interaction between the perception of stimuli, emotional and cognitive states has been widely investigated, as it will become apparent in the next paragraph.

With respect to emotions, humans are able to identify the affective relevance of stimuli, which, as showed by Phillips, Drevets, Rauch *et al.* (2003), produces and regulates stimulus-dependent affective states and behaviours. Interestingly, a recent theoretical model casts new light on the role of sensory information on emotional states and the resulting behavioural changes (Li, 2014). This model puts forward the idea that fear responses, classically dependent on the neural involvement of the amygdala, can bypass this key structure and independently elicit threat representations (and subsequent reactions) only on the basis of sensory stimuli, in particular odours (Li, 2014).

Sensory stimuli can modulate the availability of cognitive resources. In this perspective, odours have been shown to facilitate action planning and execution possibly through the reactivation of the action system (Parma, Zanatto, & Castiello, 2013), especially in the social context (Parma, Bulgheroni, Tirindelli *et al.*, 2013), to influence the memory for an

event (Bensafi, Brown, Khan *et al.*, 2004), or to interfere with language processing (Lorig, 1999; Herz, 2000).

Furthermore, odours are particularly interesting for morality issues for at least two reasons. First, as their perception usually goes unnoticed, they can be good experimental tools to investigate subliminal information processing. Second, they have been shown to impact on a series of decision-making tasks, covering a wide range of situations. There are several experimental studies showing that odours can influence unrelated choices. For instance, a disgusting ambient odour increases acceptance rate in the Ultimatum Game (Bonini, Hadjichristidis, Mazzocco *et al.*, 2011) - a game measuring cooperation among agents - or it reduces the level of participants' performance in the Iowa Gambling Task (Overman, Boettcher, Watterson *et al.*, 2011), a proxy for risk preferences. For the latter study, the authors suggested that an increment in cooperation and a reduction in risk-taking behaviours is underlined at a neural level by the involvement of the medial orbital PFC, an area favouring affective responses (Overman *et al.*, 2011). When similar laboratory tasks have been applied to real world situations, ambient odours have been found to affect consumers' behaviour. For example, the exposure to positive scents in a mall increases shoppers' spending (Chebat & Michon, 2003).

The effects of olfactory-driven decision-making go beyond the contexts involving inanimate object to reach the social world. For instance, the presentation of unpleasant odours, even if not consciously noticeable, reduced the pleasantness of face image compared to when the same faces were experienced under the exposure of neutral and pleasant odours (Li, Moallem, Paller *et al.*, 2007). More central to the study of morality, Inbar, Pizarro and Bloom (2012) reported that participants exposed to a disgusting odour evaluated gay men more negatively than those who were not exposed to such odour. Indeed, the importance of the olfactory modulation in decision-making processes related to morality clashes with the

fact that the contribution of sensory stimuli in shaping moral processes has been systematically overlooked. The only exception, as reviewed below, is constituted by the olfactory counterpart of disgust.

Odour-induced disgust and morality

The majority of the studies in which sensory information has been used to manipulate individuals' cognitive and affective state focused on the induction of disgust; instead, only a handful of studies used sensory stimuli to induce a positive mood (Valdesolo & DeSteno, 2006; Eskine, Kacinik, & Prinz, 2011; Pastötter *et al.*, 2013) or virtual reality to reproduce a life-threatening situation (Navarrete *et al.*, 2012; Patil *et al.*, 2014; Zanon, Novembre, Zangrando *et al.*, 2014). Disgust has been defined as an aversive state that motivates withdrawal from offensive substances such as animal products and certain foods (Rozin & Fallon, 1987). It originates from the innate rejection of bitter substances in the mouth that is present from birth, and has equivalents in other mammals (Rozin, Haidt, & McCauley, 2008; Rozin, Haidt, & Fincher, 2009). According to this view the emotion of disgust, often accompanied by a sense of nausea, has the main function to prevent the spread of illness, disease and infection, and the items that fall into this category are mostly body-waste products, animals, part of animals, and animal products (Rozin *et al.*, 2008).

It has been theorized that disgust might be relevant to morality (Rozin, Lowery, Imada *et al.*, 1999; Chapman, Kim, Susskind *et al.*, 2009; Pizarro, Inbar, & Helion, 2011; Chapman & Anderson, 2013). Indeed, disgust can be elicited by moral transgressions and it seems to increase the negativity of moral choices (Pizarro *et al.*, 2011). In particular, it has been shown that when disgust is manipulated in an emotion induction paradigm, the subjective experience of the physiological disgust amplifies moral choices. Landy and Goodwin (2015a) recently produced a meta-analysis that examined published and unpublished studies in which

incidental disgust was induced in participants before they made moral choices. Disgust has often been induced through the visual modality (Schnall, Haidt, Clore *et al.*, 2008; Horberg, Oveis, Keltner *et al.*, 2009; Harlé & Sanfey, 2010; Moretti & Di Pellegrino, 2010; Case, Oaten, & Stevenson, 2012; Ugazio *et al.*, 2012; Cameron, Payne, & Doris, 2013; Cheng, Ottati, & Price, 2013; Johnson, Cheung, & Donnellan, 2014; Ong, O'Dhaniel, Kwok *et al.*, 2014; Landy & Goodwin, 2015a) such as via movie clips, pictures or facial expressions. Moreover, auditory stimuli (Seidel & Prinz, 2013) as well as chemosensory stimuli evoking disgust have been used to judge the appropriateness of moral vignettes (Schnall *et al.*, 2008; Eskine *et al.*, 2011; Ugazio *et al.*, 2012 see Landy & Goodwin, 2015a for the unpublished studies). In Schnall *et al.* (2008) and Ugazio *et al.* (2012) a disgusting odour - a commercially available "fart spray" applied to a trash bag - was used as a method to prime disgust in participants. In particular, in the former study (Schnall *et al.*, 2008) the authors exposed participants to the disgusting odour while they rated four vignettes related to moral judgment. Participants were randomly assigned to one of three olfactory conditions (no fart spray vs. four vs. eight sprays applied) and, after task completion, they were asked to rate how disgusted they currently felt and whether they were consciously aware of the unpleasant odour. The authors found that participants in the strong odour condition felt significantly more disgusted than those in the other two conditions. As a consequence, the disgust experienced as being due to the olfactory exposure increased the severity of the moral judgment (Schnall *et al.*, 2008). Ugazio *et al.* (2012) used the same procedure as in Schnall *et al.* (2008) but with less intense odour stimulation (only 2 sprays applied and also induce disgust by means of video clips, and another negative emotion (i.e., anger) via negative feedback. After mood induction participants were asked to judge the permissibility of some moral scenarios. The induction of anger and disgust respectively increased and decreased the permissibility in personal and impersonal moral scenarios. In other words, these findings suggest that emotions can play an

important role in moral decision-making, but that the type of emotion induced is also relevant. Moreover, Eskine *et al.* (2011) investigated the effect of sweet beverage, bitter beverage, or water on moral judgment and found that disgust induced by bitter beverages led to more strict moral judgments (Eskine *et al.*, 2011).

This evidence, that was also entered meta-analysis by Landy and Goodwin (2015a) revealed that chemosensory induction of disgust (gustatory and olfactory) produced a stronger amplification effect (d = .37) in moral choice than visual induction (d = .13) and than the total amplification effect without considering the moderators (d = .11), even though the number of studies with visual induction is disproportionately bigger than the number of studies including chemosensory stimuli. The small effect of incidental disgust has been taken by the authors as prove against the casual role of affect in morality. Some criticisms have been raised against this conclusion: the authors did not include personality variables as moderators; they minimized the importance of the relatively large effect for incidental chemosensory disgust; and they included studies in which participants attribute the disgust feeling to its true source (Schnall, Haidt, Clore *et al.*, 2015 see Landy & Goodwin, 2015b for the reply of the authors).

Nevertheless, we think that these findings suggest two insights: i) chemosensory stimuli (and in particular olfactory stimuli) may preferentially impact on morality based on the activation of behavioural immune strategies (Terrizzi, Shook, & McDaniel, 2013; Tybur, Lieberman, Kurzban *et al.*, 2013); ii) disgust may not be the only trigger explaining this effect. In the next section we will examine in depth these aspects.

1.3 Are odours special for morality?

Chemosensory signals, and in particular olfactory stimulations, are able to influence morality, both overtly and covertly. As highlighted by Landy and Goodwin (2015a),

olfactory influences on morality are even greater than those mediated by vision, the sense we consider to be mostly reliant on. But, how do olfactory stimuli come to exert greater implicit impact as compared with stimuli presented in other modalities?

Noteworthy is the ability of odours to automatically induce mood changes. Indeed, olfactory stimuli have been variously used to induce language-free valence effects (Ehrlichman & Halpern, 1988; Schiffman, Suggs, & Sattely-Miller, 1995; Bensafi *et al.*, 2004; Herz, Eliassen, Beland *et al.*, 2004; Li *et al.*, 2007; Seubert, Rea, Loughead *et al.*, 2009; Seubert, Kellermann, Loughead *et al.*, 2010; Seubert, Gregory, Chamberland *et al.*, 2014). In light of this, it is not surprising that depressed patients tend to enjoy less chemosensory stimuli, and that anosmic individuals claim that their quality of life is reduced (Hummel & Nordin, 2005). This automatic affective induction has been related to the unique features of the olfactory system, which is anatomically connected to the limbic system involved in memory and affective and memory information processing (Ferry, Ferreira, Traissard *et al.*, 2006; Paulus & Stein, 2006; Soudry, Lemogne, Malinvaud *et al.*, 2011; Kadohisa, 2013). Furthermore, the amygdala - a primary olfactory cortex - in connection with the orbitofrontal cortex - a secondary olfactory cortex is a key constituent of the neural system sub-serving decision-making (Bechara, Damasio, & Damasio, 2000), whose role consist in integrating of cognitive, emotional as well as olfactory information (Bechara *et al.*, 2000). See Figure 1.1.

This preferred access to the limbic areas of the brain seems to suggest that an odour experienced while making a moral decision differentially impacts on the moral decision. As an example, the olfactory information can contribute to the emotional connotation of the moral dilemma. Making a moral decision exposed to negative odours could increase the participants' distress and increase the possibility of a less rationally bounded (non-utilitarian) decision.

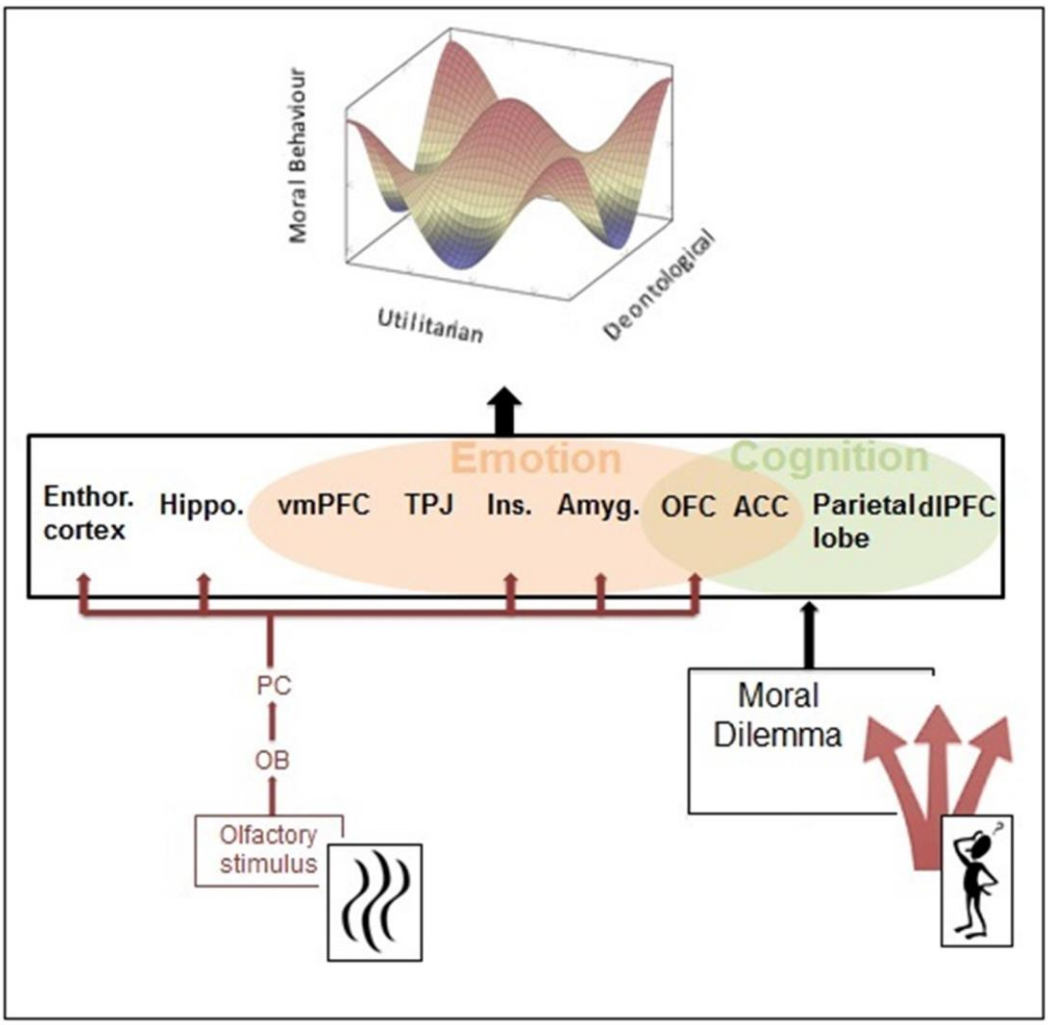

Figure 1.1 *Integration of olfactory sensory information with moral information processing. When an odour is co-experienced while making a moral decision different effects might occur on the neural network involved in morality. The olfactory information that is processed in the piriform cortex is projected to the orbitofrontal cortex, amygdala, hypothalamus, insula, entorhinal cortex and hippocampus. As shown by the red circle, there is an overlap between these areas involved in the olfactory stimuli processing and the area involved in moral choice making. The olfactory information can contribute to the emotional connotation of the moral dilemma but this information, when cognitively processed at the level of the orbitofrontal cortex, could also affect moral decision-making through multisensory integration. Entor. Cortex = entorhinal cortex; Hippo. = hippocampus; vmPFC = ventromedial prefrontal cortex; TPJ = temporo parietal-junction; Ins. = Insula; Amyg. = Amygdala; OFC = Orbitofrontal cortex; ACC = anterior cingulate cortex; dlPFC = dorsolateral prefrontal cortex; PC = piriform cortex; OB = olfactory bulb.*

On the contrary, a positive olfactory stimulus could reduce the aversive effect of the utilitarian option in favour of a calmer and reasoned approach, leading participants to make the utilitarian decision. However, we know that olfactory information is not only related to the valence of one odour. Odour can bring important information regarding the environment, and this information is cognitively processed also at the level of the orbitofrontal cortex and could affect moral decision-making through multisensory integration. In the next session we will provide an overview of the most important types of information that can be conveyed via odours, and we will attempt to explain how these events can affect moral decision-making.

1.4 Olfactory effects on morality beyond disgust

We have already discussed how odours can trigger disgust and motivate withdrawal reactions (e.g., nausea, nose wrinkle, tongue extension and the upper lip retraction) to prevent contamination (Stevenson, 2010), but the effects of threat detection from odours have not been considered yet. Our understanding of how threat signals affect morality is still incomplete in many ways, and we recognize that, as a result of these knowledge's gaps, some of the arguments we will make in the next section are speculative. Nonetheless, it is our hope that this review will sparkle the interest to further characterize how the human brain processes threat odour signals in relation of morality, and will stimulate future discussions and research.

Even though humans do not show an overt ability to "smell danger", as animals do with predators' odours for example (Staples, Hunt, Cornish *et al.*, 2005; Staples, McGregor, Apfelbach *et al.*, 2008), we are able to learn the association of odours with dangerous signals, such as the smell of smoke or hazardous gas. In some cases, the detection of these odorous signals is so important that the loss of the sense of smell could result in accidents or even

death. Olfactory aversive learning involves the amygdala (Zald & Pardo, 1997), can induce cortical plasticity by intensifying the afferents of this structure to the sensory cortex (Krusemark, Novak, Gitelman *et al.*, 2013), and may be so pervasive that, for example, even only one night of olfactory aversive exposure can significantly reduce a recurring behaviour such as cigarette smoking (Arzi, Holtzman, Samnon *et al.*, 2014). Therefore, which might be the influence of these signals on the neural activity of people, such as firemen, who have to make critical decisions? We can hypothesise that in a critical situation the aversive olfactory stimulation can elicit threat responses through the amygdala and that such information will be integrated by the vmPFC into a utilitarian assessment (Shenhav & Greene, 2014). As shown by Zanon *et al.*, (2014) in their experiment of simulated life-threatening situations, the effect of threat stimuli would be probably more related with the possible costs of either an utilitarian or a deontological action for the decision-makers.

Threat can also be extended to situations in which the danger is represented by a person or by socially relevant stimuli. Human chemosignals belong to this kind of stimuli; they are complex mixture of molecules, produced by the human body, which can be characterized by odorous substances and contain socially relevant information (Wyatt, 2014). Most of the body fluids produced by the human body carry some sort of social chemosignals but the majority of studies on human body odours have used sweat. Human chemosignals are known to carry different types of social information (e.g., age, gender, health status, sexual availability and personal predisposition (Parma, Gordon, Cecchetto *et al.*, In press) the most important of which for moral decision-making is regarding individuals' identities and emotions.

Humans are able to discriminate among their own body odour, the odour of a kin or a stranger's odour (Lundström, Boyle, Zatorre *et al.*, 2009). In particular, the body odour originated from an unknown person seems to carry a threatening message (Lundström *et al.*,

2009) and evokes cortical activations (i.e., inferior frontal gyrus and amygdala) similar to those described in response to viewing negative stimuli, including masked fearful faces (Whalen, Rauch, Etcoff *et al.*, 1998). Besides the activations of the amygdala and inferior frontal gyrus, strangers' body odours elicit also insula activations (suggesting the involvement of fear and disgust emotions), and activations in the supplementary motor area and premotor area, suggesting participants' motor preparation for some fight or flight responses (Lundström *et al.*, 2009). Compared to those elicited by common odours, the possible effects that strangers' body odours can have on moral decision-making are far more puzzling to identify. Tentatively, we make two alternative hypotheses. First, disgust and fear evoked by these stimuli could intensify the aversive emotions for harmful utilitarian actions thus leading to more deontological responses. First, disgust and fear evoked by these stimuli could intensify the aversive emotions for harmful utilitarian actions thus leading to more deontological responses. Second, the presence of the *social information* could evoke a utilitarian action because participants would try to save the maximum number of individuals. The choice would be far more difficult and painful if made in the presence of kin's body odour.

So far, it has been demonstrated that olfactory-mediated threat detection is related to emotional contagion. There is evidence showing that humans, as well as animals, seem to be able to detect chemosensory anxiety signals conveyed by the sweat of conspecific (Pause, Ohrt, Prehn *et al.*, 2004; Chen, Katdare, & Lucas, 2006; Pause, Adolph, Prehn-Kristensen *et al.*, 2009; Prehn-Kristensen, Wiesner, Bergmann *et al.*, 2009a; Zhou & Chen, 2009; Haegler, Zernecke, Kleemann *et al.*, 2010; Zernecke, Kleemann, Haegler *et al.*, 2010; Albrecht, Demmel, Schöpf *et al.*, 2011). Perceiving anxiety generates various effects. Participants, when exposed to sweat donated by fearful or anxious people, reported an increased state of their own anxiety (Albrecht *et al.*, 2011), performed more accurately on a word-association task (Chen *et al.*, 2006) and on an identification of fearful faces embedded in ambiguous stimuli (Zhou &

Chen, 2009); moreover their startle blink amplitude increases (Prehn, Ohrt, Sojka *et al.*, 2006; Pause *et al.*, 2009), as well as their risk-taking behaviour in computerized decision-making task (Haegler *et al.*, 2010). Interestingly, chemosensory anxiety signals are processed in brain areas involved in the regulation of fear and threat detection (amygdala; Mujica-Parodi, Strey, Frederick *et al.*, 2009) empathy (insula, pre-cuneus, cingulate cortex; Prehn-Kristensen, Wiesner, Bergmann *et al.*, 2009b) as well as in areas involved in the processing of social anxiety signals (fusiform gyrus; Prehn-Kristensen *et al.*, 2009b). It has been theorized that the transmission effects from sender to receiver via chemosignals could involve emotional contagion, a basic mechanism promoting coordinated thoughts and actions, mutual understanding, and interpersonal closeness (Hatfield, Cacioppo, & Rapson, 1994; Keltner & Kring, 1998). However, as demonstrated in other types of social interactions (Sartori, Betti, & Castiello, 2013), complementary states could also be triggered by chemosensory signals. For instance, emotional complementarity occurs when one person's emotions evoke different (yet corresponding) emotions in others (Mutic, Parma, Brünner *et al.*, 2015). These two mechanisms can be extended to morality. First, the chemosensory anxiety signal could affect moral decision-making by increasing the level of anxiety as it has been demonstrated that anxiety can surge utilitarian responses in participants who were presented to personal moral decision-making (Youssef, Dookeeram, Basdeo *et al.*, 2012a). Second, they might increase empathy response for the victim, by activating the brain areas involved in the regulation of empathy, and as such they might reduce utilitarian responses, as theorised by recent studies (Pizarro, 2000; Crockett *et al.*, 2010; Choe & Min, 2011; Gleichgerrcht & Young, 2013; Patil & Silani, 2014b; Sarlo *et al.*, 2014).

1.5 Aim of the thesis

In the previous paragraphs we made an attempt to integrate the evidence suggesting that the sensory systems, and olfaction in particular, are involved in moral decision-making, with the extant models of emotion, cognition and social interactions.

So far, olfactory stimuli have been used to induce disgust in participants before they made a moral choice, in this account the chemosensory modality has shown to be the one with the largest influence on morality. We argued that this effect it is not only related to the ability of the odour to modulate mood changes but it is related with the unique characteristics of this kind of stimuli, their capacity of exerting effects even when they are not consciously perceived, their importance in social communication, and the special neuroanatomical interplay between olfactory and limbic systems. We believe that the importance of olfactory stimuli in morality goes beyond disgust: indeed, they can convey threat information and produce emotional contagion through chemosensory signals, both of these effects relevant in ambiguous and stressful scenarios.

In light of the revised evidence, the present thesis was designed to further examine the several ways in which olfactory perception can impact on moral decision-making, in particular its covert effects.

However, the effect of olfactory stimuli on moral choices is hard to investigate due to many contextual factors that may highly influence the phenomenon. Contextual effects might rise up in the form of perceptual variability, individual features and cultural differences. Indeed, beyond the huge number of odorant receptor that human have (approximately 400; Keller, Zhuang, Chi *et al.*, 2007), each individual presents a unique set of genetic variations that leads to differences in how humans perceive the same odours (Keller *et al.*, 2007; Mainland, Keller, Li *et al.*, 2014). This perceptual variability interacts with the individual differences in variables that might influence moral choices (such working memory, executive

controls, emotion control strategies, disgust sensitivity and etc…). The whole picture is made even more complicated by cultural variability.

The first step (**Chapter 2**) for accounting for the many contextual factors that might influence moral decisions was to create a set of stimuli in Italian language that included all the four conceptual factors proposed by previous literature (Christensen, Flexas, Calabrese *et al.*, 2014). Starting from the English version of Christensen's dilemmas (Christensen, Flexas, Calabrese *et al.*, 2014), dilemmas were revised, by keeping also in mind the guidelines proposed by Lotto *et al.* (2014), and translated in Italian following a process of back translation and then cross culturally tested the English and Italian versions for language and reliability with native English speakers and Italian native speakers. Moreover, normative data were collected for arousal, familiarity, valence and rate of utilitarian responses for the translated set of moral dilemmas in Italian.

It has been shown that beside the social-relationship context, even individual differences in psychological traits could affect moral decisions. Researchers have focused on the people's abilities to pay attention, discriminate, and regulate their own emotions, and to understand other people's emotions and be empathic to them (Choe & Min, 2011; Koven, 2011; Gleichgerrcht & Young, 2013; Patil & Silani, 2014b; 2014a; Sarlo *et al.*, 2014; Szekely & Miu, 2014; Brewer, Marsh, Catmur *et al.*, 2015; Gleichgerrcht, Tomashitis, & Sinay, 2015). However, most of these studies have evaluated only moral judgment despite the fact that emotional involvement seems to be higher in moral decision tasks compared to moral judgment tasks (Tassy *et al.*, 2013a; Szekely & Miu, 2014). Moreover, there is still no consensus about the effects of alexithymia, a psychological trait that describes individuals who have difficulties in identifying and describing emotions (Sifneos, 1973; Larsen, Brand, Bermond *et al.*, 2003; Bermond, Vorst, & Moormann, 2006), on moral choices (Koven, 2011; Patil & Silani, 2014a; 2014b; Brewer *et al.*, 2015; Gleichgerrcht *et al.*, 2015; Patil, Melsbach,

Hennig-Fast *et al.*, 2016). **Chapter 3** was designed to fill this gap and to explore the influence of empathy and alexithymia on participants' emotional reactions with both explicit (arousal and valence ratings) and implicit measures (skin conductance response and instantaneous heart rate).

Chapters 4-5 were dedicated on examining the several ways in which perception can impact on moral decision-making, in particular its covert effects. Among sensory information, I focused on olfactory stimuli because they are the best for studying perception, emotions and moral decision-making. In particular, **Chapter 4** was devoted to find the best olfactory stimuli for studying how odours could modulate moral choices. Indeed, previous studies (Schnall et al., 2008; Ugazio et al., 2012) have tested only the effect of negative odours on moral judgment. Moreover, their results are not consistent perhaps because of the limited control shown on possible confounding variables. Therefore, in a series of three pilot studies, I tested whether the intensity of olfactory stimuli might bias moral decision-making, at the behavioural and psychophysiological level and whether and how odour valence (unpleasant and pleasant odours) affects moral decisions.

Finally, in **Chapter 5** I directed my attention on exploring whether social information might affect moral behaviour. As humans we live everyday in environments rich in social cues. In this social context, human body odours are extremely important messengers for socially relevant information (Wyatt, 2014). To shed light on the possible effects of humans body odours on moral decisions, we designed two experiments, a behavioural experiment (experiment I) and a combined fMRI (functional magnetic resonance imaging) experiment (experiment II) with two independent samples of volunteers. In both experiments, I applied a behavioural paradigm in which participants were asked to perform a moral decision-making while they were exposed to an affectively neutral odour or to a body odour concealed by the same neutral odour. In the second experiment, beside the tentative to replicate the findings of

experiment I, I additionally investigated the neural mechanisms that might mediate the body odour modulation of moral behaviour.

The results obtained in these experiments have been discussed in **Chapter 6 (General Discussion)** in light of the current theory on morality in order to make an effort in explaining whether and how contextual sensory stimuli, with a special consideration for olfactory stimuli, are able to influence moral behaviour.

CHAPTER 2

Promoting cross-culture research on moral decision-making through the use of standardized, culturally-equivalent dilemmas: the validation of the 4CONFiDe set

Abstract

Moral dilemmas have become a common tool in moral decision-making research. Here, we aimed at extending and adapting previous moral dilemma sets to create a comprehensive moral set called 4CONFiDe (4 Conceptual Factors Dilemmas). To evaluate cultural effects, English and Italian versions of the 4CONFiDe were evaluated by English-native speakers proficient in Italian, and Italian-native speakers proficient in English (Study 1). Linear mixed models showed that moral choices were made irrespective of participants' native language and dilemmas version, suggesting that the translation was culturally-representative. In Study 2 Italian-native speakers (N=112) rated arousal, valence and familiarity levels experienced with each dilemma to assess the contribution of the four conceptual factors used by Christensen *et al*. LMM results confirmed arousal, pleasantness, familiarity and moral choice were determined by Personal Force, Intentionality and

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Evitability. Promoting the use of standardized, culturally-equivalent moral sets allows researchers to further develop the field in a unified manner.

2.1 Introduction

Research on moral decision-making is flourishing in cognitive psychology and neuroscience and moral dilemmas have become a standard methodology characterizing the research on this topic (Christensen & Gomila, 2012). Moral dilemmas are hypothetical short stories that offer two morally conflicting alternatives among which a decision maker is expected to choose. Often the dilemmas are variations of the classical *Trolley* dilemma, developed by Foot (1967), in which a runaway trolley is about to run over five people and kill them. Such negative consequence can be prevented by switching a lever which will turn the trolley onto a sidetrack: in this event, the trolley will run over one person and kill her. Presented with this dilemma, most people would decide to redirect the trolley to save the highest number of people. As explained in the previous Chapter, this choice is considered *utilitarian* because, even though the action chosen will cause the death of one person, it will prevent a greater number of victims. Another classical variation of the Trolley dilemma is the *Footbridge* dilemma (Thomson, 1976), in which a runaway trolley is about to run over five people and kill them. In this case, pushing a man over a bridge can prevent the trolley to run over the five people. Very few people would decide to push the big man letting the trolley kill the five. This choice is considered *deontological* as it does not imply to end a life, irrespective of the choice's outcome (Kant, 2005).

Criticisms have been raised against these sacrificial types of stories because they are considered unrealistic and unrepresentative of the moral situations people can face (Bauman *et al.*, 2014; Kahane, 2015; Kahane, Everett, Earp *et al.*, 2015). Even though we recognize that sacrificial moral dilemmas present some limitations, however we consider moral dilemmas a useful and legitimate experimental method to shed light on the psychological and neural processes underlying moral decision-making. Indeed, rather than being unrealistic *per se*, the majority of moral dilemmas used has a low likelihood of occurrence. This becomes evident

when thinking, for instance to the many natural disasters or terrorist attacks, which took place in the last years: they are not common events, yet they are real and plausible occurrences. Furthermore, it is preferable from an experimental perspective that moral dilemmas represent events with low probability of occurrence that participants are unlikely to have previously experienced (Hauser *et al.*, 2007). This allows researchers to evaluate moral choices without the confounding effect of different levels of experience across participants.

In the effort of improving the robustness and reliability of findings inferred by the use of moral dilemmas (Borg *et al.*, 2006; Mikhail, 2007; Moore *et al.*, 2008; Christensen & Gomila, 2012), researchers must carefully consider how dilemmas are built and presented as to control how they affect moral decision-making. Indeed, in previous studies some of the stories featured could not be considered dilemmatic (e.g., a story featuring a child killing his grandmother for not buying him a gift can hardly be considered a dilemma; Rosas & Koenigs, 2014); or the linguistic features and the type of request to which participants were called to answer were inconsistent across dilemmas within the same set and across different sets (Borg *et al.*, 2006; McGuire *et al.*, 2009; Rosas & Koenigs, 2014; Kahane *et al.*, 2015). Although subsequent research has acknowledged and overcome several of these shortcomings, some of them, still remain unaccounted for.

In the following, we discuss how four different aspects significantly modulate the choice of utilitarian and deontological responses beyond personal tendencies: different conceptual factors underlying the dilemma, its structural formulation, translation and cultural interpretation, and methodological flexibility.

Conceptual factors

One of the most used set of dilemmas (n=60) was created around the concept of the proximity of harm (Greene *et al.*, 2001; Greene *et al.*, 2004), which defined dilemmas as "personal" when three criteria are met: a) the violation is likely to cause serious bodily harm; b) the harm must happen to a particular person or a group of people; and c) the harm is not the result of a deflection of an existing threat. Following this conceptualization, trolley-like dilemmas are considered impersonal and footbridge-like dilemmas personal. However, in this first formulation, the definition of personal/impersonal dilemmas has been greatly criticized (Borg *et al.*, 2006; Mikhail, 2007; Christensen *et al.*, 2014). Recently the concept of personal force of a dilemma has been defined as "the force [that] directly impacts the other person is generated by the agent's muscles, or when the agent pushes another one with one's hands or with a rigid object" (Royzman & Baron, 2002; Greene *et al.*, 2008; Moore *et al.*, 2008; Greene *et al.*, 2009).

To overcome the criticalities of the Greene's set, Moore *et al.* (2008) developed their own set of dilemmas based on the personal/impersonal distinction as well as on three further conceptual factors: a) Self-other beneficent, in which the decision maker's life is at risk (Self-beneficial) or not (Other-beneficial); b) Evitability, in which the sacrificed life would be lost in any case (Inevitable) or not (Avoidable); and c) Intentionality, in which sacrificing some lives is intended to save a greater number of people (Instrumental) or it is just an unintended consequence (Incidental). It is worth noting that this last conceptual factor is only valid for impersonal dilemmas and, as a consequence, all personal dilemmas are instrumental.

The instrumental/incidental factor has been used by Lotto and colleagues (2014) to develop a set of 60 moral dilemmas. Centered on the concepts of intentionality and benefit of the harm, this set is constituted by "instrumental dilemmas", which describe killing one individual as an intended means, and "incidental dilemmas" ("accidental" in (Christensen & Gomila, 2012), which describe killing one individual as an unintended consequence of saving

others. In half of the dilemmas, the respondent's life is at risk, in the other half the respondent is not going to be harmed (Lotto *et al.*, 2014).

To date, the largest dilemma set that reconciles all these different perspectives has been realized by Christensen *et al.* (2014), with 46 dilemmas simultaneously inspired to all four conceptual factors: personal/impersonal (*Personal Force*) or accidental/instrumental (*Intentionality*) distinction to the self/other benefits (*Benefit Recipient*) and avoidable/inevitable (*Evitability*) structures. Christensen *et al.* (2014) collected normative data about arousal and valence and showed that people's moral judgment is sensitive to all four factors.

Structural formulation

Beyond the inclusion of different conceptual factors, the language used in formulating the dilemmas can influence the way participants respond. This aspect has been controlled only in the three most recent dilemma sets (Moore *et al.*, 2008; Christensen *et al.*, 2014; Lotto *et al.*, 2014), but has not been taken into account in the one that is most used (Greene *et al.*, 2001; Greene *et al.*, 2004). Although an agreement on how such standardization should occur has yet to be reached, scholars have already highlighted three caveats. First, to be compared, all dilemmas should contain the same amount of information. This means that each description of the situation needs to be controlled at least for:

- the *antecedent situation*. If, for instance, a footbridge-like dilemma describes the man on the bridge as a serial killer, more people are likely to decide to push and kill him in order to save the individuals first designated to be invested by the trolley (Royzman & Baron, 2002; Cushman *et al.*, 2006);
- the use of the word *to kill* and *to save.* Indeed, it has been proved that people are more inclined to choose utilitaristic and deontological actions, respectively when

the word *to kill* or *to save* are emphasized (Petrinovich, O'Neill, & Jorgensen, 1993; Petrinovich & O'Neill, 1996);

- the *trade-off*. In the Greene's dilemma set (2004) different kinds of moral transgressions, with different level of emotional involvement (such as stealing, lying or killing) were presented. To avoid carry-over effect between dilemmas, the following dilemma sets used the same moral transgression (killing and letting die) across dilemmas (Moore *et al.*, 2008; Christensen *et al.*, 2014; Lotto *et al.*, 2014);
- the *decision maker's perspective*. There is evidence showing that writing the dilemma in the protagonist's perspective or in the third person – emphasizing the decision maker's observer role – leads to different neural, cognitive and emotional mechanisms (Royzman & Baron, 2002; Zahn, Moll, Paiva *et al.*, 2009).

Second, the way the decision maker is asked to answer should be consistent within the same dilemma set and across sets to allow for direct comparison of the results. The question can be introduced as a judgment ("*Is it wrong to…?*" or "*Is it acceptable to..?*"; Greene *et al.*, 2001; Greene *et al.*, 2004; Cushman *et al.*, 2006; Valdesolo & DeSteno, 2006; Moretto *et al.*, 2009; Fumagalli *et al.*, 2010; Ugazio *et al.*, 2012; Youssef *et al.*, 2012b; Pastötter *et al.*, 2013) or as a choice ("*Would you..?*"; Koenigs *et al.*, 2007; Waldmann & Dieterich, 2007; Starcke *et al.*, 2011; Sarlo *et al.*, 2012; Carmona-Perera *et al.*, 2013; Szekely & Miu, 2014). These two types of questions tap onto two different cognitive processes (Sood & Forehand, 2005) and often give rise to different answers (Tassy *et al.*, 2013b): judging an action implies to evaluate the situation from an allocentric perspective, while choosing to act in some way needs to picture oneself in that situation and consider all the possible consequences of that action. It has been demonstrated that participants can choose actions they judge as morally wrong (FeldmanHall *et al.*, 2012; Kurzban *et al.*, 2012; Tassy *et al.*, 2013a), and that the emotional investment of

choosing to act against moral rules is more intense than that in judging someone else's immoral actions (Tassy *et al.*, 2013a; Szekely & Miu, 2014).

Lastly, the previous suggestions should be implemented in dilemmas with similar word counts, to avoid differences in trial length across experimental conditions (Borg *et al.*, 2006; Moore *et al.*, 2008).

Translation and cultural interpretation

Since all but one dilemma set have been tested only in the language spoken by the participants of a given study, to date there is no evidence of how a particular test can generalize across languages, countries and cultures. This is a major drawback for the moral decision-making research for two main reasons. First, the language in which a question is posed has been found to alter moral decision processes (Costa, Foucart, Hayakawa *et al.*, 2014; Cipolletti, McFarlane, & Weissglass, 2016), and second, the same moral issues may induce opposite views depending on the participants' cultural background (Gump, Baker, & Roll, 2000; Ahlenius & Tännsjö, 2012; Cowell, Lee, Malcolm-Smith *et al.*, 2016). Furthermore, the globalization process forces us to make moral decisions that go beyond our cultural boundaries (see e.g. O'Neill & Petrinovich, 1998; Moore, Lee, Clark *et al.,* 2011; Wang, Deng, Sui *et al.,* 2014). Therefore, moral research should promote the use of experimental stimuli that allow for comparability across languages, countries and cultures, using moral dilemmas that are transferable across languages and have similar cultural meanings. The study empirical of this aspect, however, has been partly neglected by researchers. The only attempt to mitigate this issue is represented by the work by Christensen *et al.* (2014), who provide a set of dilemmas translated in 6 languages (English, French, Spanish, German, Danish, and Catalan). However, the authors neither directly compared the dilemma across languages, nor did they evaluate them in the same language across different cultures.

Methodological flexibility

Moral decision-making is typically investigated through dilemmas described in lengthy written texts. This tends to reduce the possible number of trials that can be presented to a participant before she experiences fatigue, especially considering that each dilemma cannot be repeated. More importantly, both the length of each dilemma may challenge the use of functional magnetic resonance imaging and event-related potentials (ERP) techniques in moral research (see also Lotto *et al.* 2014). In fact, the respondent needs a certain amount of time to read each dilemma, thus reducing the possibility of disentangling reading from the other processes simultaneously occurring (e.g., emotional processing). We believe that this significantly affects the design of the sequence of events from the presentation of the moral dilemma to the communication of a moral decision. The linguistic standardization particularly comes in handy to this purpose, as demonstrated by Lotto *et al.* (2014). They were the first to create a set of 60 moral dilemmas for which Italian normative values for arousal, valence, decision time and acceptability were provided. Moreover, they introduced a neat separation between the presentation of the scenario, confined in one slide, followed by the presentation of two alternative choices, each presented on a separate slide. Participants were required to make the choice only when a "decision slide" appeared following the presentation of the second choice. This trial structure makes this set suitable for neuroimaging and ERP methodologies, in that it allows to untangle the dilemma processing from the choice-related decisions, thus facilitating the attribution of the associated neural correlates to each of these mental processes.

None of the available moral dilemma sets simultaneously accounts for all aspects that are argued to modulate moral choices. Even in the dilemma set proposed by Christensen *et al.*

(2014), which to date represents the most complete attempt in terms of considered conceptual factors and standardization efforts, some of the above-mentioned issues remain unaccounted for. More specifically a) some of the scenarios proposed are not realistic (e.g., in "Burning building b" the five people are in the same hallway but the injured person is the only one that will die without air; see Appendix D for the English and Italian version of the dilemmas); b) the four conceptual factors is not clearly traceable in each dilemma (e.g., the two "Orphanage" dilemmas are defined as avoidable death dilemmas but in the description of the situation it is written that "*the soldiers will kill you all*" as such it should be included among the inevitable death dilemmas; see Appendix D); c) even though the set has been translated in six languages, the reliability of this translations has not been tested; and d) different dilemmas have different lengths (e.g., 169 vs. 93 words).

Therefore, the aim of the present work is to capitalize on Christensen et al. (2014) moral dilemma set (English version) and generate a new set, translated and culturally adapted to the Italian population (following Lotto *et al.* 2014), including dilemmas based on all four conceptual factors presented in a controlled linguistic formulation that makes them suitable for imaging applications. First, we tested the newly developed dilemma set called 4CONFIDe (acronym for 4 Conceptual Factors Italian Dilemmas) and tested with native English speakers, proficient in Italian, as well as with Italian native speakers, proficient in English to evaluate translation and cultural adaptation issues (Study 1). We expected that if the moral choices are consistent within participants, irrespective of their native language, then the new moral dilemma set is accurately translated and conveys the same cultural meaning. Second, we collected normative data on a new group of Italian adult participants for arousal, familiarity, valence and rate of utilitarian responses for the translated set of moral dilemmas (Study 2).

2.2 General Materials and Methods

The followed protocol was approved by SISSA Ethics Committee in observance of the latest release of the Helsinki Declaration and informed written consent was obtained from each participant.

Conceptual factors

We propose here a revised set of moral dilemmas, 4CONFIDe set, constituted by 52 moral dilemmas selected from two previously standardized sets (Christensen *et al.*, 2014; Lotto *et al.*, 2014). The 4CONFIDe set is an attempt to create a continuum between the previous literature focused on the personal/impersonal distinction (Greene *et al.*, 2001; Greene *et al.*, 2004; Cushman *et al.*, 2006; Koenigs *et al.*, 2007; Greene *et al.*, 2008; Moore *et al.*, 2008; Greene *et al.*, 2009; Shenhav & Greene, 2014) and the literature focused on the intentionality of the action (Borg *et al.*, 2006; Hauser *et al.*, 2007; Sarlo *et al.*, 2012; Lotto *et al.*, 2014; Sarlo *et al.*, 2014). Moreover the 4CONFIDe set considers two further factors that have been showed to influence moral choices: benefit recipient (Bloomfield, 2007; Moore *et al.*, 2008; Christensen *et al.*, 2014) and evitability (Hauser et al., 2007; Moore et al., 2008; Christensen et al., 2014). Thus, each dilemma of the 4CONFIDe set is categorized as: a) personal or impersonal, depending on whether the agent is directly involved in the production of the harm or she is only indirectly involved in the process that causes the harm (Christensen *et al.*, 2014); b) accidental, when the victim of the dilemma dies as a non-desired side effect of the action, or instrumental, when the respondent intentionally uses the death of the victim as mean to save the others (Christensen *et al.*, 2014; Lotto *et al.*, 2014); c) self-beneficial or other-beneficial, depending on whether the agent life is at risk or not (Moore *et al.*, 2008; Christensen *et al.*, 2014); d) avoidable death, if the individual to be sacrificed would not be harmed, or inevitable death, if the action leads to inevitable consequences (Moore *et*

al., 2008; Christensen *et al.*, 2014). Please, refer to Table1A of Appendix A for the complete list of dilemmas.

Structural formulation

In line with the guidelines proposed by Christensen *et al.* (2014) and Lotto *et al.* (2014), we revised the existing dilemmas and created the new ones according to the following working points:

i) the antecedent situation: as to avoid the moral choice to be unbalanced by the use of tendentious specifies – which can make some of the people described in the scenario expendable - we made sure that the characters involved in each scenario were all neutrally described;

ii) the use of word *kill* and *save*: following Christensen *et al.* (2014) directions, we ensured the use of both the word *kill* and the word *save* at the end of each scenario as to specify the consequences of the moral choice to be chosen;

iii) Trade-off: all dilemmas were homogeneous in the moral transgression outlined. Indeed, the moral choice is between *killing* a person to *save* a number of people. To avoid additional confounders, we maintained the number of individuals involved in each scenario (5-10; 11-50; 100-150 and "thousands" of people) consistent with those proposed by (Christensen *et al.*, 2014);

iv) the decision maker's perspective: all dilemmas were designed in first person to emphasize the involvement of the decision maker (Papeo, Corradi-Dell'Acqua, & Rumiati, 2011);

v) Question: in order to emphasize the consequences of the choice made by the decision maker, we included a direct question in the form of "*Do you… So that…*" (in Italian "*Fai questo… così che…*"). Participants could select one of four options: "I certainly do it", "I do

it", "I do not do it" and "I certainly do not do it". A four-point scale represents an attempt to capitalize on the advantages of two response methods previously used: while Lotto *et al.* (2014) utilized a binary yes/no response to the question "*Would you do it*?", Christensen *et al.* (2014) used a seven point-Likert scale to the question "*Do you… So that…*". The dichotomic choice is more realistic and it forces the respondents to make clear decisions but it does not give the opportunity to measure the degree of certainty. On the other hand, the Likert scale allows to uncover the degree of conflict experienced by the decision-maker, but an odd-point scale increases the chance that respondents choose the halfway point, that does not suggest a preference for either utilitarian or deontological choices;

vi) Word count: we made an effort to homogenize the word count across dilemmas. In the 4CONFIDe set the average number of words in the English version is 138.17 words (SD = 13.66) and in the Italian version the average is 122.11 (SD = 12.68). As compared to the Christensen *et al.* (2014)'s set (M = 144.54; SD = 19.66), the English version of 4CONFIDe shows a significantly reduced number of words per dilemma: w (102) = 2188.5, $p < 0.0001$, [95% CI: 10.10; 21.00]; see Table 1A of Appendix A for word count of English and Italian dilemmas). As an additional control, we assessed the reading time of the each dilemma presented in Italian – our version of primary interest – by asking 60 Italian native speakers to read the each dilemma and press a key when they finished reading (total reading time, M = 11.14 seconds; SD = 6.65 seconds; trials with RTs 2 SD above or below the individual mean were discarded).

Methodological flexibility

To apply the 4CONFIDe set to imaging studies, dilemmas were designed to allow for the separation of the dilemma processing from choice-related processes, as proposed by Lotto *et al.* (2014). Thus each dilemma is composed of three paragraphs: the first paragraph

describes the situation, the second the problem, and the last one poses the question. Dilemmas should be presented in two different slides, with the first slide (called "scenario screen") containing the first two paragraphs, the second slide (called "question screen") containing the question.

Data analysis

Differently from the majority of previous studies, we used *mixed-effects models* to analyse our data. Indeed, different studies have shown a relationship between inter-individual differences, such as emotional awareness (Patil & Silani, 2014a), empathy (Patil & Silani, 2014a; Sarlo *et al.*, 2014; Gleichgerrcht *et al.*, 2015), emotion regulation (Szekely & Miu, 2014) but also working memory and executive control (Moore *et al.*, 2008), and moral decisions. Mixed-effects models with participants as *random effect* allow accounting for this high variability across individuals. LMM were fitted and analysed using R (version 2.10.1; http://www.r-project.org/) using the *multinom* function from the nnet package (https://cran.r-project.org/web/packages/nnet/nnet.pdf) and the *glmer* function from the lme4 package (http://cran.r-project.org/web/packages/lme4/index.html). To avoid a warning of non-convergence, an optimizer (bobyqa) was chosen. 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 each dependent variable, we compared different LMM to find the best models fitting to the data. Models were compared with the likelihood ratio tests using the generic *anova* function. Best models are described in detail in the main text, while all the rejected models and results of likelihood ratio tests among models are reported in the supplemental material.

2.3 Study 1 – Evaluation of translation and cultural adaptation of 4CONFiDe set

2.3.1 Methods

Participants

A total of 28 volunteers, consisting of 11 English Native Speakers proficient in Italian, and living in the United States or United Kingdom (Age, M = 33.27, SD = 10.84; Education, M = 17.27, SD = 2.65) and 17 Italian Native Speakers proficient in English, and living in Italy (Age, M = 28.05, SD = 7.53; Education, M = 17.52, SD = 2.53) were recruited through email invitations.

Stimuli

The 52 English moral dilemmas obtained by the revision of the set proposed by Christensen *et al.* (2014) and Lotto *et al.* (2014) were translated in Italian language, following a back-translation procedure (Brislin, 1970). The dilemmas were presented in two separate surveys through Google Forms. Each survey was composed by two sessions: each session was constituted by 26 Italian and 26 English dilemmas, for a total of 52 dilemmas per session. Dilemmas were presented in a random order within each session, as black-colored text (font: Calibri, size: 24) against a white background. The beginning of each session presented English or Italian instructions, according with the language of the session.

Procedure

After giving their approval to take part in the study, each participant received by email both survey links within a two-week timeframe. For each survey they completed a series of questions about personal data (age, gender, education level, nationality, self-rating of Italian and English language proficiency levels) and they answered to 52 moral dilemmas. The instructions were similar to those proposed by Christensen *et al.* (2014): "*In the following test*

you will read a series of short stories about difficult interpersonal situations, similar to those that you could see on the news every day or may watch in a movie. For each of the difficult situations a solution will be proposed. You have to decide whether or not you would act as suggested. Do not linger too much for thinking but try to identify yourself with the characters of the stories".

Data analysis

Between-group comparisons were performed using the Wilcoxon-test for continuous variables (age and education) and the Chi-Square test for categorical variables (gender and dilemmas' languages). Multilevel mixed-effect multinomial logistic regressions (LMM; (Hosmer Jr & Lemeshow, 2004; Hilbe, 2009) and binary logistic regressions (Faraway, 2005) were performed with choice as a dependent variable, age, education, gender, language of dilemmas (English, Italian), group (English or Italian native speakers), personal force (personal, impersonal), intentionality (accidental, instrumental), benefit recipient (self, other) and evitability (avoidable, inevitable) as fixed factors and Subject as a random factor. The first type of analysis was performed to evaluate if the 4-point scale proposed is sensitive to the effects of the above-mentioned factors on the four types of choice. As baseline choice we defined the third point "I do not do this". Wald test was used to obtain *z* scores and *p* values of regression coefficients. Binomial logistic regressions were performed to allow for comparisons with the studies that use dichotomous answers. To verify the reliability of translation between group cultures and languages specific for each dilemma, Chi-square tests were performed on the answers of each dilemma between the Italian and English native speaker groups and between the Italian and English dilemma versions. Finally, for testing the internal consistency of the Italian version of dilemmas, Cronbach's alpha test was applied on

the 4-point scale answers of native English and Italian native speakers for the Italian dilemma set

2.3.2 Results

Certainty of response depends on conceptual and cultural factors

The likelihood of choosing the "I certainly do not do this" option increases when the harm was personal, the receivers of the benefit were other people and when death was avoidable. The likelihood of choosing the strong utilitarian choice "I certainly do it" increases for males, when the harm was impersonal, the benefits were extended to the respondent himself and death was inevitable. Being an Italian native speaker increases the likelihood of choosing the utilitarian "I do this" as compared to the deontological option "I do not do this" ($p < 0.001$; see Table 2.1).

Table 2.1 *Summary of multinomial logistic regression on moral decisions for Study 1*

Factors	***Coef.***	***SE***	***z value***	***p value***	***95%CI***	
					Lower	***Upper***
I certainly do it						
Intercept	-2.61	0.24	-10.67	**<0.001**	-3.096	-2.135
Group (*Italian*)	-0.25	0.14	-1.80	0.072	-0.533	0.023
Gender (*Male*)	2.14	0.15	14.18	**<0.001**	1.844	2.435
Dilemma language (*Italian*)	0.06	0.14	0.45	0.649	-0.206	0.331
Personal Force (*Impersonal*)	0.50	0.14	3.54	**<0.001**	0.222	0.771
Intentionality (*Instrumental*)	0.41	0.21	1.89	0.058	-0.015	0.827
Benefit Recipient (*Self*)	0.59	0.14	4.11	<0.001	0.308	0.869
Evitability (*Inevitable*)	0.59	0.23	2.61	**0.009**	0.148	1.036
Evitability*Intentionality (*Inevitable, Instrumental*)	-0.57	0.28	-1.98	**0.047**	-1.124	-0.008
I do it						
Intercept	-0.09	0.14	-0.66	0.511	-0.376	0.187
Group (*Italian*)	-0.33	0.09	-3.49	**<0.001**	-0.512	-0.143
Gender (*Male*)	0.67	0.12	5.43	**<0.001**	0.440	0.915
Dilemma language (*Italian*)	0.06	0.09	0.66	0.508	-0.119	0.240
Personal Force (*Impersonal*)	0.37	0.09	3.96	**<0.001**	0.187	0.553
Intentionality (*Instrumental*)	-0.36	0.13	-2.71	**0.007**	-0.629	-0.101
Benefit Recipient (*Self*)	0.20	0.09	2.17	**<0.001**	0.020	0.389
Evitability (*Inevitable*)	0.28	0.14	1.99	**0.047**	0.004	0.560
Evitability*Intentionality (*Inevitable, Instrumental*)	-0.12	0.19	-0.67	0.505	-0.489	0.241
I certainly do not do it						
Intercept	-0.30	0.16	-1.87	0.061	-0.623	0.014
Group (*Italian*)	-0.14	0.11	-1.35	0.176	-0.354	0.065
Gender (*Male*)	0.31	0.14	2.14	**<0.001**	0.027	0.591
Dilemma language (*Italian*)	0.09	0.13	0.85	0.395	-0.114	0.290
Personal Force (*Impersonal*)	-0.13	0.11	-1.28	**<0.001**	-0.344	0.072
Intentionality (*Instrumental*)	0.12	0.15	0.81	0.413	-0.170	0.413
Benefit Recipient (*Self*)	-0.24	0.11	-2.27	**<0.001**	-0.453	-0.034
Evitability (*Inevitable*)	-0.31	0.19	-1.68	0.092	-0.680	0.051
Evitability*Intentionality (*Inevitable, Instrumental*)	0.30	0.22	1.32	0.185	-0.142	0.736

"*I do not do it*" is the baseline outcome

Dichotomizing moral choice removes cultural/language differences

When considering all LMM 24 models, that with group, dilemma language, gender, personal force, benefit recipient and the interaction between intentionality and evitability as predictors explained the most variance (χ^2_1= 4.78, p = 0.029). Three predictors reached statistical significance (see Table 2.2): the likelihood of choosing the utilitarian options increased incrementally when the dilemma was impersonal, the benefit receiver included the respondent (self-benefit) and when death was inevitable. Otherwise, the likelihood of choosing the utilitarian options decreased when harm was intentional (instrumental dilemmas) and when the combination on inevitable death and intentional harm was present.

Table 2.2 *Summary of linear mixed effects model on moral decisions for study 1*

	β	***SE***	***z value***	***p value***	***βexp***	***95%CI***	
Fixed effects						***Lower***	***Upper***
Intercept	-0.90	0.42	-2.15	**0.031**	0.407	0.179	0.922
Group (*Italian*)	-0.31	0.49	-0.63	0.531	0.733	0.277	1.938
Gender (*Male*)	1.26	0.59	2.14	**0.032**	3.524	1.112	11.161
Dilemma language (*Italian*)	0.03	0.08	0.38	0.700	1.033	0.874	1.222
Personal Force (*Impersonal*)	0.55	0.09	6.28	**<0.001**	1.732	1.459	2.055
Intentionality (*Instrumental*)	-0.32	0.12	-2.55	**0.011**	0.727	0.569	0.929
Benefit Recipient (*Self*)	0.46	0.09	5.27	**<0.001**	1.590	1.338	1.890
Evitability (*Inevitable*)	0.54	0.14	3.97	**<0.001**	1.725	1.318	2.258
Evitability*Intentionality (*Inevitable, Instrumental*)	-0.38	0.17	-2.18	**0.029**	0.682	0.483	0.961

Note: β = estimate; SE = standard error; *CI* = confidence interval.

Comparisons per groups and languages for single dilemmas

Chi-square tests revealed a difference between the two groups for the dilemma number 13 ("Rescue 911 b"; X^2 = 9.62, p = .02) and for dilemma number 22 ("Bus Plunge b"; X^2 = 11.28, p = .01), in both dilemmas English native speakers gave more utilitarian responses

compared to Italian native speakers. Please refer to Table 2A of Appendix A for a summary of results, which include no other significant differences between the English and Italian versions of dilemmas.

Internal consistency

Cronbach's alpha test was applied on the answers of native English and Italian native speakers for the Italian dilemma set revealed that $\alpha = 0.96$, indicating high consistency among the proposed dilemmas.

2.3.3 Discussion

The analyses revealed that, in agreement with the study by Christensen *et al.* (2014), moral choices showed to be influenced by the four conceptual factors even when presented in foreign language. Although this result is in contrast with previous studies, showing that participants become more utilitarian in foreign language (Costa *et al.*, 2014; Cipolletti *et al.*, 2016), such result can be explained in light of the cultural adaptation of the dilemma, reflected through the back translation process applied. However, the analysis of the four choices revealed a cultural effect: indeed, being Italian native speakers increases the probability of choosing the utilitarian answer "I do this" respectively to the deontological option "I do not do this", supporting the hypothesis that moral choices are affected by cultural/linguistic backgrounds (Ahlenius & Tännsjö, 2012; Cowell *et al.*, 2016). This culture effect is not replicated by the dichotomized choice analysis suggesting that this effect is noticeable only with a more sensitive scale. The relationship between language and moral choice has been tested not only for the whole dilemma set but also for each dilemma. Even though two dilemmas (13 and 22, both included in previous analyses) showed significantly higher rate of utilitarian choices from English native speakers compared to Italian native

speakers, no dilemma showed differences in moral choices between the two language versions. This might indicate that even translations of dilemmas 13 and 22 are valid.

In Study 2, we will assess how the four conceptual factors used by Christensen *et al*. relate to different levels of arousal, valence and familiarity experienced with each dilemma.

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In Study 2, we will assess how the four conceptual factors used by Christensen *et al*. relate to different levels of arousal, valence and familiarity experienced with each dilemma.

2.4 Study 2 – Arousal, valence, familiarity ratings and moral choices of the 4CONFIDe set

In Study 2, we aimed at exploring whether arousal, valence, familiarity ratings and moral choices are affected by the four conceptual factors (Personal force, Benefit Recipient, Intentionality and Evitability). Normative data for arousal and valence of the dilemmas were already provided by Lotto *et al.* (2014) and Christensen *et al.* (2014). Here, we collected normative data also for familiarity to evaluate whether participants had previously encountered the scenarios described, since it has been suggested that being familiar or present personal attachment to the particular details could influence the choice (Hauser *et al.*, 2007).

2.4.1 Methods

Participants

A total of 112 Italian native speakers (70 women) were recruited for Study 2 through online advertisement as volunteers in a web survey. The survey webpage was promoted through online forums, social networks, and word of mouth. Upon responding to the invite, participants were automatically directed to two equivalent versions of the survey (version A or version B). Sixty-four participants completed survey A (41 women; Age, M = 30.44 years, SD = 5.96; Education, M = 18.11 years, SD = 2.39; aka Group A), while 48 participants completed survey B (aka Group B; 28 women; Age, M = 29.87 years, SD = 5.59; Education, M = 17.83 years, SD = 2.35).

Stimuli

Two surveys were created and presented through Google Forms. Each survey lasted about one hour and it was composed by 26 dilemmas presented in random order, for a total of

52 dilemmas. We asked participants to complete only one survey to increase compliance. If no differences between characteristics of the two groups will emerge, the data will be collapsed. Each dilemma was presented as a black ink text (font: Calibri, size: 24) against a white background.

Procedure

Following the provision of written informed consent at the beginning of the survey, participants completed a series of socio-demographic questions (age, gender, education level and nationality) and answered to 26 moral dilemmas. Instructions given to participants included the instructions of Study 1 plus the request to answer to three additional questions per dilemma: "How arousing is the dilemma?", "How pleasant is the dilemma?", "How familiar is the dilemma?". Participants gave their answers using a seven-point likert scale (arousal, 1 = not at all, 7 = highly arousal; valence, 1 = unpleasant, 7 = pleasant; familiarity, 1 = not at all, 7 = highly familiar) that allow for the emergence of subtle differences between dilemmas, as suggested by Christensen *et al*., (2014).

Data analysis

Between-group comparisons for age, education and gender were performed using Wilcoxon tests for continuous variables and Chi-square test for categorical variable. T-tests were performed for each rating between the average value of each dilemma and the neutral or middle point (3.5 for valence rating and familiarity) or the baseline point (0 for arousal) to test whether the rating value is significantly different from the neutral or baseline value. LMM were performed for the four dependent variables: arousal, valence, familiarity and choice. LMM were performed to determine whether age, gender, education, personal force, intentionality, benefit recipient and evitability would influence the moral choice, and the

arousal, valence and familiarity ratings of dilemmas. For all the models, as random effects, we included the groups and their relative participants. Bootstrapping procedures were applied to the best model to estimate the 95% confident intervals (CIs) with 5000 replications (Efron & Tibshirani, 1994).

2.4.2 Results

Participants in Groups A and B are equivalent from a socio-demographic perspective

The two groups were matched for Gender (X^2 = 0.38, p = .54), Age (w = 1570, p = 0.87, 95%CI: [-2.00, 1.99] and Education (w = 1392, p = 0.37, 95% CI: [-3.18, 3.37]). Therefore, data from the two groups were collapsed.

Ratings are significantly different compared to the neutral and baseline points

T-tests on arousal, valence and familiarity ratings against the neutral or baseline values revealed that valence ratings are significantly unpleasant compared to the neutral point (t(102) = -27.03, p < .0001, 95% CI: [1.87, 3.50]), moreover, dilemmas are rated as significantly more arousal (t(102) = 44.99, p < .0001, 95% CI: [3.35, 3.66]) and less familiar than the middle point (t(102) = -31.89, p < .0001, 95% CI: [-1.82, -1.61]).

Arousal variance is explained by conceptual factors alone, valence and familiarity variance also by participants' education and gender

In Table 3A in Appendix A the normative value of ratings and choices for each dilemma are provided. For arousal ratings (overall M = 3.50; SD = 1.93), after comparing 13 models, the best model was the one without age, education, and gender as factors but only with the four conceptual factors as fixed effects, interaction between personal force and benefit recipient, personal force and evitability, intentionality and benefit recipient (χ^2_1= 111.44, p < 0.0001).

After Bootstrapping, all significant contrasts survived except for the predictor benefit recipient alone and in interaction with personal force (see Table 2.3). The likelihood of rating a dilemma as less arousing increased when the dilemma was impersonal, when the death was inevitable and when the dilemmas presented both the characteristics of self-beneficial and instrumental harm. On the other hand, ratings reflected reduced arousal when the harm was instrumental and when the dilemmas were at the same time inevitable death (in which the sacrificed life would be lost in any case) and impersonal.

For valence ratings (overall M = 1.87; SD = 1.43), the best model, resulted from the comparison of the 22 models, included education, gender, personal force, intentionality, evitability, and the interactions personal force * evitability, personal force * intentionality and intentionality * gender as fixed factors (χ^2_2= 44.82, p < 0.0001). After applying the bootstrap procedure, five predictors emerged as significant. The likelihood of rating a dilemma as less pleasant increased when participants had higher education and they were female, and when dilemmas included inevitable deaths. Moreover, the likelihood of rating a dilemma as less pleasant increased when the dilemmas were impersonal and death was inevitable death, as well as when female participants rated instrumental dilemmas (see Table 2.4).

For familiarity rating (overall M = 1.80; SD = 1.30), the best model resulting from the comparison across 15 models, included the interactions between personal force * gender, benefit recipient * intentionality, and evitability * intentionality as fixed factors (χ^2_3= 20.65, p = 0.0001). Five variables resulted significant after bootstrapping: the likelihood of rating the dilemmas as less familiar increased when the respondent was female, when, in the dilemma, the receiver of the benefit was the respondent himself (self-benefit) and with the dilemmas that presented combinations of intentional harm and inevitable death. On the other hand, familiarity seemed to increase when the dilemmas were instrumental and the respondent was one of the beneficiaries of the harm (self-beneficial; see Table 2.5).

Table 2.3 *Summary of the best linear mixed effects models on arousal ratings for Study 2.*

Arousal Ratings	***β***	***SE***	***z value***	***p value***	***Boot***	***Percent.***	
Fixed effects					***Mean***	***2.5%***	***97.5%***
Intercept	2.98	0.27	10.91	**<0.001**	3.276	2.544	4.112
Personal Force (*Impersonal*)	-1.65	0.21	-7.90	**<0.001**	-1.739	-2.500	-1.066
Intentionality (*Instrumental*)	0.87	0.17	5.20	**<0.001**	0.922	0.454	1.405
Benefit Recipient (*Self*)	0.16	0.22	0.70	0.484	0.175	-0.501	0.869
Evitability (*Inevitable*)	-1.65	0.18	-9.25	**<0.001**	-1.747	-2.404	-1.155
Personal Force*Benefit Recipients (*Impersonal, Self*)	0.53	0.23	2.29	**0.022**	0.559	-0.131	1.249
Personal Force*Evitability (*Impersonal, Inevitability*)	2.06	0.24	8.57	**<0.001**	2.171	1.446	2.983
Benefit Recipients*Intentionality (*Self, Instrumental*)	-0.90	0.22	-3.94	**<0.001**	-0.955	-1.647	-0.304

Note: β = estimate; SE = standard error; Percentile CI's estimated with 5000 bootstrap replications.

Table 2.4 *Summary of the best linear mixed effects models on valence ratings for Study 2.*

Valence Ratings	***β***	***SE***	***z value***	***p value***	***Boot***	***Percent.***	
Fixed effects					***Mean***	***2.5%***	***97.5%***
Intercept	4.14	1.30	3.19	**0.001**	4.49	1.740	7.432
Education	-0.23	0.07	-3.09	**0.002**	-0.25	-0.413	-0.094
Gender (*Female*)	-1.37	0.37	-3.71	**<0.001**	-1.50	-2.269	-0.737
Personal Force (*Impersonal*)	0.21	0.18	1.18	0.238	0.23	-0.286	0.744
Intentionality (*Instrumental*)	-0.17	0.19	-0.90	0.370	-0.19	-0.729	0.354
Evitability (*Inevitable*)	0.36	0.14	2.63	**0.009**	0.39	-0.035	0.829
Personal Force*Evitability (*Impersonal, Inevitable*)	-1.31	0.20	-6.48	**<0.001**	-1.38	-2.028	-0.752
Personal Force*Intentionality (*Impersonal, Instrumental*)	0.49	0.20	2.43	**0.015**	0.52	-0.082	1.125
Intentionality*Gender (*Instrumental, Female*)	-0.62	0.20	-3.04	**0.002**	-0.65	-1.215	-0.084

Note: β = estimate; SE = standard error; Percentile CI's estimated with 5000 bootstrap replications.

Table 2.5 *Summary of the best linear mixed effects models on familiarity ratings for Study 2.*

Familiarity Ratings	***β***	***SE***	***z value***	***p value***	***Boot Mean***	***Percent.***	
Fixed effects						***2.5%***	***97.5%***
Intercept	-0.10	0.36	-0.27	0.786	-0.11	-0.907	0.689
Gender (*Female*)	-1.27	0.44	-2.91	**0.004**	-1.37	-2.268	-0.470
Personal Force (*Impersonal*)	-0.00	0.15	-0.00	0.997	-0.001	-0.442	0.460
Benefit Recipient (*Self*)	-0.59	0.16	-3.63	**<0.001**	-0.64	-1.150	-0.139
Intentionality (*Instrumental*)	0.26	0.17	1.55	0.120	0.27	-0.240	0.748
Evitability (*Inevitable*)	0.16	0.16	0.96	0.335	0.16	-0.289	0.615
Personal Force*Gender (*Impersonal, Female*)	0.51	0.20	2.54	**0.011**	0.54	-0.086	1.151
Benefit Recipient*Intentionality (*Self, Instrumental*)	0.70	0.21	3.36	**<0.001**	0.75	0.098	1.425
Intentionality*Evitability (*Instrumental, Inevitable*)	-0.55	0.21	-2.65	**0.008**	-0.575	-1.151	-0.019

Note: β = estimate; SE = standard error; Percentile CI's estimated with 5000 bootstrap replications.

Moral choices are affected by gender, personal force and intentionality factors

Sixteen models were constructed and compared between each other to evaluate moral choice. The best model included as predictors gender, personal force, interaction benefit recipient * intentionality, and evitability (χ^2_1= 6.72, p = 0.009). Five variables reached the significance level after bootstrapping: the likelihood of choosing utilitarian responses decreased with female respondents, with personal or instrumental dilemmas or when they implied a possibly avoidable death (see Table 2.6).

Table 2.6 *Summary of linear mixed effects model on moral choices for Study 2.*

	β	***SE***	***z value***	***p value***	***βexp***	***95%CI***		***BootMean***	***Percent.***	
Fixed effects						***Lower***	***Upper***		***2.5%***	***97.5%***
Intercept	0.45	0.21	2.10	**0.035**	1.566	1.031	2.380	0.49	0.014	0.965
Gender (*Female*)	-0.72	0.22	-3.22	**0.001**	0.487	0.314	0.754	-0.78	-1.232	-0.326
Personal Force (*Impersonal*)	0.44	0.08	5.12	**<0.001**	1.549	1.310	1.831	0.46	0.239	0.682
Intentionality (*Instrumental*)	-0.87	0.13	-6.82	**<0.001**	0.419	0.326	0.538	-0.91	-1.289	-0.545
Benefit Recipient (*Self*)	0.04	0.14	0.31	0.756	1.043	0.798	1.363	0.04	-0.340	0.432
Evitability (*Inevitable*)	0.25	0.08	2.88	**0.004**	1.280	1.082	1.513	0.26	0.036	0.484
Benefit Recipient*Intentionality (*Self, Instrumental*)	0.45	0.17	2.60	**0.009**	1.568	1.117	2.200	0.47	-0.020	0.955

Note: β = estimate; SE = standard error; 95 % CI = confidence interval; Percentile CI's estimated with 5000 bootstrap replications

2.4.3 Discussion

In Study 2, we sought to assess the contribution of the four conceptual factors used by Christensen *et al*., to the levels of arousal, valence and familiarity experienced with each dilemma. To reach our aim, different LMMs were compared using the likelihood ratio tests to find the best model to explain our data.

First, arousal ratings are directly predicted by the four conceptual factors, and not by socio-demographic variables, as, instead, occurs when considering valence and familiarity ratings. Arousal ratings tended to be higher when the harm was described as personal (compared to impersonal) and intentional (compared to accidental). However, when the harm of the victim could have been avoided, the impersonal dilemmas were rated as highly arousing; similarly, when the harm was intentional the dilemmas were rated as more arousing if the decision maker was not among the beneficiaries. This result is only partially in line with previous studies (Christensen *et al.*, 2014; Lotto *et al.*, 2014). Lotto *et al.* (2014), that considered only intentionality and benefit recipient factors and found that both of them affected arousal ratings: accidental dilemmas and other beneficent dilemmas were rated as more arousing than instrumental and self-beneficial dilemmas. Christensen *et al.* (2014), who took the four conceptual factors into account, showed that arousal ratings depend on personal force, benefit recipient factors and by the interaction of intentionality with benefit recipient.

Second, dilemmas are rated as unpleasant, as the average ratings suggests. In particular, dilemmas were considered more negative when the respondents were females as well as when they were highly educated. Valence is also explained by the interaction of intentionality with gender: females rated as more negative dilemmas where the harm is intentional (compared to accidental). This finding is in contrast with both Lotto *et al.* (2014) and Christensen *et al.* (2014) who found no significant main effects for intentionality factors but only for benefit recipient (Lotto *et al.*, 2014; self beneficial dilemmas were rated as more

unpleasant that other beneficial dilemmas) and for personal force and benefit recipient factors (Christensen *et al.*, 2014; here again self beneficial dilemmas were rated as more unpleasant than other beneficial dilemmas, while personal dilemmas were rated as more unpleasant than impersonal). Only Christensen *et al.* (2014) found a significant interaction between intentionality factor and personal force and benefit recipient factors.

Moreover, in contrast with previous normative studies (Christensen *et al.*, 2014; Lotto *et al.*, 2014), here we also provided the normative data for familiarity of the dilemmas. Importantly, all dilemmas were rated by our participants as unfamiliar suggesting that their experience with the scenario was limited. Familiarity ratings are explained only by the main factors of gender (females rated dilemmas as less familiar compared to males), and by benefit recipient (dilemmas are rated less familiar when the beneficial of the harm is the respondent himself) and by some interactions: dilemmas are rated as more familiar when the beneficial of the harm is the respondent herself and the harm is intentional (compared to accidental); dilemmas are rated as more familiar when the death is avoidable and the harm is intentional (compared to accidental). We believed that this information is important to confirm the validity of this set of dilemmas, since respondents to a moral task should be all at the same level of knowledge when are presented to the dilemmas for not biasing the choices (Hauser *et al.*, 2007).

To our knowledge, this is the first time that the effect of arousal, valence and familiarity ratings was considered on the moral choice. At variance with our expectations, we found that moral choices were not predicted by these ratings. This result may be influenced by the limited variance in ratings across participants, such as in the case of valence (SD = 1.43; on a total of 7 points). Furthermore, self-reports may not be reliable indicators of the participants' reactions to the dilemmas. Although not specific to the arousal, valence and familiarity measurements, this hypothesis would be in line with what found by (Lotto *et al.*, 2014), who

revealed a dissociation between what the participants perceived in terms of moral acceptability and how they actually decided to behave: indeed, people consider more acceptable to kill someone to save others when their own life is not at risk, but when they are asked how they would act they are more likely to save themselves.

Except for arousal ratings, gender was found to affect both ratings and moral choices. Females usually are less utilitarian and they rated the dilemmas as more unpleasant and less familiar. This finding is in line with (Fumagalli *et al.*, 2010; Lotto *et al.*, 2014) but only partially with (Christensen *et al.*, 2014)], in showing that men gave more utilitarian responses.

In line with several previous studies (Greene *et al.*, 2004; Mendez *et al.*, 2005; Valdesolo & DeSteno, 2006; Koenigs *et al.*, 2007; Greene *et al.*, 2008; Moore *et al.*, 2008; Greene *et al.*, 2009; Moretto *et al.*, 2009; Moore *et al.*, 2011; Youssef *et al.*, 2012a; Christensen *et al.*, 2014), we confirm that (healthy) participants are more prone to give a deontological answer when the moral dilemma is described as personal, that is when the harmful action involves physical contact between the agent and the victim.

Similarly, intentionality significantly predicted moral choices in our participants thus confirming the extant literature: participants made more utilitarian decisions when the action of killing one person is an unintended consequence of saving others (accidental dilemmas), compared to when it is an intended means to save others (instrumental dilemmas; (Borg *et al.*, 2006; Cushman *et al.*, 2006; Hauser *et al.*, 2007; Moore *et al.*, 2008; Greene *et al.*, 2009; Sarlo *et al.*, 2012; Christensen *et al.*, 2014; Lotto *et al.*, 2014) but see (Waldmann & Dieterich, 2007) for a negative result). This conceptual factor is based on the *principle of double effect*, which states that it is acceptable to harm someone for the greater good only if the harm comes as a side effect of the action (Aquinas, 1947; 1965; Foot, 1967; Thomson, 1976; Fischer & Ravizza, 1992; Kamm, 1998).

Finally, we found that evitability was a significant predictor for moral choices. Consistent with what was found by Moore *et al.* (2008) and Christensen *et al.* (2014), our analysis revealed that it is more probable that participants decide to act in an utilitaristic way when the person killed by the harmful action is going to die anyway compared to when she is not.

Even though, our results showed no significant main effects for Benefit recipient, they revealed that this factor significantly interact with the Personal force and intentionality factors. Previous studies (Moore *et al.*, 2008; Christensen *et al.*, 2014; Lotto *et al.*, 2014) showed that participants found more appropriate, and gave more utilitarian responses, when they were asked to kill someone to save themselves and other rather than when they were asked to kill in order to save only others (Moore *et al.*, 2008; Christensen *et al.*, 2014), while yet another study found a dissociation between moral judgment and moral behaviour (Lotto *et al.*, 2014). However, in these studies, the authors did not consider the random effects carried by inter-individual differences. In this perspective, our data are more conservative due to the use of "participants" as random factor within the models and for the bootstrap procedure.

2.5 Conclusions

The aim of the present study was to capitalize on Christensen's set (English version) and generate a new, extended set of moral dilemmas, culturally adapted to the Italian population as in Lotto *et al.* (2014). Based on all four conceptual factors, these dilemmas are carefully controlled for linguistic length and suitable for imaging applications.

In Study 1, we showed that participants' native language and that in which the dilemmas were written did not influence moral decisions, indicating that the same meaning

was decoded across translations. The back translation procedure was used to ensure that the same meaning of dilemmas is transferable across languages.

Study 2 confirmed that the proposed dilemmas were perceived by participants with different degrees of arousal, pleasantness and familiarity based on some of the conceptual factors and conceptual factors determined participants' moral choices.

Moreover, when *mixed-effects models* with participants as random effect were used, we found that inter-individual differences have a remarkable effect on moral decisions. Other studies too have suggested the existence of a link between moral decisions and inter-individual differences, such as emotional awareness (Patil & Silani, 2014a), empathy (Patil & Silani, 2014a; Sarlo *et al.*, 2014; Gleichgerrcht *et al.*, 2015), emotion regulation (Szekely & Miu, 2014) but also working memory and executive control (Moore *et al.*, 2008). Future research should take inter-individual differences into account.

In conclusion, here we provided a revised set of 52 moral dilemmas selected from the previous standardized sets (Christensen *et al.*, 2014; Lotto *et al.*, 2014) and based on the four conceptual factors present in Christensen's set. The proposed set has been designed to be suitable for imaging experiments with dilemmas being controlled for confounding factors and for transferability across languages. We believe that these procedures should be adopted in future studies on moral decision-making that want to promote the use of experimental stimuli that allow for comparability across cultures, and methodologies.

CHAPTER 3

Emotional reactions in moral decision-making are influenced by empathy and alexithymia

Abstract

The roles of cognitive versus emotional processes in driving moral choices remain debated. Extant studies suggest that emotional situations lead to deontological choices that favour people's inviolable rights independently of the outcomes. In contrast, cognition more often gives rise to utilitarian choices based on the idea that it is morally acceptable to cause harm for a greater outcome. Accordingly, diminished emotional processing and reduced empathy have been associated with utilitarian judgments. In this study, we investigated the influence of empathy and alexithymia on behaviour and emotional responses while participants performed a moral decision task. Self-report (valence and arousal ratings) and physiological (skin conductance and heart rate) measures were collected during the task. Results showed that empathy and alexithymia shaped emotional reactions to moral decisions, but did not bias moral choices. The more empathic the participants, the more dilemmas were perceived as unpleasant and arousing, and the greater the increase in skin conductance. Conversely, alexithymia was characterized by a reduced physiological activation during moral decisions, but normal self-report ratings. Heart rate was not modulated by empathy or alexithymia. These results add new evidence to the field of moral decision showing that empathy and alexithymia modulate emotional reactions to moral decision.

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3.1 Introduction

Over the course of the past decade, a large amount of studies has focused on the role of emotions in morality. Greene and collaborators provided one of the most influential theoretical contributions in this domain (Greene, Morelli, Lowenberg *et al.*, 2008; Greene, Sommerville, Nystrom *et al.*, 2001; Greene, Nystrom, Engell *et al.*, 2004; Greene & Haidt, 2002). According to their dual-process model, moral decisions are driven by the interaction between two competing processing systems mediated by partially dissociable neural networks: a fast, automatic emotional system engaging mainly the medial prefrontal cortex, and a slow, controlled cognitive system engaging mainly the dorsolateral prefrontal cortex and the inferior parietal lobe (Greene *et al.*, 2001; Greene *et al.*, 2004; Greene & Haidt, 2002). In this view, cognitive processes drive *utilitarian* choices, which lead to violation of societal norms and values for what the agent thinks is a greater good, whereas emotional processes prompt *deontological* (non-utilitarian) choices, which instead follow societal norms.

As seen in Chapter 2, during the presentation of hypothetical scenarios involving moral violations, emotions are also thought to be differently engaged depending on the nature of the dilemma. For example, *Personal* dilemmas tend to elicit strong emotional responses. They describe a situation in which personal harm is caused to another person directly by the agent. For instance, in the footbridge dilemma the agent can push a man from a bridge, if he wants to stop a trolley running underneath and save the lives of five workers on the tracks (Thomson, 1976; Greene *et al.*, 2001; Greene *et al.*, 2004). In contrast, in *impersonal* dilemmas physical harm is only caused indirectly and, as such, elicits weaker emotional responses. An example is the trolley dilemma, in which the agent has the possibility to hit a switch to divert a trolley on another track to save five people's lives, while sacrificing the life of one person (Foot, 1967; Greene *et al.*, 2001; Greene *et al.*, 2004).

Compared to controls, clinical populations with a deficit in emotion processing make significantly more utilitarian choices in moral dilemmas, thus confirming the role of emotions in moral decisions as described in Greene's model. This is the case of patients with lesions in the ventromedial prefrontal cortex (Koenigs, Young, Adolphs *et al.*, 2007; Moretto, Làdavas, Mattioli *et al.*, 2009; Ciaramelli, Muccioli, Làdavas *et al.*, 2007; Thomas, Croft, & Tranel, 2011), as well as of patients with frontal traumatic brain injury (Martins, Faísca, Esteves *et al.*, 2012) or with frontotemporal dementia (Mendez, Anderson, & Shapira, 2005).

Similar results have also been observed in non-clinical populations with emotional deficiencies, such as those with a lack of empathy or with high levels of alexithymia. Empathy, which generally motivates pro-social behaviour, is defined as the ability to understand what others feel (Eisenberg, 2000; Singer & Lamm, 2009; Batson, 2014). According to current theories, empathy is composed of three components (Blair, 2005; Hein & Singer, 2008; Singer & Lamm, 2009; Decety & Jackson, 2004). "Motor empathy" (Blair, 2005) is the capacity to become affectively aroused by emotions of others – and it likely involves mimicry of other people's emotional expressions (Wood, Rychlowska, Korb *et al.*, 2016; Neufeld, Ioannou, Korb *et al.*, 2015). "Affective empathy" corresponds to the urge to care for another's welfare. It includes two key aspects: *empathic concern*, that is the tendency of experiencing sympathy and concern for unfortunate others, and *personal distress* - the tendency of experiencing anxiety in response to others' distress. "Cognitive empathy", which encompasses both *fantasy* - the ability to imagine oneself into the feelings and actions of characters in books and movies, and *perspective taking* - the ability to adopt the psychological point of view of others, is the ability to attribute thoughts and intentions to oneself and to others (Singer & Lamm, 2009; Decety & Cowell, 2014a). In the past decade, empathy has been increasingly associated with morality both in theory (Hoffman, 1994; Pizarro, 2000; Decety & Batson, 2009; Decety & Cowell, 2014a; 2014b; Ugazio, Majdandzic, & Lamm, 2014) and empirically (Sarlo *et al.*, 2014;

Patil & Silani, 2014b; Gleichgerrcht & Young, 2013; Gleichgerrcht, Torralva, Roca *et al.*, 2011; Crockett, Siegel, Kurth-Nelson *et al.*, 2015; Crockett, Clark, Hauser *et al.*, 2010). In particular, greater percentages of utilitarian choices have been linked to the inability to fully experience emotional empathy in healthy individuals (Sarlo *et al.*, 2014; Patil & Silani, 2014b; Gleichgerrcht & Young, 2013; Choe & Min, 2011), and were described in psychopathy, a personality disorder characterized by a marked lack of emotional empathy (Young, Koenigs, Kruepke *et al.*, 2012; Glenn, Koleva, Iyer *et al.*, 2010; Langdon & Delmas, 2012; Gao & Tang, 2013; Tassy, Deruelle, Mancini *et al.*, 2013a). This evidence suggests that in dilemmas requiring the decision to harm someone in order to save a greater number of lives, utilitarian choices are more common in participants lacking emotional empathy and the experience (and understanding) of unpleasant emotions in response to other people's suffering (Sarlo *et al.*, 2014; Decety & Cowell, 2014a; Patil & Silani, 2014b; Choe & Min, 2011).

Alexithymia – Greek for "no words for feelings" – is a psychological construct that describes individuals who have difficulties in identifying and describing their feelings to others (Nemiah, Freyberger, & Sifneos, 1976; Larsen, Brand, Bermond *et al.*, 2003; Bermond, Vorst, & Moormann, 2006; Sifneos, 1973). Despite alexithymia being associated with a variety of psychiatric and neurological conditions (Sifneos, 1973; Taylor, Bagby, & Parker, 1999; Sturm & Levenson, 2011), a prevalence rate of 10% can also be observed in the general healthy population (Salminen, Saarijärvi, Äärelä *et al.*, 1999). Like empathy, alexithymia is not a unitary construct but comprises an affective and a cognitive dimension, each with its own neural substrates (Goerlich-Dobre, Bruce, Martens *et al.*, 2014; Goerlich-Dobre, Votinov, Habel *et al.*, 2015). The affective dimension refers to the extent to which emotions are subjectively experienced, and it comprises *emotionalising* (the degree to which someone is emotionally aroused by emotion-inducing events) and *fantasising* (the degree to which someone is inclined to imagine, day-dream, etc.). The cognitive dimension implies difficulties in the

conscious interpretation of emotions and it comprises difficulties in *identifying* (the degree to which one is able to define one's arousal states), *analysing* (the degree to which one seeks out explanations of one's own emotional reactions), and *verbalising* feelings (the degree to which one is able or inclined to describe or communicate about one's emotional reactions; Bermond, Clayton, Liberova *et al.*, 2007). Furthermore, alexithymia may be associated with low empathy (Neumann, Zupan, Malec *et al.*, 2013; Moriguchi, Decety, Ohnishi *et al.*, 2007; Guttman & Laporte, 2002; Goerlich-Dobre, Lamm, Pripfl *et al.*, 2015; Bird & Cook, 2013), and with poor pro-sociality (Berthoz, Pouga, & Wessa, 2011).

A higher tendency to make utilitarian choices has been described also in alexithymic individuals (Koven, 2011; Patil & Silani, 2014b; 2014a; Gleichgerrcht, Tomashitis, & Sinay, 2015; Brewer, Marsh, Catmur *et al.*, 2015). For instance, Patil and Silani (2014b) investigated the influence of alexithymia on moral judgments among more than 300 healthy participants in an online survey. Higher alexithymia scores were linked to a greater proportion of utilitarian choices in personal moral dilemmas, which are usually more emotionally aversive than impersonal ones. Moreover, two recent studies examining the relationship between alexithymia and utilitarian tendencies in both healthy and clinical populations (multiple sclerosis and autism) showed that in healthy individuals, but not in patients, moral acceptability judgments were predicted by higher alexithymia (Gleichgerrcht *et al.*, 2015; Brewer *et al.*, 2015). According to Koven (2011), individuals who are better at reasoning about their own emotions experience prolonged negative mood in response to moral dilemmas and tend to make deontological choices. On the other side, people who are confused about their emotional experiences (e.g., alexithymics), feel a less negative affect and therefore make more utilitarian choices. Therefore, alexithymia *per se* drives utilitarian judgments. On the other hand, Patil and Silani (2014b) proposed that utilitarian choices in alexithymics are

driven by a lack of empathy since they observed that empathic concern mediated the relation between alexithymia and acceptance of utilitarian choices.

To date, the influence of alexithymia on morality has only been investigated using moral judgment tasks (Koven, 2011; Patil & Silani, 2014b; 2014a) in which participants they are asked to judge the appropriateness or moral permissibility of *somebody else*'s actions. As explained in Chapter 1, differences exist between moral decision and moral judgment tasks (Szekely & Miu, 2014; Tassy *et al.*, 2013b). Indeed in moral decision-making task participants are asked to decide what *they* would do in a hypothetical moral dilemma. Coherently, it has been proposed that these two tasks reflect different psychological constructs (Monin, Pizarro, & Beer, 2007) and rely on different neural underpinnings (Tassy *et al.*, 2013b). However, no study has jointly investigated the influence of both empathy and alexithymia on moral decision-making.

In the present study, we aimed at filling this gap. Furthermore, we examined the influence of empathy and alexithymia on participants' emotional reactions with both explicit and implicit measures by assessing arousal and valence – considered the core dimensions of the affective experience (Lang, 1995; Bradley, 2009).

First, we asked participants to rate the valence and arousal of emotions raised by the decision itself. These explicit measures were collected to clarify participant's perceived emotional reactions during the moral choice. Secondly, we measured skin conductance response (SCR) and instantaneous heart rate (IHR), which are implicit indexes of, respectively, arousal and valence (Lang, 1995; Bradley, 2009). In particular, psychophysiological measures are more reliable in providing insights into the individual's level of engagement and arousal since they overcome self-report limitation in emotional reports. This aspect may be particularly useful in the case of alexithymic individuals, which have difficulty in distinguishing and describing their emotions. Therefore, the use of both

explicit and implicit indices of emotional reactions is helpful to elucidate whether empathy and alexithymia can affect both the conscious experience of emotion and the automatic physiological response (Cacioppo, Berntson, Larsen *et al.*, 2000).

Even though the moral dilemma set described in Chapter 2 was designed on four conceptual factors, for the present study we decided to restrict the analysis only on three conceptual factors: Personal force (the type of action), Intentionality (whether the harm is intentional or not), and Benefit recipient (who benefits from the action). This decision was prompted by the consideration that previous literature on empathy and/or alexithymia considered mainly the personal force or intentionality factors (Patil *et al.,* 2016; Brewer *et al.,* 2015; Gleichgerrcht *et al.,* 2015; Crockett *et al.,* 2010; Sarlo *et al.,* 2014; Patil & SIlani, 2014a). Moreover, the nature of empathy, considered as an index of the propensity toward pro-social behaviour, motivated the inclusion of the benefit recipient factor, which distinguishes between self-benefit and other-benefit.

Three main predictions were formulated. First, according to the dual-process theory, we expected the number of utilitaristic responses to be low in people with high empathy, and high in people with high alexithymia. Second, individuals with high, compared to low empathy would consider more arousing and more unpleasant the dilemmas. In contrast, we predicted that individuals with high alexithymia would consider less arousing and less unpleasant the dilemmas, due to the poor awareness of their own emotional experience. Third, we expected greater SCR and IHR deceleration in participants with high empathy and low alexithymia, while we foresaw lower SCR and less IHR deceleration in participants with low empathy and high alexithymia (Bermond, Bierman, Cladder *et al.*, 2010a; Pollatos, Werner, Duschek *et al.*, 2011). In addition, we also anticipated that the type of decision (utilitaristic vs. deontological) and the type of dilemma (personal/impersonal, accidental/instrumental, self/other) would influence emotional reactions in both explicit and implicit measures (Sarlo *et al.*, 2012;

Christensen, Flexas, Calabrese *et al.*, 2014; Lotto, Manfrinati, & Sarlo, 2014; Moretto, Làdavas, Mattioli *et al.*, 2009).

It is important to keep in mind, however, that this is the first study to investigate the influence of alexithymia and empathy on three conceptual factors, and that the here detailed predictions are based on studies that instead considered only one/or two conceptual factors at a time (Moretto *et al.*, 2009; Sarlo *et al.*, 2012; Lotto, Manfrinati, & Sarlo, 2014; Patil & Silani, 2014b; 2014a; Sarlo *et al.*, 2014).

3.2 Methods

Participants

Forty-one right-handed healthy, Italian native language participants (21 females; age 19 – 35 years, M = 24.66, SD = 3.69; education 11 – 19 years, M = 16.19, SD = 2.06) were enrolled through online advertisement. Exclusion criteria were a history of neurological or psychiatric disorders and a score above 19 on the Beck Depression Inventory II (Beck, Steer, & Brown, 1996). The study was approved by SISSA's ethics committee.

Self-Report Questionnaires

Empathy and its components were assessed with the IRI (Interpersonal Reactivity Index; Davis & Association, 1980), a self-report instrument using Likert scales ranging from 0 *(doesn't describe me at all)* to 4 *(describes me very well)*. IRI's four components are: fantasy (FS: the proclivity to identify with fictitious characters), perspective taking (PT: the ability to adopt the perspective of others in common life), empathic concern (EC: the tendency to experience feelings of compassion and sympathy from others' misfortune), and personal distress (PD: the proneness to feel uncomfortable about the distress of others). Each dimension contains seven statements, giving 28 items, for a total maximum score of 112.

Alexithymia was assessed using the Bermond–Vorst Alexithymia Questionnaire, form B (BVAQ-B; Bermond & Oosterveld, 1994). The BVAQ-B consists of 20 items rated on a five-point scale with total scores ranging from 20 to 100; participants with a score above 53 are considered alexithymic. The BVAQ was designed to measure the five dimensions of alexithymia: emotionalising, fantasising, identifying, analysing and verbalising (Vorst & Bermond, 2001). The BVAQ subscales produce the two orthogonal dimensions that constitute alexithymia: the affective dimension comprises the subscales emotionalising and fantasising, while the cognitive dimension comprises the subscales verbalising, identifying and analysing (Bermond *et al.*, 2007).

To increase the reliability of the screening, all participants were additionally assessed for alexithymia with the TAS-20 (Bressi, Taylor, Parker *et al.*, 1996). The TAS-20 consists of 20 items rated on a five-point scale with total scores ranging 20 to 100. It includes three subscales: Difficulty in Identifying Feelings (F1), Difficulty in Communicating Feelings (F2) and Externally Oriented Thinking (F3). The international cut-off values are the following: 20–50 = non-alexithymic subjects; 51–60 = borderline alexithymic subjects; 61–100 = alexithymic subjects (Bressi *et al.*, 1996). In contrast to the BVAQ, the TAS-20 scale focuses only on the cognitive dimension of the alexithymia (Bermond *et al.*, 2010). See Table 3.1 for the summarized results of the IRI, BVAQ and TAS-20 questionnaires and their subscales.

Table 3.1 *Summary table of Empathy and Alexithymia questionnaires.*

	Mean (SD)	**Range**
IRI	61.32 (14.28)	19-88
PT	16.73 (4.45)	5-26
FS	17.00 (5.13)	5-27
EC	17.24 (4.82)	5-25
PD	10.27 (5.48)	0-22
BVAQ	51.76 (12.09)	21-82
B1	12.54 (4.09)	4-19
B2	8.93 (3.41)	4-18
B3	10.00 (3.18)	4-17
B4	10.83 (3.62)	5-19
B5	9.44 (3.13)	4-17
Affective component	19.76 (5.74)	9-37
Cognitive component	31.98 (8.74)	12-53
TAS-20	48.44 (12.92)	25-82
F1	14.34 (4.47)	7-23
F2	14.80 (5.63)	5-25
F3	19.19 (6.22)	10-34

Note: BVAQ = Bermond–Vorst Alexithymia Questionnaire; B1 = verbalising, B2 = fantasising; B3 = identifying; B4 = emotionalising; B5 = analysing; TAS-20 = 20-items Toronto Alexithymia Scale; F1 = difficulty in identifying feelings; F2 = difficulty in communicating feelings; F3 = externally oriented thinking; IRI = Interpersonal Reactivity Index; PT = perspective taking; FS = fantasy; EC = empathic concern; PD = personal distress.

Stimuli

Forty-six dilemmas of the 4CONFiDE moral set, validated in Chapter 2, were used. For the present study we considered three of the four proposed conceptual factors, since they have been used most frequently in previous studies (Christensen & Gomila, 2012; Christensen *et al.*, 2014): Personal force (Personal, Impersonal), Intentionality (Accidental, Instrumental), Benefit recipient (Self, Other). Importantly, each dilemma contains a combination of all three factors. Each dilemma was presented on two subsequent screens. The first screen described the scenario: the life of a group of people is in danger, and they can be saved through a hypothetical action, which however simultaneously causes the death of another person. The second screen presented the question *Do you...[action verb] so that…?* A direct question was used to emphasize the consequences of the choice made by the agent. Participants had to

choose between four options: “I definitely do it”, “I may do it”, “I may not do it”, and “I definitely do not do it”. The first two options are considered utilitarian choices, as they maximise overall utility (i.e., saving more lives), whereas the last two are counted as deontological choices. Dilemmas were presented using black font color (font: Calibri, size: 24) against a white background on a 19-inch computer screen at a viewing distance of 60 cm. Stimulus presentation was accomplished with E-prime 2.0 software (Psychology Software Tools, Pittsburgh, PA).

Moral decision-making task

Before starting the task, participants performed two practice trials. The instructions were the same described in Chapter 2. Each trial included the scenario (36 seconds), the question slide (with the four choices displayed below), and a rating slide (Figure 3.1). Participants were instructed to make their choice as fast as possible and then to rate on two 10-point scales the valence (unpleasantness/pleasantness) and arousal (calmness/activation), felt during the decision. Higher scores indicated higher pleasantness/arousal. Each trial ended with a blank screen shown for 10 seconds. Dilemmas were presented in three blocks of 16 trials. In each block, dilemmas were matched for factors Personal force, Intentionality and Benefit recipient. The order of the three blocks was randomized across participants. Participants were allowed to take a short break at the end of each block.

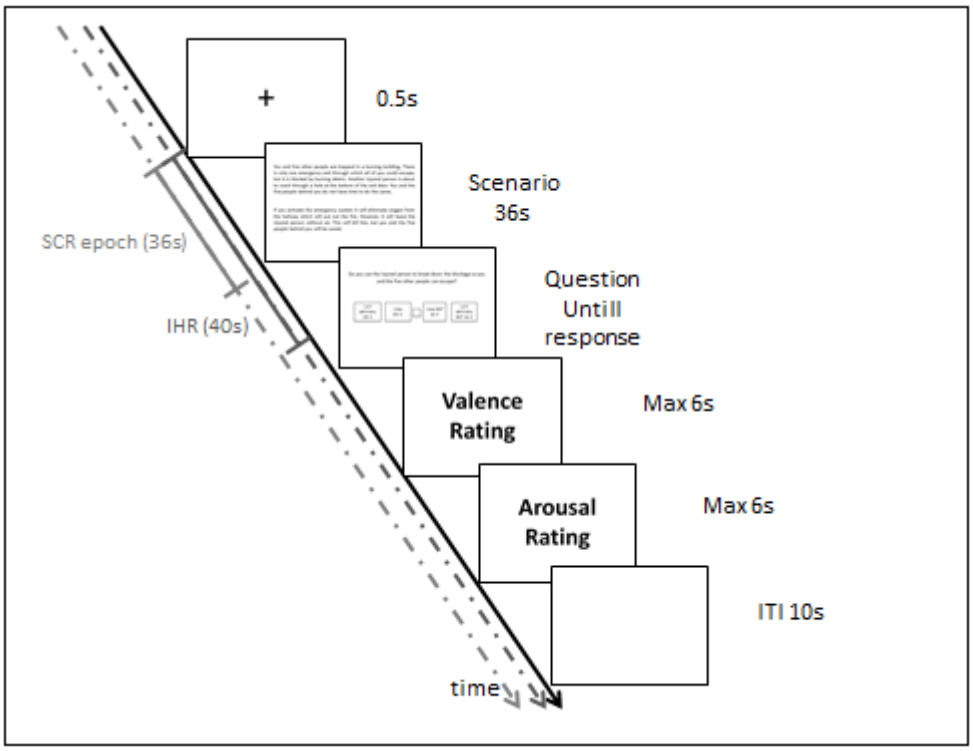

Figure 3.1 *Sequence of events in the experiment. Psychophysiological measures were recorded time-locked to the scenario onset. ITI = intertrial interval.*

Procedure

Upon arrival, participants signed informed consent, sat in a quiet room and had electrodes attached for HR and SCR recording. Following a 10-min adaptation period, psychophysiological measures were recorded during a 1-minute baseline and throughout the moral decision-making task. At the end of the experiment, participants completed the three self-report questionnaires.

Psychophysiological data acquisition and analysis

SCR and HR were recorded during the moral decision-making task with a *PROCOMP infiniti system* (Thought Technology, Montreal, Canada). After a 10-minutes adaptation period, and before starting the task, one minute of baseline was recorded.

SCR was measured according to guidelines (Figner & Murphy, 2011; Boucsein, 2012), using two 8 mm Ag/AgCl electrodes, attached to the medial phalanx surfaces of the index and

ring finger of the left hand. Conductive gel was used to reduce impedance. The electrode pair was excited with a constant voltage of 0.5 V and conductance was recorded using a DC amplifier with a low-pass filter set at 64 Hz. A photoplethysmographic probe (3.2 cm/1.8 cm, photodetector LED type), placed on the middle finger of the non-dominant hand was used to assess HR at a sample rate of 2048 Hz. SC and HR data were analysed with Matlab using in-house scripts partially using the EEGLAB toolbox (http://sccn.ucsd.edu/eeglab/). Data from five participants were removed due to a lack of sufficient physiological responsiveness or to technical problems during the recording.

SCR data were filtered with a 10 Hz low-pass filter and epoched over the 36 seconds of scenario presentation. The two seconds before the scenario-screen presentation served as baseline. The following SC parameters were analysed: (1) *peak amplitude*, defined as the difference in μSiemens between the mean value during baseline and the peak after stimulus onset; (2) *rise time*, defined as milliseconds between scenario onset and the time of the peak. Trials with peak amplitudes below 0.01 μSiemens were excluded from the SC analysis and peak amplitudes were log-transformed to improve interpretability (Boucsein, 2012).

HR data were filtered with a 1 Hz high-pass filter and resampled to 256 Hz. Beat detection was performed automatically, verified visually, and corrected, if necessary. Frequency was computed as beats per minute (bpm). The 40 seconds from the dilemma presentation were divided in 10 time windows of 4 seconds. Interbeat intervals were computed, transformed to HR values and averaged for each 4-seconds window. Each time window was then corrected by subtracting the 4 seconds before scenario presentation to obtain the Instantaneous Heart Rate (IHR; Palomba *et al.*, 2000). As to the trial design, the dilemma was presented from time window 1 and 9, while the question slide appeared at the beginning of the tenth time window.

Statistical Analysis

Data were analyzed with linear mixed-effects models (LMMs) using 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 (*lme4* package; http://cran.r-project.org/web/packages/lme4/index.html). To account for individual differences (e.g., some people are more "deontological" than others), participants were included in the models as *random*. To avoid a warning of non-convergence, an optimizer (bobyqa) was applied (Powell, 2009). 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 each dependent variable (type of moral choice, valence and arousal ratings, SCR peak amplitude, rise-time of SCR, IHR) we compared different LMMs, with and without interactions among conceptual factors and between conceptual factors and empathy and alexithymia scales, to find the best models fitting with the data. Models were compared with the likelihood ratio tests using the *Anova* function. For post-hoc comparisons of significant interactions the *lsmeans* package was used. Since for all dependent variables no significant differences were found between models including total scores of IRI and BVAQ and the models including their subscales, it was decided to refer to the models including the subscales to better identify the role of each subcomponent. Only the total score of the TAS-20 was inserted in the models because this questionnaire refers solely to the cognitive dimension of alexithymia (Bermond *et al.*, 2010). Best models are described in detail in the Results section. Trials with reaction times (RTs) more than 2 SDs above or below the individual mean were discarded from analyses.

3.3 Results

Moral choice was explained by the three conceptual factors but not by alexithymia or empathy

The best fitting model for the moral choice data included as predictors gender, affective and cognitive dimensions of the BVAQ questionnaire, the TAS-20, the four subscales of the IRI and the three conceptual factors (see Table 3.2 for β, z, p values and CIs). A significant main effect of personal force was found ($z(1885) = 6.54$, $p < .001$), which was due to more utilitarian responses occurring when the agent was only indirectly (impersonal dilemma) compared to directly (personal dilemma) involved in the harm-causing process. A significant main effect of benefit recipient ($z(1885) = 2.97$, $p = .003$) was explained by more utilitarian choices when decision maker's life was at risk (self beneficial dilemmas compared to other beneficial dilemma). Finally, a significant main effect of intentionality ($z(1885) = -4.07$, $p < .001$) reflected more utilitarian choices when the victim of the dilemma died as a non-desired side effect of the action (accidental dilemmas compared to instrumental dilemmas).

Table 3.2 *Summary of the best fitting LMM for moral (number of utilitarian) choices.*

Moral Choice	***β***	***SE***	***z value***	***p value***	***β exp***	***95%CI***	
Fixed effects						***Lower***	***Upper***
Gender (*Male*)	0.25	0.45	0.57	0.570	1.290	0.536	3.104
Affective component (BVAQ)	0.02	0.05	0.55	0.585	1.026	0.936	1.124
Cognitive component (BVAQ)	0.001	0.03	-0.01	0.989	1.000	0.933	1.071
TAS-20	-0.02	0.03	-0.61	0.542	0.983	0.930	1.039
PT (IRI)	-0.04	0.06	-0.69	0.487	0.960	0.855	1.077
PD (IRI)	0.03	0.04	0.71	0.479	1.028	0.953	1.109
EC (IRI)	-0.06	0.05	-1.16	0.244	0.939	0.844	1.044
FS (IRI)	0.04	0.05	0.78	0.435	1.043	0.938	1.160
Personal force (*Impersonal*)	0.71	0.11	6.54	**< 0.001**	2.031	1.642	2.512
Benefit recipient (*Self*)	0.32	0.11	2.97	**0.003**	1.374	1.114	1.694
Intentionality (*Instrumental*)	-0.48	0.12	-4.07	**< 0.001**	0.619	0.492	0.780

Note: β = estimate; SE = standard error; 95% CI = confidence interval; BVAQ = Bermond–Vorst Alexithymia Questionnaire; TAS-20 = 20-items Toronto Alexithymia Scale; IRI = Interpersonal Reactivity Index; PT = Perspective taking; FS = fantasy; EC = Empathic concern; PD = Personal distress; β exp = exponential of β coefficient. Significant p values are in bold. Reference condition for categorical factors is reported in italic inside bracket.

Higher fantasy and empathic concern increased dilemma unpleasantness

The best model for valence ratings included gender, the affective and cognitive dimensions of the BVAQ questionnaire, the TAS-20, the four subscales of the IRI, the three conceptual factors and type of moral choice (see Table 1B in Appendix B for *β*, *z*, *p* values and CIs). Lower valence ratings were linked to higher scores on the fantasy ($t(34) = -2.52$, $p = .02$) and the empathic concern ($t(34) = -2.11$, $p = .04$) subscales of the IRI. Moreover, lower valence ratings were found when dilemmas were personal ($t(1851) = 2.04$, $p = .04$), self-beneficial ($t(1851) = -3.28$, $p = .001$), or accidental ($t(1851) = 3.34$, $p < .001$), and when participants chose utilitarian compared to deontological options ($t(1851) = -3.68$, $p < .001$).

Higher empathic concern increased level of arousal

The model fitting best the arousal ratings was the same as for the valence including ratings gender, affective and cognitive dimensions of BVAQ questionnaire, the TAS-20, the

four subscales of IRI, type of moral choice and the three conceptual factors (see Table 2B in Appendix B for β, z, p values and CIs). Significantly higher arousal ratings were associated with higher scores on the empathic concern subscale ($t(34) = 2.36$, $p = .02$), and were found for self-beneficial ($t(1851) = 3.50$, $p < .001$), and accidental dilemmas ($t(1851) = -2.79$, $p = .005$), as well as when participants chose utilitarian responses ($t(1851) = 3.36$, $p < .001$).

Higher score at personal distress and TAS-20 biased SCR in opposite directions

The best model for SCR during dilemma presentation included as predictors gender, age, education, affective and cognitive dimensions of the BVAQ questionnaire, the TAS-20, the four subscales of the IRI, type of moral choice and the interaction among the three conceptual factors (see Table 3B in Appendix B for β, z, p values and CIs). Two significant main effects revealed that a greater SCR occurred in participants with high personal distress ($t(27) = 2.95$, $p = .006$) and low TAS-20 scores ($t(27) = -2.09$, $p = .04$). Moreover, a significant interaction was found between personal force and benefit recipient ($t(1015) = 2.14$, $p = .03$). Post-hoc comparisons revealed that SCR was greater during the impersonal, self-beneficial dilemmas compared to the impersonal, other-beneficial dilemmas ($t(1015) = -3.34$, $p = .005$) and to the personal, self-beneficial dilemmas ($t(1015) = -2.76$, $p = .029$).

Higher scores at empathic concern increased the rise-time of SCR, which indicates that the SCR needs more time to reach the peak

The best fit was found for a model including as predictors gender, age, education, affective and cognitive dimensions of BVAQ questionnaire, the TAS-20, the four subscales of the IRI, type of moral choice and the interaction among the three conceptual factors (see Table 4B in Appendix B for β, z, p values and CIs). A significant main effect of empathic concern was due to slower SCR rise-time in participants with high empathic concern ($t(28) =$

2.08, p = .04). A marginally significant main effect of Moral choice was also found (t(1682) = 1.86, p = .06, ns), due to slower SCR rise-time when participants chose utilitarian response. No other effect reached significance or trend level (all t < 1.7, all p > 1)

IHR was affected by dilemma conceptual factors and type of choice

The best fitting model included time windows 2-10, the affective and cognitive dimensions of the BVAQ questionnaire, the TAS-20, the four subscales of the IRI, type of moral choice and the three conceptual factors (see Table 5B of Appendix B). First, IHR was affected by the type of dilemma, as shown by 1) a significant main effect of benefit recipient (t(46512) = -6.45, p < .001), with lower IHR for self vs. other benefit dilemmas; 2) a significant main effect of Intentionality (t(46512) = -7.94, p < .001), with lower IHR during instrumental compared to accidental dilemmas; and 3) a marginal effect of personal force (t(46512) = 1.80, p = .07), due to lower IHR for personal compared to impersonal dilemmas. Second, IHR was affected by the type of Moral choice (t(46512) = -2.08, p = .04), and decelerated when participants chose utilitarian responses. Third, a time effect was present (see Figure 3.2). The IHR was decelerated during the entire trial (relative to the first time window). However, two phases could be distinguished. An initial deceleration peaked 16 seconds after dilemma onset (time window 4), and was followed by another acceleration towards the end of the dilemma presentation and throughout the question slide (time windows 7 - 10), as shown by exploratory t-tests (Time 4 vs 7: t(46512) = -3.57, p = .01; Time 4 vs 8: t(46512) = -5.69, p < .001; Time 4 vs 9: t(46512) = -4.60, p = .002; Time 4 vs 10: t(46512) = -5.99, p < .001).

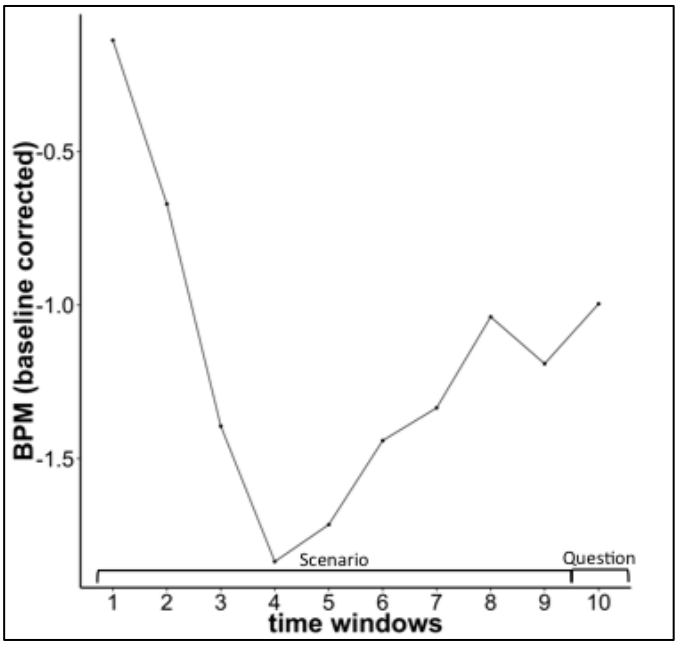

Figure 3.2 *IHR per time windows.*

3.4 Discussion

The present study investigated the influence of empathy and alexithymia on choices and emotional reactions in a moral decision task. It was found that empathy and alexithymia did not bias participants' moral choices, but both influenced their emotional reactions to moral decisions. However, while the influence of several empathy components was evident in both explicit and implicit measures of emotional reactions, alexithymia influenced, in the opposite direction, only SCR. These results confirm the nature of both the empathy and the alexithymia constructs and add new evidence to the field of moral decision-making.

Our first relevant result is that empathy and alexithymia were not significant predictors of moral choices. This unexpected result is in contrast with our hypotheses and with the existent literature (Sarlo et al., 2014; Koven, 2011; Patil & Silani, 2014b; 2014a; Gleichgerrcht & Young, 2013; Crockett et al., 2015; Crockett et al., 2010). However, some aspects need to be taken into account. One source of such inconsistencies could be that previous studies used task paradigms that differed in terms of instructions provided to the participants. For instance, in the majority of the studies that investigated the influence of

alexithymia on morality participants were asked to rate the appropriateness of an action (Koven, 2011; Patil & Silani, 2014b; 2014a). However, as argued in the introduction section, some differences could exist between the tasks tested in the current and previous experiments. Although it has been suggested that emotional involvement may be higher in moral decision compared to moral judgment tasks (Szekely & Miu, 2014; Tassy et al., 2013a), the question is far from being understood. For instance, a recent meta-analysis of 28 fMRI studies did not found a specific involvement of the ventromedial prefrontal cortex in moral decision-making tasks (Garrigan et al., 2016), an area associated with emotional processing (Öngür & Price, 2000; Rolls, 2007). Importantly, the results of the only study so far, in which a moral decision-making task was used to investigate alexithymia in morality (Patil et al., 2016), are consistent with the here presented evidence. Patil et al. (2016) enrolled participants with ASD and healthy participants. Even though the autistic individuals showed higher alexithymia scores compared to the healthy participants, they did not show differences in moral choices. Moreover, they did not report significant correlations between alexithymia and moral behaviour in healthy participants (Patil et al., 2016).

Only one study investigated the influence of empathy on moral decision-making in healthy participants (Sarlo et al., 2014). The authors found that personal distress, measuring the state of anxiety and discomfort prompted by others in need, was negatively associated with the number of utilitarian decisions. However, it should be noted that personal distress scores in Sarlo et al. (2014) were higher than in our sample (range 6-30 compared to 0-22 in our study), and this aspect may explain the contrasting results. Future studies should carefully consider participants' distribution in both alexithymia and empathy scores.

Secondly, while the influence of several empathy components was evident in both explicit and implicit measures of emotional reactions, the influence of alexithymia, going in the opposite direction, emerged only in the SCR.

Even though individual differences in empathy did not bias moral choices, empathy sub-components affected emotional reactions during the moral decision-making task, independently of the type of dilemma. In particular, the more participants showed a propensity to experience compassion and concern for others (empathy concern), the more they considered moral dilemmas arousing and unpleasant. Interestingly, valence ratings were also influenced by fantasy scores – an empathy component that measures the propensity of identifying with characters of books or movies. Even though this subscale was not correlated with valence or arousal ratings in a previous study (Sarlo et al., 2014), the here reported finding is in line with prior hypotheses. Indeed, participants were explicitly asked to "try to identify yourself with the characters of the stories", thus it was expected that the more they are able to imagine themselves in the described situation, the more they perceive the situation as unpleasant. This data confirms the dissociation between cognitive and affective empathy proposed by Sarlo et al. (2014), in modulating emotional reactions during moral decision-making. Furthermore, the influence of empathy on emotional reactions to moral decision was also evident considering implicit measures, in particular SCR. The arousal measured through SCR revealed that individuals presenting higher personal distress and higher empathic concern, both affective components of empathy, presented greater and slower SCR, indicating higher bodily arousal, than individuals with lower personal distress and empathic concern. This evidence confirms that the intensity of emotional reactions evoked by moral decision is biased by the individuals' urge to care for another's welfare.

Conversely, the influence of alexithymia was evident only when we considered an implicit measure of arousal. Participants with higher alexithymia showed lower SCR compared to those with lower alexithymia scores. This result is in line with previous studies and suggests that alexithymia is characterized by limited affective reactivity, or a condition of hypoarousal (Franz, Schaefer, & Schneider, 2003; Bermond et al., 2010a; Pollatos et al., 2011;

Neumann et al., 2004). No influence of alexithymia was observed in the valence and arousal ratings. This result does not confirm our hypothesis. However, it is in line with the reported discordance between physiological responses and self-report measures in alexithymia (Peasley-Miklus et al., 2016). This suggests that alexithymics' reports of emotional experience after moral choices may be based on what they know is socially acceptable (e.g. one should feel sorry for a certain type of situation) rather than on their psychophysiological reactions. As discussed by Peasley-Miklus et al. (2016), the inability of alexithymics' to describe their feelings may only become evident when they are requested to spontaneously describe their own emotional experiences, in which case it is more difficult to rely on external information.

Neither empathy nor alexithymia influenced IHR. However, a pattern of generalized deceleration was found during the first part of the dilemma presentation, probably due to the negative emotional state induced by the moral dilemmas (Palomba et al., 2000; Bradley, 2009) followed by a slight IHR acceleration. This pattern characterizes all type of dilemmas.

Results concerning the influence of the conceptual factors are in line with the previous literature. Participants provided more deontological responses when the moral dilemma was personal (Greene et al., 2004; Mendez et al., 2005; Koenigs et al., 2007; Greene et al., 2008; Moore et al., 2008; Greene et al., 2009; Moretto et al., 2009; Christensen et al., 2014), instrumental (Hauser et al., 2007; Greene et al., 2009; Sarlo et al., 2012; Christensen et al., 2014; Lotto et al., 2014), and/or self-beneficial (Moore et al., 2008; Christensen et al., 2014; Lotto et al., 2014). Generally, the more arousing and unpleasant a dilemma was perceived, as shown by the arousal and valence ratings and by the IHR modulation, the fewer utilitarian choices it induced. Personal dilemmas were considered more arousing and less pleasant than impersonal dilemmas and were characterized by less utilitarian responses (Greene et al., 2008; Greene et al., 2001; Greene et al., 2004; Shenhav & Greene, 2014; Koenigs et al., 2007; Moretto et al., 2009; Ciaramelli et al., 2007; Thomas et al., 2011; Christensen et al., 2014).

Similarly, self-beneficial dilemmas were considered more arousing and less pleasant, and resulted in fewer utilitarian responses than other-beneficial dilemmas (Bloomfield, 2007; Moore et al., 2008).

This study also provides new information about different cardiac modulations as depending on the moral conceptual factors: personal, self and instrumental dilemmas evoked greater deceleration in cardiac activity, a pattern that has been associated with negative emotional state (Bradley, 2009). In line with results of arousal and valence ratings, the analysis of IHR also confirms that utilitarian choices are those characterized by higher negative emotional reactions (Moretto et al., 2009), as they evoke greater deceleration in cardiac activity as well as higher unpleasantness and arousal ratings. These negative emotional reactions are those that discourage the selection of utilitarian options in future decisions.

In contrast with previous studies, in which the Intentionality factor was considered in relation to arousal and valence (Sarlo et al., 2012), we found that participants considered dilemmas in which the harm was a side-effect (accidental dilemmas) as more arousing and less pleasant compared to dilemmas in which the harm was deliberate and used instrumentally (instrumental dilemmas). Nevertheless, instrumental dilemmas evoked greater IHR deceleration, an index for unpleasant stimuli, and they resulted in a higher percentage of utilitarian responses than accidental dilemmas. This unexpected pattern in affective ratings for the intentionality factor has been found also in other studies (Lotto et al., 2014; Christensen et al., 2014). In Lotto et al. (2014), accidental dilemmas were rated as more arousing than instrumental dilemmas even though participants gave more utilitarian responses for accidental than instrumental dilemmas. Lotto et al. (2014) argued that during the evaluation of accidental dilemmas participants are focused on the computation of the ratio between costs and benefits of the harmful action instead of the emotional conflicts typical of

the instrumental dilemmas. The more arousing the dilemmas are, the greater the effects of the attentional processing (Lotto et al., 2014). In the second study (Christensen et al., 2014), the accidental harm was rated as more unpleasant and more arousing than instrumental harm only when the dilemma was self-beneficial. According to the authors, this is due to a consequence of the less conflicting experience that characterizes the self-benefit dilemmas. Our result clearly supports the theory proposed by Lotto et al. (2014) and it points out a peculiar characteristic of the intentionality factor: since the instrumental dilemmas evoke very strong emotional reactions, participants choose deontological responses; on the other hand, as accidental dilemmas do not lead to strong emotional engagement, participants are freer to think about the consequences of the actions. Arousal and valence ratings reflect a greater cognitive effort.

In conclusion, the evidence that empathy and alexithymia did not bias moral decisions seems to suggest that participants, when asked to perform a moral decision-making task, rely less on the perception of their own emotions than previously suggested for moral judgment, and more on reasoning about the information provided by the dilemmas. However, individual differences in empathy or alexithymia influence emotional reactions to moral dilemma, in both self-report measures of arousal and valence and implicit arousal (in the case of empathy) or only in implicit arousal (in the case of alexithymia). These findings reinforce the view that interactions between individual differences in emotional awareness and moral decision-making are very complex and need to be addressed further and taken in consideration in future studies on moral decision-making.

CHAPTER 4

Relative contribution of odour intensity and valence to moral decision

Abstract

Meta-analytic evidence showed that the chemical senses preferentially affect moral decisions. However, how odours impact on morality is currently unclear. Through a set of three studies, we aim at assessing whether and how odour intensity biases moral choices (Study 1a), its psychophysiological correlates (Study 1b), as well as the behavioural and psychophysiological effects of odour valence on moral choices (Study 2). Study 1a suggests that the presence of an odour plays a role in moral choice, when particular dilemma features are present (e.g., others as benefit recipients). Study 1b reveals that of two iso-pleasant versions of the same neutral odour, only that presented sub-threshold (vs. supra-threshold) favours deontological moral choices. As expected, this odour intensity effect is tracked by skin conductance responses, whereas no difference in cardiac activity – proxy for the valence dimension - is revealed. Study 2 suggests that the same neutral odour presented sub-threshold increases deontological choices even when compared to iso-intense ambiguous odour, perceived as pleasant or unpleasant by half of the participants, respectively. Skin conductance responses, as expected, track odour pleasantness, but cardiac activity fails to do so. Results are discussed in the context of mechanisms underlying moral choices alternative to disgust induction.

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4.1 Introduction

The chemical senses have proven to be ideal model systems to disentangle the role of arousal and valence (Anderson, Christoff, Stappen *et al.*, 2003; Winston, Gottfried, Kilner *et al.*, 2005), the two core dimensions of affective experiences (e.g., Lang, 1995). Indeed, odours (as well as flavours) can be described based on their intensity (a proxy for arousal, Bensafi, Rouby, Farget *et al.*, 2002) and - perhaps more often - based on their hedonic value (or valence, Yeshurun & Sobel, 2010). Beyond the modulation of subjective experiences, odour intensity and valence induce changes in a variety of physiological and behavioural processes. For instance, Bensafi and colleagues (2002) report that skin conductance variations track odour intensity, heart rate variations track odour pleasantness and the two indices highly correlate. Furthermore, odour intensity judgements affect cross-modal perception (i.e., color lightness, Kemp & Gilbert, 1997; sweetness, Stevenson, Boakes, & Prescott, 1998), whereas odour valence is able to promote mood changes (Chen & Haviland-Jones, 1999).

The study of the effects of odour intensity and valence has mostly focused on perceptual issues, and only recently it has moved towards the impact that such olfactory dimensions have on higher cognitive functions (Yeshurun & Sobel, 2010; Mainland, Lundström, Reisert *et al.*, 2014). Few attempts have been recently produced in the context of decision-making processes. In real life situations, intensity-controlled, pleasant ambient odours promote positive emotions in consumers and bias their decision making processes towards spending (Chebat & Michon, 2003). In the lab, Bonini and colleagues (2011) revealed that male participants exposed to a disgusting odour increased cooperation during the Ultimatum Game, suggesting that the disgust felt for poor offers was misattributed to the odour, rather than to the offer itself (Bonini, Hadjichristidis, Mazzocco *et al.*, 2011). As the meta-analysis by Landy and Goodwin (2015) suggests, the most interesting attempts at evaluating chemosensory effects on decision processes refer to the moral domain. Their

analysis showed that olfactory (and gustatory) induction of disgust produced stronger amplification effects in moral behaviour as compared to the induction of disgust through videos or images. However, the number of studies inducing disgust through chemosensory stimuli is disproportionately smaller (3 published studies) than the number of studies including visual induction of disgust (12 published studies). With specific reference to the olfactory modulation of moral behaviours, Inbar, Pizarro, and Bloom (2012) reported that a disgusting odour (vs. no odour) lead participants to evaluate gay men more negatively, whereas both Schnall and colleagues (2008) and Ugazio and co-workers (2012) used commercially available "fart spray" to prime disgust in participants while they rated four vignettes requiring either a moral judgment (Schnall, Haidt, Clore *et al.*, 2008) or while they judged the permissibility of some moral scenarios (Ugazio, Lamm, & Singer, 2012). In Schnall *et al.* (2008), authors assigned participants to one of three olfactory conditions (no vs. four vs. eight sprays applied). After they completed the task, they were asked to rate how disgusted they felt and whether they were consciously aware of the unpleasant odour presence. Participants were significantly more disgusted in the strong odour condition than in the other two conditions and the more participants experienced olfactory-triggered disgust, the more severely they judged the proposed vignettes (Schnall *et al.,* 2008). Ugazio *et al.* (2012) used the same procedure as in Schnall *et al.,* (2008), but with less intense odour stimulations (only 2 sprays applied), which lead to the disappearance of a disgust effect.

Taking a chemosensory standpoint, some considerations are in order. First, the comparison of Schnall *et al.* (2008) results with Ugazio *et al.* (2012) suggests an interesting possible modulation of moral behaviour based on odour intensity, aspect tightly linked to the awareness of the odour (Smeets, Schifferstein, Boelema *et al.*, 2008). Indeed, Schnall *et al*. (2008) showed significant modulation of moral behaviour when participants were exposed to an odour that was consciously perceivable (especially in the strongest condition – 8

sprays), whereas Ugazio *et al.* (2012) failed to find such effect with lower intensities of the odour (2 sprays). Second, the use of disgusting odours based on the emotional congruency with moral disgust promoted the testing of negative odours only (e.g., Schnall *et al*., 2008; Ugazio *et al*., 2012). As revealed by Winston and colleagues (Winston *et al.,* 2005), the interdependent nature of odour intensity and odor pleasantness is reflected at the level of judgments and physiological correlates. Altogether this evidence calls for an extension of the exploration of the olfactory effects on moral behaviours that goes beyond negative odours. Moreover, studies that encompass neutral and pleasant odours are needed in order to disentangle the role played by valence as well as by multimodal stimulations. Third, the evaluation of the odour stimuli, their delivery (e.g., (Lundström, Gordon, Alden *et al.*, 2010)) and the inclusion/exclusion criteria of participants (Boesveldt, Lindau, McClintock *et al.*, 2011), an aspect generally neglected in the moral literature - should be promoted as to reduce potential confounding effects.

In order to shed light on the effects that arousal and valence of olfactory stimuli might have on moral behaviours, we designed three studies in which normosmic participants were asked to perform a moral decision-making task in the presence of different odour conditions. In line with previous Chapters, we asked participants to perform a moral decision-making task. According to the most influential theory (the dual process model; e.g., Greene, 2009), moral choices are driven by the interaction between two competing processing systems mediated by partially dissociable neural networks. First a fast, automatic emotional system that leads to the fast, intuitive deontological choice, which is based on the idea that an individual's principle should not be infringed, even when the welfare of a greater number of people is at stake. However, this intuitive choice needs to be overridden by cognition through executive function to choose an utilitarian response. This is based on the idea that it is acceptable to cause harm to a few for a greater good, and following a cost-benefit analysis, it

reduces the overall harm produced across the options. In this sense, utilitarian option is the one that required more cognitive resources (Greene, Morelli, Lowenberg et al., 2008; Van Dillen, van der Wal & van den Bos, 2012) to contrast emotional, intuitive answers, but it is also the option that evoke higher negative emotional reactions because of the involvement of immoral act (e.g. kill one person; Moretto, Ladavas, Mattioli, *et al*., 2009).

Additionally, as seen in Chapters 2 and 3, emotional reactions depend also on the nature of the moral dilemmas. For example, dilemmas could be defined as *personal* or *impersonal.* An example of personal dilemmas is the *Trolley* dilemma (Foot, 1967), in which a runaway trolley is about to run over and kill five people. To save the group of five participants have to hit a switch that will turn the trolley onto a side-track. This act will cause the death of the one person, standing on the track. An example of impersonal dilemmas is the *Footbridge* dilemma (Thomson, 1976), in which participants can save the five by pushing a big man off an overpass onto the track below. The man will die but the five people will be saved. Personal dilemmas tend to elicit stronger emotional responses and participants give more deontological answers compared to impersonal dilemmas (Greene, Nystrom, Engell *et al.*, 2004; Koenigs, Young, Adolphs *et al.*, 2007; Greene *et al.*, 2008; Greene, Cushman, Stewart *et al.*, 2009).

In light of the scarcity of evidence on the effects produced by olfactory stimuli on other types of moral behaviours (e.g., moral judgement, Inbar *et al*., 2012; Schnall *et al.*, 2008; Ugazio *et al.*, 2012), we set out to test a series of hypotheses on whether and how odour intensity and odour valence affect moral choice.

In Study 1a and 1b we will test the role of odour intensity across iso-pleasant stimuli in impacting moral choice. Specifically, we will assess whether the supra-threshold vs. sub-threshold versions of a neutral odour will comparably modulate moral choice tendencies, with respect to a no-odour condition. Three hypotheses are proposed. First, a neutral odour

condition, irrespective of its intensity, might increase deontological responses due to the activation of limbic areas through olfaction (Zald & Pardo, 1997). Indeed, the olfactory and limbic system share common areas (e.g amygdala, insula, anterior gyngulate cortex, and orbitofrotal cortex; Soudry, Lemogne, Malinvaud *et al.,* 2011) and, in particular, a previous study has showed that odor intensity is associated with amygdala activation (Anderson *et al.,* 2003). Second, if only the supra-threshold odour condition will produce an increase of deontological responses, compared to the sub-threshold odour, we could suggest that an olfactory stimulus needs to be presented in high concentration to affect moral behaviour. Third, if the sub-threshold condition selectively increases the number of deontological responses, we hypothesize that this effect is due to the bypassing of strategic control of irrelevant sensory information, due to insufficient sensory inputs (Li *et al*., 2007). In other words, lower concentrations of an olfactory stimulus, possibly by the effect of lack of awareness, may be key to the emergence of deontological moral choices.

In Study 1b, we will try to conceptually replicate the above study in an independent group of participants and, additionally, we will collect psychophysiological responses to implicitly assess the intensity and valence effects of olfactory stimuli during moral decisions. We foresee that, beyond the arousal induced by the processing of the moral dilemma, odour intensity will be tracked by skin conductance (SCR) measurements, showing an increased activity in the supra-threshold odour condition compared to sub-threshold and no odour conditions, respectively. This effect should be evident for both utilitarian (more arousing) and deontological choices (less arousing, Moretto *et al*., 2009). Given that odour valence is expected to be equivalent between sub- and supra-threshold odour conditions, we do not foresee modulations at the level of instantaneous heart rate (IHR; Palomba, Sarlo, Angrilli *et al.*, 2000), an implicit valence index (Bradley, Codispoti, Cuthbert *et al.*, 2001; Bradley, Greenwald & Hamm, 1993; Palomba, Angrilli & Mini, 1997). In line with previous literature on

pleasant and unpleasant stimuli (Palomba *et al.*, 2000), we foresee a greater deceleration of IHR for deontological rather than utilitarian choices.

In Study 2, we will test the role of valence in iso-intense olfactory stimuli. We will compare the modulatory effect of neutral, pleasant and unpleasant odour on moral tendencies. Since it has been shown that an ambiguous odour can be perceived as either pleasant or unpleasant (de Araujo, Rolls, Velazco et al., 2005), we presented a group of participants with the same ambiguous odour (butyric acid) and we then split them in two groups, based on their reported pleasantness evaluation. Following previous studies on morality and induced affective states (Valdesolo & DeSteno, 2006; Schnall et al., 2008; Youssef, Dookeeram, Basdeo et al., 2012b; Pastötter, Gleixner, Neuhauser et al., 2013), we outline three alternative hypotheses, the first in which odour valence is not critical to moral choice, and the latter two in which it is. First, if odour valence is not critical to moral choice, then the presence of a pleasant, unpleasant or neutral odour, irrespective of its valence, may increase deontological choices as compared to the no odour condition. Second, we hypothesize a generalized effect of valence (as in Seubert, Kellermann, Loughead *et al.*, 2010), emerging as an increase of deontological responses for the pleasant and unpleasant odour, as compared to the neutral and no odour conditions. Third, if disgust is critical to moral decisions, as suggested elsewhere (e.g., Chapman, Kim, Susskind *et al.*, 2009; Rozin, Haidt, & Fincher, 2009), we expect an inverse relationship between odour pleasantness and the increment in deontological choices (e.g., the less pleasant the odour, the more deontological choices). At the psychophysiological level, we expect SCR to track the effects of odour pleasantness (Bradley, 2009), and also to reflect decreased arousal in association with deontological moral choices. With respect to the IHR, we foresee the unpleasant odour to produce the maximal decrease in IHR, as compared to the neutral and pleasant odour, respectively.

Finally, previous literature has shown that moral choices are modulated also by individual variability in emotions recognition (Koven, 2011; Patil & Silani, 2014b; 2014a), sensitivity to disgust (Schnall *et al.*, 2008; Choe & Min, 2011; Ugazio *et al.*, 2012), autistic traits (Moran, Young, Saxe *et al.*, 2011; Buon, Dupoux, Jacob *et al.*, 2013), and anxiety (Starcke, Wolf, Markowitsch *et al.*, 2008; Youssef *et al.*, 2012a). To control for this variability, we will ask participants to complete questionnaires that measure these individual traits. Moreover, since our hypothesis is that the attention that people address to odours could modulate the effects that odours might have on moral choices, our participants will perform also the questionnaire for the awarness of odour in the environment (Smeets *et al.*, 2008).

4.2 Study 1a – Does odour intensity affect moral choice?

4.2.1 Material and methods

Participants

Seventeen participants were included in Study 1a, based on their eligibility according to the following exclusion criteria: history of neurological or psychiatric disorders, being an active smoker, using psychopharmacological substances or other systemic medications, having experienced a head trauma leading to unconsciousness, score less than 10 at the Sniffin Sticks Identification test (Hummel, Sekinger, Wolf *et al.*, 1997). Please, refer to Table 4.1 for details on the participants' characteristics. The local University Ethics Committee approved all studies, which were in accordance with the Declaration of Helsinki and informed written consent was obtained from each participant.

Table 4.1 *Summary table of demographic characteristics and questionnaires of Study 1a and 1b.*

	Study 1a Mean (SD)	**Range**	**Study 1b Mean (SD)**	**Range**
N°	17		15	
Gender	9 Females	-	11 Females	
Age	23.23 (3.25)	18 - 32	23.13 (1.62)	20 - 26
Education	16.18 (1.28)	11 - 18	16.47 (1.55)	13 - 18
Threshold test	12.53 (1.69)	8.5 - 15.5	7.90 (0.90)	6 - 9.25
Identification test	12.23 (1.52)	10 - 14	12.87 (1.26)	10 - 15
BVAQ	42.59 (7.04)	28 - 53	42.13 (5.09)	34 -49
DS	16.17 (5.43)	7.5 - 25	16.03 (3.38)	10 - 21.5
STICSA (Trait)	34.18 (6.64)	25 - 49	36.71 (7.40)	24 - 50
AQ	17.94 (5.37)	10 - 30	18.50 (4.45)	11 - 27
OAS	122.82 (12.75)	101 - 142	117.07 (17.29)	80 - 138
STAI (State - PRE)	40.18 (4.36)	27 - 45	34.33 (7.58)	21 - 51
STAI (State - POST)	41.00 (4.73)	33 - 47	36.20 (5.49)	27 - 47

Note: *BVAQ = Bermond–Vorst Alexithymia Questionnaire; DS = Disgust Scale; STICSA = State Trait Inventory for Cognitive and Somatic Anxiety; AQ = Autism-Spectrum Quotient; OAS = Odour Awareness Scale; STAI (State) = State–Trait Anxiety Inventory; POMS = Profile of Mood States.*

Self-report questionnaires

The following *paper and pencil* questionnaires were administered to assess interpersonal characteristics that have shown to affect moral decisions: Bermond–Vorst Alexithymia Questionnaire, form B (BVAQ-B; Bermond & Oosterveld, 1994) was used to assess Alexithymia; Disgust Scale (DS; Rozin, Haidt, McCauley *et al.*, 1999) was used as measure of the individual differences in sensitivity to disgust; the *Trait scale* of the State Trait Inventory for Cognitive and Somatic Anxiety (STICSA; Ree, French, MacLeod *et al.*, 2008) to assess anxiety at trait level; the Autism-Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner *et al.*, 2001) to measure the degree of presence of traits associated with the autism spectrum; the Odour Awareness Scale (OAS; Smeets *et al.*, 2008) to measure individual differences in awareness of odours in the environment; the State subscale of the State–Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1968). STAI State was performed

on the computer both before and after the moral decision-making task, and a differential score STAI State post-pre was created and introduced in the analyses.

Odour stimuli

Three odour conditions were used in the task of both studies: no odour, sub-threshold neutral odour and supra-threshold neutral odour (Cedarwood oil; Sigma-Aldrich, Italy). This odour was selected on the basis of on a pilot Study (N = 53) showing that its 100% concentration was perceived as a neutral odour (valence rating, M = 5.0; SD = 2.76 on a scale ranging from 1 to 10). Detection thresholds were determined using a 2-alternative forced-choice (2AFC) ascending staircase paradigm with 7 reversals and no feedback (Doty, 1991; Lundström, McClintock, & Olsson, 2006; Lundström, Boyle & Jones-Gotman, 2008). Each trial included one target (a bottle with the odour in diluent) and one control stimulus (a bottle with only diluent). Odour was presented in ascending concentrations until the participant discerned correctly the odour in two successive trials, which triggered a reversal. Mineral oil (Sigma-Aldrich, Italy) was used as diluting agent to create all the concentrations of the odour threshold test necessary to determine the sub- and supra-threshold stimulus for each participant. The dilution series was prepared starting from 100% volume to volume (v/v) in liquid phase of cedarwood oil. From there, the odour was diluted in 16 consecutive dilution steps using a 0.5 volume dilution series (end concentration 0.00305% v/v). Two series of the odour were prepared and used to allow the odour to saturate the headspace between potential repetitions of the same dilution step. Each dilution step and the matched diluent only were delivered using amber 2 oz glass bottles, all visually identical and containing 10 mL of liquid each. Detection threshold was defined as the geometric mean of the last 4 reversals. One step below and above the detection threshold was considered as odour concentrations for sub- and supra-threshold conditions, respectively.

Moral dilemmas

Visual stimuli for both studies were 48 moral dilemmas, selected from the 4CONFiDe moral set (Chapter 2). In this study all the four conceptual factors were considered (Personal force; Intentionality; Benefit recipient; Evitability). As for Chapter 3, 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, plus a hypothetical action that would save these people but harm others. The second screen presented the question. Participants had to choose between four options. However, as done in Chapter 3 the analysis were performed on the dichotomized responses: the first choice is considered to be utilitarian, whereas the second choice was considered deontological. The moral tendency of each participant is based on the relative frequency of these reciprocal choices. Dilemmas were presented using black font color (font: Calibri, size: 24) against a white background on a 19-inch computer screen at a viewing distance of 60 cm. Stimulus presentation was delivered with E-prime 2.0 software (Psychology Software Tools, Pittsburgh, PA).

Procedure

Upon arrival, each participant was seated in a quiet room and asked to complete the self-report questionnaires, the odour identification test (Hummel *et al.*, 1997) and the odour detection threshold test. Afterwards, participants were asked to seat in front of a computer screen and they performed a practice session (2 moral dilemmas) and then the moral decision-making task. The instruction given to participants was the same described in Chapter 2. Each trial began with a white screen presented for 4 sec followed by a black and green crosses displayed respectively for 6 sec (jittered) and 0.5 sec. Successively, the scenario was presented, displayed until the participants' click of the mouse, followed by a white screen during which the odour was released for 3 sec. Odours were presented birhinally using a

computer-automated olfactometer delivering odours in a temporally-precise, square-shaped manner (Lundström *et al.*, 2010). A low birhinal flow rate of 3.0 L/m (a total of 1.5 L/m per nostril) for a total duration of 3 sec per stimulus was used to prevent irritation of the nasal mucosa over time (Lötsch, Ahne, Kunder *et al.*, 1998; Lundström *et al.*, 2010). After each odour presentation, clean air was presented to minimize odour residuals (Seubert, Gregory, Chamberland *et al.*, 2014; Parma, Ferraro, Miller *et al.*, 2015), while the question slide was presented. The two choice options were displayed below the question. Participants were instructed to make their choice as fast as possible but there was no time restriction. Following every answer, two rating slides were presented. Participants rated how arousing and pleasant the odour was on a 10-cm Visual Analog Scale (VAS). Higher scores indicate greater arousal and pleasantness. Participants were instructed to answer even if they did not perceive any odour within a 6-s time window/rating. Dilemmas were presented in three blocks of 16 trials (a total of 48 trials/subject), in which odours were presented in an event-related manner. Participants were allowed to take a short break at the end of each block. At the end of the moral decision-making task, participants completed the second version of the STAI State.

Statistical Analysis

As for previous studies described in Chapters 2 and 3, data were analyzed with linear mixed-effects models (LMMs). All models included odour factor, as the main interest of our analysis, and the four conceptual moral factors (Personal force, Intentionality, Benefit recipient, Evitability), as factors describing our items. Moreover, for each dependent variable, at the beginning, all self report questionnaires, relative to our participants traits, and second-level interactions as fixed effects was built, were included (Crepaldi *et al.,* 2012; Wehling *et al.*, 2016; McLean, Sanders, & Stroup, 1991; Faraway, 2005) 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). Final models are described in detail in the results sections. Outliers with respect of reading times and reaction times were removed considering the outlier-labelling rule (Hoaglin, Iglewicz, & Tukey, 1986). From a starting number of 816 trials, 19 trials were removed because of extremes reading times (>49.27 second; N = 19/816, 2.32%) while 33 trials were removed because of extremely long choice reaction times (>9.25 seconds; N = 33/797, 4.14%).

4.2.2 Results

Sub- and supra-threshold odour conditions do not differ in arousal and valence ratings

The LMM on arousal ratings (no-odour: M = 7.22, SD = 0.07; sub-threshold neutral odour: M = 7.08, SD = 0.07; supra-threshold neutral odour: M = 7.02, SD = 0.07; Figure 4.1A) showed no significant differences across odour conditions (all $t < 1.3$, all $p > 0.2$). Please refer to Table 1C of Appendix C for descriptive data.

The LMM on valence ratings (no-odour: M = 4.76, SD = 0.06; sub-threshold neutral odour: M = 4.68, SD = 0.06; supra-threshold neutral odour: M = 4.45, SD = 0.07) revealed no significant difference between sub- and supra-threshold odour condition and between sub-threshold and no-odour conditions (all $t < 0.7$, all $p > 0.1$; Figure 4.1B). Considering no-odour condition as reference the model showed a significant difference between supra-threshold and no-odour conditions [$t(745) = -2.22$, $p = .03$]

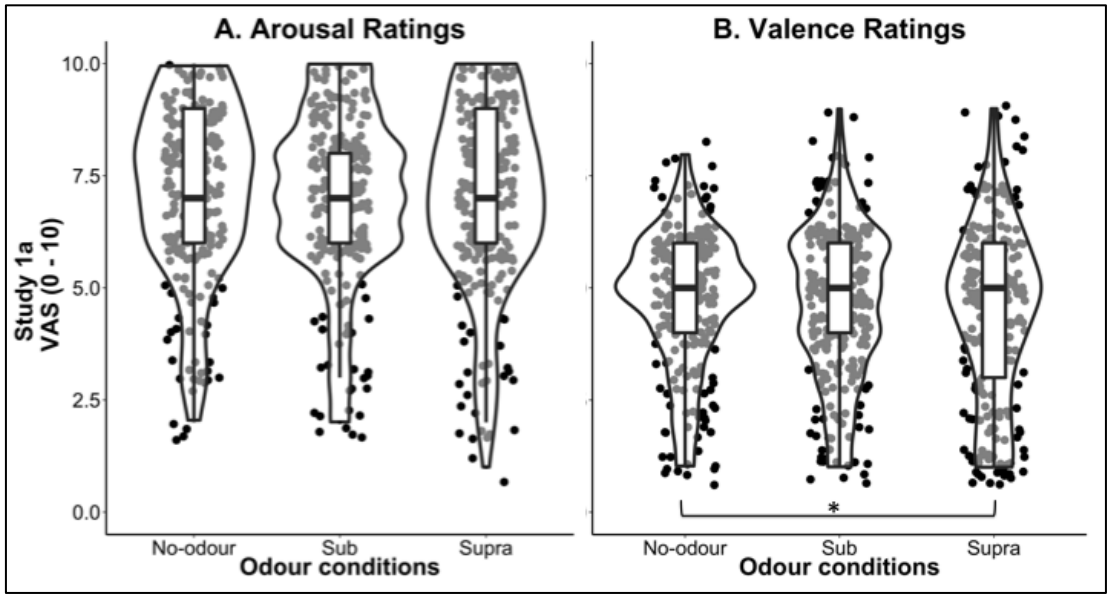

Figure 4.1 *Panel A) distribution of participants' arousal odour ratings of Study 1a. Panel B) distribution of participants' valence ratings of Study 1a. The black dots represent the value of each participant's rating, per odour condition, whereas the box-plot represents the interquartile range of each 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.*

Sub-threshold neutral odour increases deontological choices

The best fitting model for moral choice data (reference factor: utilitarian choice) resulted being the one including the odour factor ($p < 0.001$), personal force ($p < 0.001$), intentionality ($p < 0.001$), benefit recipient ($p = 0.04$), evitability ($p = 0.38$), the interaction of odour and each of these three factors, and the scores at AQ ($p = 0.001$), DS ($p = 0.001$) and STAI ($p = 0.03$; see Table 4.2 for descriptive data of single parameters). No effect of single odour conditions on moral choice was retrieved (all $z < 0.3$, all $p > 0.2$). However, odour significantly interacted with the dilemma factor personal force (reference factors: sub-threshold odour and personal). Post-hoc tests (lsmeans function) revealed a selective effect of odour on impersonal dilemmas. Specifically, the supra-threshold odour condition, as compared to the no-odour condition, significantly increased the number of deontological choices to impersonal dilemmas ($p = .02$). The sub-threshold odour showed a significant effect

in the same direction (sub-threshold vs. no odour, p = .04). However, no other contrasts reached the significance level. Additionally, odour significantly interacted with the dilemma factor intentionality (reference factors: sub-threshold odour and accidental). Post-hoc tests (lsmeans function) showed a selective increase of deontological responses on instrumental dilemmas following the exposure to the supra-threshold odour (vs. no-odour, p = 0.01) and following sub-threshold odour (vs. no-odour, p = 0.001). Finally, the factor odour interacts with the benefit recipient factor (reference factors: sub-threshold odour and other). Post-hoc tests (lsmeans function) showed a selective increase of deontological responses on other-recipient dilemmas following the exposure to the sub-threshold odour (vs. no-odour, p = 0.04). Irrespective of the odour, the likelihood of choosing the deontological option increased when dilemmas were personal (vs. impersonal), instrumental (harm was intentional vs. accidental), and other-benefit (vs. self-benefit), with reduced autistic traits (i.e., lower AQ scores), increased anxiety (i.e., greater STAI scores) and increased disgust sensitivity (i.e., greater DS scores).

Table 4.2 *Summary of the best linear mixed effects model on moral choices for Study 1a.*

Moral choices	***β***	***SE***	***z value***	***p value***	***βexp***	***95%CI***	
Fixed effects						***Lower***	***Upper***
Intercept	0.01	0.81	0.02	0.987	1.013	0.206	4.971
No-Odour	0.10	0.52	0.19	0.852	1.101	0.401	3.022
Supra-threshold Neutral Odour	-0.34	0.58	-0.58	0.563	0.713	0.227	2.243
Personal force (*Impersonal*)	-0.81	0.32	-2.52	**0.012**	0.447	0.239	0.835
Intentionality (*Instrumental*)	1.20	0.33	3.58	**<0.001**	3.316	1.721	6.392
Benefit recipient (*Self*)	-0.83	0.31	-2.65	**0.008**	0.437	0.237	0.806
Evitability (*Inevitable)*	-0.35	0.33	-1.08	0.281	0.704	0.372	1.333
AQ	-0.15	0.04	-3.69	**<0.001**	0.859	0.792	0.931
DS	0.17	0.04	3.73	**<0.001**	1.182	1.082	1.290
STAI trait difference	0.06	0.03	2.24	**0.025**	1.063	1.008	1.121
No-Odour* Personal force (*Impersonal*)	-1.57	0.60	-2.63	**0.009**	0.209	0.065	0.672
Supra-Odour* Personal force (*Impersonal*)	0.23	0.44	0.52	0.603	1.260	0.527	3.011
No-Odour* Intentionality (*Instrumental*)	-1.19	0.49	-2.44	**0.015**	0.305	0.118	0.791
Supra-Odour* Intentionality (*Instrumental*)	-0.43	0.45	-0.95	0.343	0.652	0.269	1.578
No-Odour* Benefit recipient (*Self*)	0.75	0.43	1.72	0.085	2.111	0.902	4.944
Supra-Odour* Benefit recipient (*Self*)	1.17	0.52	2.25	**0.024**	3.224	1.164	8.927
No-Odour* Evitability (*Inevitable*)	0.38	0.45	0.84	0.399	1.457	0.607	3.498
Supra-Odour* Evitability (*Inevitable*)	-0.28	0.57	-0.50	0.619	0.752	0.246	2.305

Note: β = estimate; SE = standard error; CI = confidence interval; β exp = exponential of β coefficient; Sub-threshold Odour = sub threshold neutral odour condition; Supra-threshold Odour = supra threshold neutral odour condition; DS = disgust scale; STAI = State subscale of the State–Trait Anxiety Inventory; AQ = Autism-Spectrum Quotient. Significant p values are reported in bold. Table shows model with utilitarian choice and Sub-threshold odour condition set as references. Contrast condition from the reference for categorical factors is reported in italic inside bracket.

4.2.3 Discussion

Study 1a was designed to investigate whether moral decision-making is biased by different intensities of an emotionally-neutral olfactory stimulus, either supra-threshold sub-threshold intensities. Subjective ratings of arousal and valence did not reveal any difference between sub and supra-threshold odour conditions but only between no-odour and supra-odour conditions for valence ratings. The homogeneity in the arousal ratings might indicate that sub- and supra-threshold odour conditions were not sufficiently different at the perceptual level. This might justify the lack of main effect of odour on deontological response rate. This data seems to support our first hypothesis, stating that odour intensity does not critically modulate moral choice, perhaps because neutral odours are not inducing a disgust reaction in the decision maker. If this were completely true, no odour effect on moral choice should be present. However, results of Study 1a reveal three odour-dilemma factor interactions. First, both supra-threshold and sub-threshold odour conditions increase the choice of deontological responses, but such effect is confined to impersonal and instrumental dilemmas. Second, the sub-threshold odour increases deontological responses only for dilemmas in which other benefit from the moral choice. Altogether this data advocates that the odour – irrespective of its intensity – increases deontological responses to the dilemmas perceived as less arousing (Lotto, Manfrinati, & Sarlo, 2014; Moore *et al.*, 2008; Christensen *et al.,* 2014).

In line with previous literature, participants provided more deontological responses when the moral dilemma was personal (Greene *et al.*, 2004; Mendez, Anderson, & Shapira, 2005; Koenigs, Young, Adolphs *et al.*, 2007; Greene *et al.*, 2008; Moore, Clark, & Kane, 2008; Greene, Cushman, Stewart *et al.*, 2009; Moretto, Làdavas, Mattioli *et al.*, 2009; Moore, Lee, Clark *et al.*, 2011; Christensen *et al.*, 2014), accidental (Borg, Hynes, Van Horn *et al.*, 2006; Cushman, Young, & Hauser, 2006; Hauser, Cushman, Young *et al.*, 2007; Moore *et al.*, 2008;

Greene *et al.*, 2009; Sarlo, Lotto, Manfrinati *et al.*, 2012; Christensen *et al.*, 2014; Lotto *et al.*, 2014), and/or self-beneficent (Moore *et al.*, 2008; Christensen *et al.*, 2014; Lotto *et al.*, 2014).

Moreover, according to the literature, we confirmed that the deontological moral tendency is reduced in individuals reporting autistic traits (Moran, Young, Saxe *et al.*, 2011; Buon, Dupoux, Jacob *et al.*, 2013 but see Patil, Melsbach, Hennig-Fast *et al.*, 2016), higher anxiety (Starcke, Wolf, Markowitsch *et al.*, 2008; Youssef *et al.*, 2012a) and increased in those exhibiting higher disgust sensitivity (Schnall *et al.*, 2008; Choe & Min, 2011; Ugazio *et al.*, 2012 but see Ong, O'Dhaniel, Kwok *et al.*, 2014).

In light of the lack of significant effects between sub- and supra-threshold arousal ratings, in the next study we will assess the hypotheses tested here in an independent sample of participants, incrementing the concentration difference between sub- and supra-threshold odour conditions. Furthermore, we will extend the evaluation of odour-induced arousal and valence effects to physiological reactions, known implicit indicators of emotional experiences (e.g., Lang, 1995).

4.3 Study 1b – Does odour intensity affect the psychophysiological correlates of moral choice?

4.3.1 Material and methods

Participants

Fifteen participants were included in Study 1b. All screening procedures were the same as Study 1a. See Table 4.1 for participants' characteristics.

Stimuli

The same moral dilemmas, odour conditions, as well as the procedure for establishing odour concentrations used in Study 1a were used in Study 1b. As to avoid the distribution of

odour thresholds across participants being skewed towards one end of the intensity scale, the average threshold found for Study 1a was centered on the dilution series scale. In this way, the dilution series in Study 1b was prepared using 12.5% v/v as dilution starting point. From there, the odour was diluted in 16 consecutive dilution steps using a 0.5 volume dilution series (end concentration 0.00038% v/v). To increase the perceptual distance between odour conditions, two steps below and two above the detection threshold of each participant were considered as odour concentrations for sub- and supra-threshold conditions, respectively.

Procedure

The procedure and task was the same as in Study 1a except for the following improvements. SCR electrodes and the photoplethysmographic probe to measure cardiac activity were attached ~10min before the beginning of the tasks and ~1min of baseline was recorded at the beginning of first block. To avoid fatigue effects due to a long experimental session, we presented the odour ratings at the beginning and at the end of the moral decision-making task. Each odour presentation was preceded by a green fixation cross on the screen for 0.5 sec followed by a black screen while an odour was presented for 4 sec; a white screen followed for an average inter-stimulus interval of 6 sec (± 0.12 sec). Subsequently, three questions were asked in random order, namely "How intense was the odour you just smelled?" and "How pleasant was the odour you just smelled?". Perceptual ratings for odour intensity and pleasantness were collected on a 10-cm computerized VAS, ranging from "not at all" to "very much". Participants were instructed to answer even if they did not perceive odour. In the moral decision-making task, the scenario was presented for a fixed time (10 sec) plus the time needed by participants to complete reading the slide. Moral decisions were timed to a maximum of 6 seconds.

Psychophysiological Data Acquisition and Analysis

SCR and HR were recorded with a *PROCOMP infiniti system* (Thought Technology, Montreal, Canada). SCR was recorded using a pair of prewired 8 mm Ag/AgCl electrodes, attached to the surface of the medial phalanx of the index and ring fingers of the non-dominant hand as suggested on the *PROCOMP infiniti system* manual. Conductive gel was used to reduce impedance. The electrode pair was excited with a constant voltage of 0.5 V and conductance was recorded using a DC amplifier with a low- pass filter set at 64 Hz. Such procedures are in accordance with the guidelines by Figner and Murphy (2011) and Boucsein (2012). A photoplethysmographic probe (3.2 cm/1.8 cm, photodetector LED type), placed on the middle finger of the non-dominant hand was used to assess HR in beats per minute (bpm) at a sample rate of 2048 Hz. SCR and HR data were analysed with Matlab using the same in-house scripts used in our previous study (Cecchetto, Korb, Rumiati *et al.*, Under review), and partially using the EEGLAB toolbox (http://sccn.ucsd.edu/eeglab/).

SCR data were filtered with 10 Hz lowpass filters and epoched over the 21 sec from the odour presentation. Two seconds before each odour presentation served as baseline. *Peak amplitude* was analysed, defined as the difference in μSiemens between the mean value during baseline and the peak after stimulus onset. Trials with peak amplitudes below 0.01 μSiemens were excluded from the analysis. To improve interpretability, peak amplitudes were log-transformed (Boucsein, 2012).

Heart rate data were filtered with 1 Hz highpass filter and resampled to 256 Hz. Beat detection was performed automatically, verified visually, and corrected, if necessary. Frequency was computed as beats per minute (bpm). The 9 sec from the odour presentation were divided in six time windows of 1.5 sec. Interbeat intervals were computed, transformed to heart rate values and averaged for each 1.5 sec window. Each time windows was then corrected by subtracting the 1.5 sec before odour presentations to obtain the Instantaneous

Heart Rate (IHR; Palomba *et al.*, 2000). Relatively to the trial design, the odour was presented during time window 1 and 2, the question slide appeared at the beginning of the third time window and the amount of time available to the participants to the answer ended at the end of the sixth time window.

Statistical Analysis

For the behavioural and IHR analyses, no RT choice outliers were identified (720 trials). For the SCR analyses, a subset of data was included. Specifically, data from one subject was removed due to technical issues. Of the remaining 672 trials, 139 were removed due to SCR peak amplitude lower than 0.01 μSiemens (Roth *et al.,* 2012; N = 139/672, 20.7%, mostly due to habituation issues towards the end of the last two blocks, Boucsein, 2012, pp 275-282). Final analyses were run on a sample of 533 trials distributed over conditions. For all other aspects, analyses are equivalent to those presented for Study 1a. Please refer to Study 1a statistical analysis section for details.

4.3.2 Results

The supra-threshold odour is more intense– but not more pleasant – than the sub-threshold odour

We tested whether the three odour conditions had the expected perceptual impact. Since there were no significant differences between the ratings before and after the moral decision-making task, data from the two sessions were collapsed. As evident from Figure 4.2A, a LMM on odour intensity ratings (no-odour: M = 2.70, SD = 0.21; sub-threshold neutral odour: M = 3.97, SD = 0.25; supra-threshold neutral odour: M = 6.97, SD = 0.20) revealed a significant difference between odour conditions. Post-hoc contrasts showed that the supra-threshold odour condition was perceived as significantly more intense than both no-odour (*p*

< .0001) and sub-threshold odour conditions (p < .0001), moreover although no-odour was nominally reported as less intense than the sub-threshold odour, this difference did not reach the significance level (p = .053).

For valence ratings (no-odour: M = 4.31, SD = 1.93; sub-threshold neutral odour: M = 4.03, SD = 2.35; supra-threshold neutral odour: M = 3.60, SD = 1.89) no significant differences were found (Figure 4.2B). For the full LMM results, please refer to Table 2C of Appendix C.

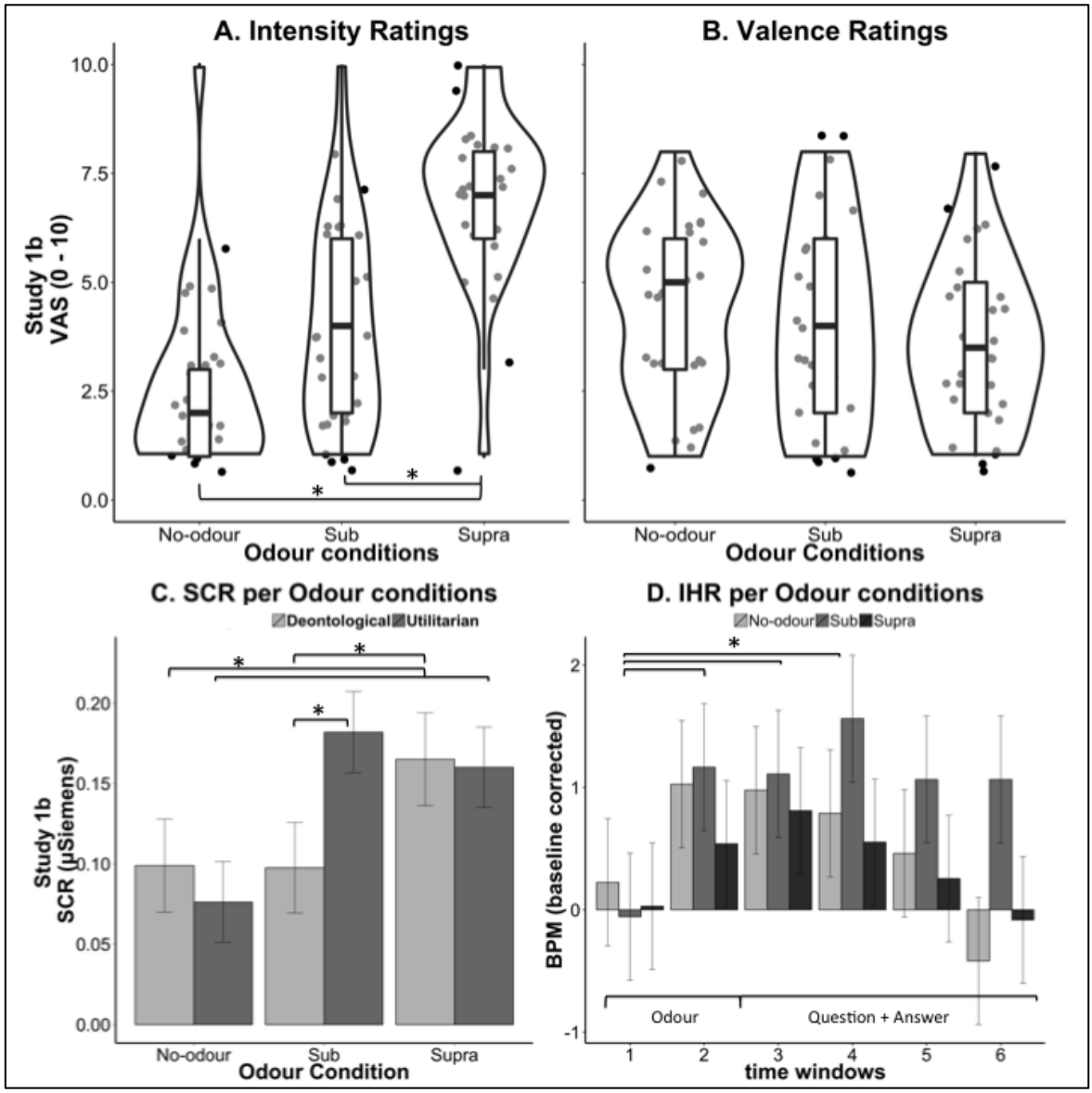

Figure 4.2 *Panel A) distribution of participants' intensity odour ratings of Study 1b. Panel B) distribution of participants' valence ratings of Study 1b. Panel C) SCR per odour conditions of Study 1b. Panel D) IHR per time window and odour conditions of Study 1b. In panel A) and B) the black dots represent 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 are indicated.*

Deontological choice rate increases during the sub- threshold odour condition

The best fitting model for moral choice data (reference factor: utilitarian choice) resulted being the one including the odour factor ($p < 0.001$), personal force ($p = 0.001$),

intentionality ($p < 0.001$), benefit recipient ($p = 0.01$) and evitability ($p = 0.004$), the interaction of odour and each of these three factors, and the scores at AQ ($p = 0.03$; see Table 4.3 for descriptive data of single parameters). Four main effects were found to modulate the moral choice tendency: the odour condition, the personal force factor, the evitability factor and AQ (reference factors: sub-threshold odour and personal). The likelihood of choosing deontological responses significantly increased following the exposure to the sub-threshold odour as compared to the supra-threshold odour condition. Changing no-odour condition as reference factor reveals an increment of deontological responses following the exposure to the sub-threshold odour when compared to the no-odour condition [$z(720) = 2.26$, $p = .02$]. Although the model produced three significant interactions (odour*intentionality, odour*benefit recipient and odour*evitability; reference factors: sub-threshold odour, accidental, other, avoidable), the post-hoc contrasts (lsmeans function) reveal meaningful significant contrasts only for the interaction odour*evitability: a selective increase of deontological responses on avoidable dilemmas following the exposure to the sub-threshold odour compared to no-odour ($p = 0.02$) and compared to supra-threshold odour conditions ($p = 0.03$). Moreover, as found in Study 1a, the likelihood of choosing deontological responses increased when the dilemmas were personal (vs. impersonal), when avoidable (vs. inevitable), and with lower AQ scores.

Table 4.3 Summary of the best linear mixed effects model on moral choices for Study 1b.

Moral choices	***β***	***SE***	***z value***	***p value***	***βexp***	***95%CI***	
Fixed effects with reference to sub-threshold odour						***Lower***	***Upper***
Intercept	2.20	0.88	2.50	**0.012**	9.012	1.610	50.440
No-Odour	-1.17	0.52	-2.26	**0.024**	0.310	0.112	0.857
Supra-threshold Neutral Odour	-1.74	0.54	-3.25	**0.001**	0.175	0.061	0.500
Personal force (*Impersonal*)	-1.13	0.31	-3.60	**<0.001**	0.324	0.176	0.598
Intentionality (*Instrumental*)	0.32	0.34	0.95	0.343	1.378	0.710	2.675
Benefit recipient (*Self*)	-0.12	0.36	-0.33	0.739	0.886	0.434	1.808
Evitability (*Inevitable*)	-0.90	0.31	-2.87	**0.004**	0.406	0.219	0.752
AQ	-0.10	0.04	-2.30	**0.022**	0.907	0.834	0.986
No-Odour* Personal force (*Impersonal*)	0.80	0.54	1.49	0.136	2.235	0.777	6.430
Supra-Odour* Personal force (*Impersonal*)	0.63	0.46	1.37	0.169	1.877	0.765	4.607
No-Odour* Intentionality (*Instrumental*)	0.99	0.48	2.03	**0.042**	2.679	1.036	6.928
Supra-Odour* Intentionality (*Instrumental*)	0.75	0.47	1.59	0.112	2.120	0.840	5.347
No-Odour* Benefit recipient (*Self*)	-1.46	0.64	-2.30	**0.022**	0.231	0.066	0.807
Supra-Odour* Benefit recipient (*Self*)	0.18	0.51	0.36	0.719	1.200	0.445	3.234
No-Odour* Evitability (*Inevitable*)	1.56	0.47	3.32	**0.001**	4.760	1.897	11.944
Supra-Odour* Evitability (*Inevitable*)	1.22	0.45	2.72	**0.006**	3.392	1.408	8.172

Note: β = estimate; SE = standard error; β exp = exponential of β coefficient; 95% CI = confidence interval; Sub threhsold Odour = sub threshold neutral odour condition; Supra threshold Odour = supra threshold neutral odour condition; AQ = Autism-Spectrum Quotient. Significant p values are reported in bold. Table shows model with utilitarian choice and Sub-threshold odour condition set as references. Contrast condition from the reference for categorical factors is reported in italic inside bracket.

SCR is greater for sub- and supra-threshold odour conditions compared to clean air

The best fitting model for SCR resulted being the one including the odour factor ($p < 0.001$), moral choice ($p = 0.09$) and the interaction between the two factors, personal force ($p = 0.064$), intentionality ($p = 0.007$), benefit recipient ($p = 0.09$) and evitability ($p = 0.34$) and the scores at AQ ($p = 0.04$; see Table 3C of Appendix C for descriptive data of single parameters). The likelihood of presenting greater SCR increases during supra-threshold odour conditions compared to sub-threshold odour condition ($p = .03$) and to no-odour condition ($p = .03$), but no significant difference is evident in SCR between sub-threshold and no-odour conditions ($p = 0.97$). Moreover, the SCR significantly increases for utilitarian choice compared to deontological choice. The odour significantly interacts with the moral choice (reference factors: sub-threshold odour conditions and utilitarian choices): post-hoc analysis (lsmeans function) indicates that in utilitarian choices greater SCR is associated to both odour conditions (sub: $p < 0.001$; supra: $p = 0.007$), irrespective of their intensity (Figure 4.2C). Although no significant differences in post-hoc contrasts were revealed for deontological choices, greater SCR is nominally associated with supra-threshold, but not with sub-threshold and no-odour conditions. Moreover, the likelihood of showing a greater SCR increases when the dilemmas presented were accidental. Moreover, the likelihood of presenting greater SCR increases with higher AQ scores.

IHR decelerates during sub- and supra-threshold odour condition

The best model resulted being the one including time ($p = 0.02$), odour conditions ($p = 0.004$), personal force ($p = 0.93$), intentionality ($p = 0.66$), benefit recipient ($p = 0.08$), evitability ($p = 0.67$) moral choice ($p = 0.21$) and the scores at STAI ($p = 0.04$; see Table 4C of Appendix C for descriptive data of single parameters). The likelihood of presenting an decelerated IHR is affected by the odour smelled. In detail, a significant IHR deceleration is

evident when participants smell the sub- and supra-threshold odour conditions compared to no-odour (p = 0.004 and p = 0.005, respectively), but no differences emerge between sub- and supra-threshold odour conditions (p = 0.91). Also, a time effect is present: IHR significantly accelerates compared to odour onset (time window 1) during the second half of the odour stimulation (irrespective of the odour valence), during the presentation of the question slide (time windows 2 to 4; Figure 4.2D). Finally, there is an effect of anxiety: the IHR decelerates when score at STAI increases.

4.3.3 Discussion

The goal of Study 1b was to re-evaluate the hypotheses on the effects of odour intensity on moral choice tested in Study 1a, by using odour conditions that were more perceptually discriminable between each other. As the analysis of the odour intensity ratings reveals, in Study 1b the three odour conditions are parametrically distributed: the supra-threshold odour condition was significantly more intense than the sub-threshold odour condition, which itself was significantly more intense than the no-odour condition. Furthermore, the odour valence ratings resulted homogenous across conditions, indicating that the olfactory effects on moral choice at the behavioural and psychophysiological level can be attributed to odour intensity alone.

Deontological choices are more likely to be made in the presence of a sub-threshold odour as compared to the supra-threshold odour and no odour. This pattern of results supports the hypothesis that the neutral odour condition impacts on moral choice only when it is presented sub-threshold. We suggest that this effect might emerge because the elaboration of irrelevant sensory information – whose sensory signal is minimal – can escape strategic inhibitory control (e.g., Li, Moallem, Paller *et al.* 2007). As previously shown, odours – even when presented with very low concentration - can constitute a distractor for the

process of acting, whether acting is considered as a real movement (i.e., Parma, Straulino, Zanatto *et al.*, 2012; Parma, Bulgheroni, Scaravilli *et al.*, 2013) or, as in the present case, whether acting is considered as a decision to act. In other words, during moral decision-making task, the information irrelevant to the decision is processed unconsciously and it biases the moral choice towards a more emotional tendency, given that cognitive resources have been taxed by the presence of the irrelevant stimulus (Greene *et al.*, 2008).

One may think that the results of Study 1b are in contrast to the results of Study 1a. However, we confirm the effects on moral choice that are not dependent on odour variables, revealing a consistent increase in deontological responses for personal dilemmas as well as the tendency of participants reporting higher autistic traits to prefer utilitarian choices. With respect to the odour variables, a clearer definition of the relative intensity of the odour conditions allowed to show that a disgust reaction is not the only factor able to modulate moral choices.

The psychophysiological analyses confirm that the behavioural findings are strictly dependent on differences in intensity of the odours. Indeed, arousal measured through SCR reveals that arousal is increased following the exposure to the supra-threshold odour condition with respect to the sub-threshold odour condition. This is in line with the idea that increments in SCR correspond to the orientation towards newly introduced stimuli (e.g., Frith & Allen, 1983). Furthermore, the analysis of SCR is consistent with the differences in odour intensity reported subjectively. Interestingly, this effect is conserved when considering deontological choices, whereas SCR does not track odour intensity in utilitarian choices. Considering that the literature reports that utilitarian choices are associated with greater SCR as compared to deontological choices (Moretto *et al.*, 2009), the odour effect is hidden by the ceiling effect of arousal in utilitarian choice. In other words, the arousal induced by the

processing of the utilitarian choice is already high enough not to leave room for the influence of the odour.

To strengthen the idea that in Study 1b the effect of odour pleasantness was minimal, in line with the homogeneity of pleasantness ratings, the analysis of IHR showed no significant differences across sub- and supra-threshold conditions. This is in line with previous evidence showing that cardiac responses vary with hedonic values and reports of pleasantness (Alaoui-Ismaïli, Robin, Rada *et al.*, 1997; Alaoui-Ismaili, Vernet-Maury, Dittmar *et al.*, 1997; Bensafi *et al.*, 2002). The reduction of the cardiac output emerging in the presence of both odour conditions as compared to the no-odour condition is to be attributed to the attentional processing of the stimuli (Bradley, 2009).

Here, we extend for the first time the study moral behavioural and psychophysiological effects to the odour intensity of an emotionally neutral stimulus, suggesting that odour intensity impacts on moral decision-making, by promoting a deontological moral tendency, as confirmed by the psychophysiological findings. However, the effect of odour valence on moral decision-making has still to cover the full spectrum of possibilities, ranging from unpleasant to pleasant odours. In Study 2, we address this issue by considering the effect of a neutral, pleasant and unpleasant sub-threshold odours in moral decision-making.

4.4 Study 2 – Does odour valence affect the behavioural and psychophysiological correlates of moral choice?

4.4.1 Material and methods

Participants

A total of naïve 15 participants (Table 4.4), following the screening procedures of Study 1a and 1b, were included in Study 2.

Table 4.4 *Summary table of demographic characteristics and questionnaires of Study 2.*

	Mean (SD)	**Range**
Gender	13 Females	-
Age	25.80 (4.95)	19 - 38
Education	16.93 (2.49)	13 - 20
Threshold test (*Cedarwood Oil*)	8.75 (1.12)	6.25 - 12.25
Threshold test (*Butyric Acid*)	12.38 (0.34)	11.5 - 14.5
Identification test	13.27 (1.33)	11 -16
BVAQ	46.07 (5.50)	35 - 52
DS	15.17 (4.16)	7 - 24
STICSA (*Trait*)	39.53 (11.09)	23 - 65
AQ	17.87 (6.01)	8 - 28
OAS	120.40 (12.29)	103 - 139
STAI (State - PRE)	35.00 (6.96)	25 - 52
STAI (State - POST)	37.13 (810.20)	25 - 59

Note: BVAQ = Bermond–Vorst Alexithymia Questionnaire; DS = Disgust Scale; STICSA = State Trait Inventory for Cognitive and Somatic Anxiety; AQ = Autism-Spectrum Quotient; OAS = Odour Awareness Scale; STAI (State) = State–Trait Anxiety Inventory; POMS = Profile of Mood States.

Odour stimuli

In Study 2, three odour conditions were presented during the moral decision making task: no-odour, neutral sub-threshold odour condition (cedarwood oil, Sigma-Aldrich, Italy) and a solution of butyric acid presented in sub-threshold concentration (Sigma-Aldrich, Italy). Butyric acid was chosen in virtue of its hedonic ambiguity. Indeed, it has been reported to be perceived either as a pleasant odour (e.g., parmesan cheese) or an unpleasant odour (e.g., vomit; (Herz & von Clef, 2001; Herz, 2006), while keeping the chemical properties constant. Mineral oil (Sigma-Aldrich, Italy) was used as diluting agent for cedarwood oil, while propylene glycol (Sigma-Aldrich, Italy) was used for butyric acid. All concentrations below are given as volume to volume (v/v) in liquid phase. Odour concentrations for the cedarwood oil and butyric acid odours were established for each participant through the same odour detection threshold test used in Study 1b.

Based on the pre-/post-task average valence rating of each participant, the original group was split in a Pleasant (N = 8; rating above median split, pleasantness > 5/10) and an

Unpleasant group (N = 7; rating below median split, <5/10). In case the mean was 5.0, values of ratings at the end of the study were considered (rating above median split, namely ≥ 5/10, Pleasant group; rating below median split, namely <5/10, Unpleasant group).

Procedure

In Study 2 we replicated the procedure, visual stimuli, psychophysiological acquisition and statistical analyses used in Study 1b. Only the odour conditions, describes above, have partially changed.

Statistical Analysis

Behavioural and IHR analyses were performed on a total of 720 trials: no outliers were identified considering the reaction times. Analyses on SCR data were calculated on a total of 537 trials, due to SCR peak amplitude lower than 0.01 μSiemens (Roth *et al.,* 2012; N = 183/720, 25.41%, mostly due to habituation issues towards the end of the last two blocks, Boucsein, 2012, pp 275-282). Removed trials were distributed over 15 subjects and over conditions. The analyses are equivalent to those presented for Study 1a and 1b, except for the addition of Wilcoxon test for the analysis of the ratings across groups.

4.4.2 Results

Odour conditions are perceived as different in intense and in valence

Given that no significant differences between the answers before and after the moral decision-making task was found, the data from the two sessions were collapsed. The LMM on odour intensity ratings (no-odour: M = 2.77, SD = 0.17; neutral odour: M = 3.80, SD = 0.22; pleasant odour: M = 4.25, SD = 0.21; unpleasant odour: M = 3.21, SD = 0.17) showed a main effect of odour condition (reference factor no-odour): pleasant odour condition and neutral odour conditions were rated as more intense than no-odour condition (respectively: p = 0.02

and p = 0.01; Figure 4.3A). Changing the reference factor does not reveal other significant effects.

Wilcoxon tests on odour valence ratings were performed to evaluate whether no-odour and neutral odour conditions were equivalent across groups. Results showed that no significant differences were evident for no-odour condition (group Pleasant: M = 4.88, SD = 0.07; group Unpleasant: M = 4.29, SD = 0.33; w = 123, p = 0.23, 95%CI: [-1.03*10-6, 2.00]) and for neutral odour condition (group Pleasant: M = 5.06, SD = 0.21; group Unpleasant: M = 3.93, SD = 0.29; w = 156.5, p = 0.06, 95%CI: [-3.85*10-5, 2.99]). As expected, there was a significant difference in the valence attributed to butyric acid across groups (group Pleasant: M = 5.38, SD = 0.14; group Unpleasant: M = 3.36, SD = 0.31; w = 182.5, p = 0.002, 95%CI: 0.99, 3.00]). A LMM on odour valence ratings showed a significant effect of odour: unpleasant odour condition was perceived as significantly more unpleasant than no-odour condition (p = 0.038; see Figure 4.3B). Setting the pleasant odour as reference revealed that unpleasant odour condition was perceived as significantly more unpleasant than pleasant condition (t(72) = -2.74, p = 0.008). No other significant effects were found. Please refer to Table 5C of Appendix C for intensity and valence ratings LMMs' details.

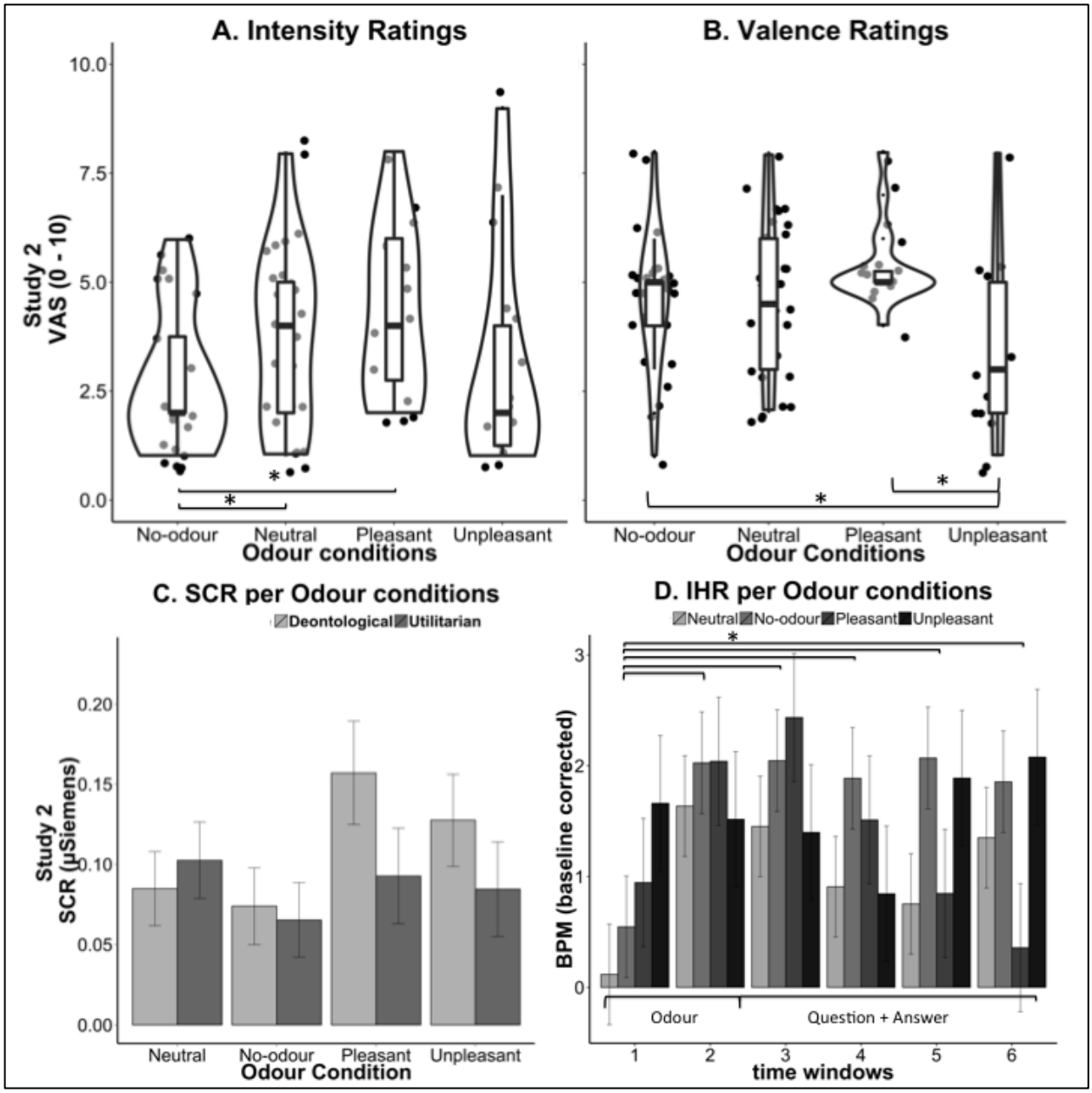

Figure 4.3 *A) and B) Intensity and valence odour ratings for Study 2; C) SCR per odour conditions; D) IHR per time windows and odour conditions. In panel A) and B) the black dots represent single data points, whereas the box-plot represents the interquartile range of each distribution, with the thick black horizontal bar corresponding to the median. Each box-plot is surrounded by a violin plot representing the smoothed distribution of data. Significant differences are indicated.*

Deontological responses increased while exposed to the neutral odour but not to pleasant and unpleasant odour conditions

The best fitting model for moral choice data (reference factor: utilitarian choice) resulted being the one including the odour factor ($p < 0.001$), personal force ($p = 0.01$), intentionality ($p < 0.001$), benefit recipient ($p = 0.02$) and evitability ($p = 0.008$), the interaction of odour and each of these three factors, and the scores at STICSA ($p = 0.02$; Table 4.5). Deontological choices increase during the neutral odour condition compared to the pleasant ($p = .01$), unpleasant ($p = .005$) and no-odour conditions ($p < .0001$; reference factors: neutral odour and utilitarian choices). Changing reference in odour condition factor did not show other significant effect. Increment in deontological moral choices was also promoted by the odour in interaction with the intentionality factor, respectively (reference factors: accidental). Relevant post-hoc (lsmeans function) tests showed that participants gave more deontological responses when exposed to the neutral odour condition compared to no odour for accidental ($p = .01$) dilemmas. Moreover, the likelihood of choosing deontological answers increased for personal (vs. impersonal) and avoidable (vs. inevitable) dilemmas as well as for lower STICSA scores.

Table 4.5 *Summary of the best linear mixed effects model on moral choices for Study 2.*

Moral choices	***β***	***SE***	***z value***	***p value***	***βexp***	***95%CI***	
Fixed effects with reference to neutral odour						***Lower***	***Upper***
Intercept	3.06	0.94	3.25	**0.001**	21.311	3.369	134.809
No-odour	-2.00	0.52	-3.83	**<0.001**	0.136	0.049	0.377
Pleasant Odour	-1.50	0.62	-2.42	**0.016**	0.222	0.066	0.753
Unpleasant Odour	-1.87	0.68	-2.76	**0.006**	0.154	0.041	0.582
Personal force (*Impersonal*)	-0.93	0.32	-2.93	**0.003**	0.396	0.213	0.736
Intentionality (*Instrumental*)	0.17	0.33	0.51	0.608	1.187	0.617	2.283
Benefit recipient (*Self*)	-0.34	0.36	-0.94	0.345	0.714	0.354	1.438
Evitability (*Inevitable*)	-0.82	0.31	-2.65	**0.008**	0.441	0.240	0.808
STICSA *(Trait)*	-0.05	0.02	-2.34	**0.019**	0.951	0.912	0.992
Odour* Personal force *(No-Odour, Impersonal*)	1.00	0.53	1.90	0.058	2.710	0.968	7.589
Odour* Personal force *(Pleasant Odour, Impersonal*)	0.17	0.53	0.32	0.748	1.186	0.418	3.367
Odour* Personal force *(Unpleasant Odour, Impersonal*)	0.47	0.58	0.81	0.416	1.606	0.514	5.020
Odour* Intentionality (*No-Odour, Instrumental)*	1.45	0.48	3.01	**0.003**	4.255	1.659	10.915
Odour* Intentionality (*Pleasant Odour, Instrumental*)	0.14	0.53	0.27	0.789	1.153	0.407	3.269
Odour* Intentionality (*Unpleasant Odour, Instrumental*)	0.08	0.57	0.13	0.894	1.079	0.351	3.319
Odour* Evitability (*No-Odour, Inevitable)*	-0.95	0.61	-1.56	0.118	0.386	0.117	1.271
Odour* Evitability (*Pleasant Odour, Inevitable*)	0.63	0.58	1.08	0.278	1.873	0.602	5.826
Odour* Evitability (*Unpleasant Odour, Inevitable*)	1.21	0.62	1.93	0.053	3.337	0.983	11.335

Note: β = estimate; SE = standard error; CI = confidence interval; β exp = exponential of β coefficient; STICSA = State Trait Inventory for Cognitive and Somatic Anxiety. Significant p values are reported in bold. Table shows model with utilitarian choice and neutral odour condition set as references. Contrast condition from the reference for categorical factors is reported in italic inside bracket.

SCR is greater for pleasant odour conditions

The best model included the odour factor (p = 0.08), moral choice (p = 0.46), personal force (p = 0.21), intentionality (p < 0.001), benefit recipient (p = 0.16) and evitability (p = 0.27), the interaction of odour and moral choice (Table 6C). Participants showed greater SCRs increased during the pleasant odour condition compared to the neutral (p = .03) and no-odour conditions (p = .01; setting pleasant odour as reference). The unpleasant odour condition showed a tendency for greater SCR as compared to no odour (p = 0.06). Even though the interaction between odour condition and moral choice is not significant, nominally, the pattern (Figure 4.3C) seems to be in line with the arousal elicited by the unpleasant odour but not by the neutral odour. Moreover, the likelihood that participants showed greater SCRs increased when dilemmas were accidental.

IHR is reduced during the neutral odour condition compared to no-odour conditions

The best model resulted being the one including time (p < 0.001), odour conditions (p = 0.05), personal force (p = 0.53), intentionality (p = 0.78), benefit recipient (p = 0.58), evitability (p = 0.02) and moral choice (p < 0.001; Table 7C in Appendix C; reference factors: neutral odour). The likelihood to present a reduced IHR is greater for the exposure to neutral odour condition compared to the no odour condition (p = .007) while there is only a tendency between neutral odour condition compared to unpleasant condition (p = .08). Setting difference reference factors does not revealed other significant effects. Moreover, the likelihood of presenting a reduced IHR increased when participants made deontological choices and when they answered to inevitable death dilemmas. Furthermore, a time effect is present. Relevant post-hoc contrasts reveal that irrespective of the odour condition, the first

time window, namely the odour onset, shows a significantly decreased IHR as compared to all following windows (all $p < .03$; Figure 4.3D).

4.4.3 Discussion

Study 2 was designed to investigate whether odour valance can affect moral choices. Taking advantage of the peculiar characteristics of ambiguous odours, which could either be perceived as pleasant or unpleasant stimuli (de Araujo *et al.*, 2005), we keep constant the chemical stimulation while having participants differentially judge the pleasantness of the odour. As expected, the butyric acid was perceived as significantly more pleasant by the Pleasant group and significantly more unpleasant by the Unpleasant group. However, the intensity rating results show that the there were significant differences between the three odour conditions.

Overall, we found that unpleasant and pleasant odours did not bias moral choices while the neutral odour did. Although this pattern of results does not overlap with any of our hypotheses, it leans towards the first alternative, suggesting that odour valence has no effect on moral choice. Specifically, smelling the neutral odour has a greater effect on deontological tendencies as compared to the pleasant/unpleasant odours and no odour. We advance that this result may emerge due to a novelty effect specific to the neutral odour (Bradley, 2009). Indeed, cedarwood oil may be an odour less familiar to our participants as compared to butyric acid. An additional, though not necessarily contrasting, explanation posits that for the odour valence effect to emerge on moral choice, higher concentration of the stimulus is necessary. Here, all odours were presented sub-threshold. As in Ugazio *et al*. (2012), during the olfactory condition characterized by lower sprays, the effect on moral behaviour is not evident. Furthermore, Study 2 confirmed the findings obtained in Study 1b showing that

moral choices were biased towards deontological answers by the neutral odour presented sub-threshold.

The moral choice analyses confirmed the majority of predictors significantly increasing deontological choices found in Study 1b, the study in which the odour manipulation successfully differentiated conditions, as here in Study 2. Indeed, participants gave more deontological answers when the moral dilemma was described as personal (Greene *et al.*, 2004; Mendez *et al.*, 2005; Valdesolo & DeSteno, 2006; Koenigs *et al.*, 2007; Greene *et al.*, 2008; Moore *et al.*, 2008; Greene *et al.*, 2009; Moretto *et al.*, 2009; Moore *et al.*, 2011; Youssef, Dookeeram, Basdeo *et al.*, 2012a; Christensen *et al.*, 2014) and avoidable (Hauser et al., 2007; Moore et al., 2008; Christensen et al., 2014).

As previously found in Studies 1a and 1b, participants' characteristics showed also an effect on moral choices. However, here the test scores significantly predicting deontological responses were a reduced trait anxiety (STICSA) – as expected from the literature (Starcke *et al.*, 2008; Youssef *et al.*, 2012a but see Starcke, Polzer, Wolf *et al.*, 2011 for negative result). The lack of a significant effect of autistic traits probably depends on the distribution of AQ scores across participants, which in this rather small sample is shorter ranging and more balanced than in Studies 1a and 1b.

In line with the idea that deontological choices are associated with lower physiological activation (Moretto *et al*., 2009), SCR data shows a tendency toward lower arousal associated with the exposure to the neutral odour as compared to the pleasant odour. Consistently, the behavioural data on moral choice reveal a significant increment of deontological responses following the neutral odour condition. Specifically, greater arousal for deontological responses following the pleasant odour condition tends towards significance when compared to the arousal of deontological responses for the no-odour condition. The reduced arousal shown in connection with the neutral odour is in line with the electrodermal activity elicited

by neutral novel stimuli, which is reported to be smaller than that provoked by novel pleasant and unpleasant stimuli (Bradley, 2009).

Moreover, even though we were expecting the cardiac activity to discriminate between pleasant and unpleasant odour stimulations (Bensafi *et al.*, 2002), we did not found such result but only a cardiac output reduction during the presentation of the neutral odour. Our hypothesis to explain such effect is that the negative emotional state induced by the moral dilemmas and by making moral choices – evident in the generalized acceleration post dilemma processing - hid the odour valence effect on cardiac activity. We propose that the effect of the neutral odour only survives in light of its attention-grabbing power, which promotes cardiac activity reduction.

4.5 Conclusions

Previous studies have shown that olfactory stimuli can impact on decision-making domains (Bonini *et al*., 2001; Chebat & Michon, 2003), preferentially in the context of moral choices (Landy & Goodwin, 2015). Previous studies (Schnall *et al.*, 2008; Ugazio *et al.*, 2012) have tested the effect of negative odour stimuli on moral judgment, but their results are not consistent, perhaps in light of the limited control shown on possible confounding variables relevant to chemosensory research. Therefore, the present study had two main goals: to investigate whether the intensity of olfactory stimuli might bias moral decision-making, at the behavioural and psychophysiological level and whether and how a wider range of odour valence (namely, odours other than unpleasant) affects moral decisions.

Overall, the results of three studies here reported can be summarized as follows. First, only when olfactory stimuli were presented in a sub-threshold concentration they have shown to be effective in biasing moral choices towards a deontological tendency; second, pleasant and unpleasant odours might not differentially affect moral choices. Study 1a

suggested that olfactory stimuli may interact with particular aspects of moral dilemmas, such as the personal force and benefit recipient. But it is Study 1b that revealed a clear effect of a neutral odour in biasing moral decisions towards deontological responses. Specifically, the deontological bias in moral choice emerges when the odour is presented sub-threshold, indicating that differences in odour intensity are sufficient to modulate moral choice. We suggest that this effect is underlined by a lack of inhibitory control: when the sensory input is unconsciously perceived, the strategic regulation function of inhibiting the processing of irrelevant sensory input is less effective (Li *et al*., 2007). In this condition the neutral odour presented sub-threshold might act as a distractor during the decision-making act, in a modality similar to the one explained with the cross-modal interference effect shown with real actions (Castiello, Zucco, Parma *et al.*, 2006; Parma *et al.*, 2012; Parma *et al.*, 2013). Interestingly, the modulating effect of sub-threshold neutral odour on moral choices has been replicated also in Study 2, in an independent group of participants and with different odour qualities, supporting the idea that this pattern of results is not spurious.

Our findings systematically evaluate, for the first time, the effects of sub-threshold olfactory stimuli in the moral domain. Odours presented sub-threshold are shown to affect, for instance, patterns of EEG activity (Lorig, Herman, Schwartz *et al.*, 1990), mood (Kirk-Smith, Van Toller, & Dodd, 1983; Zucco, Paolini, & Schaal, 2009) and social preferences (Li *et al.*, 2007). This capacity, which makes olfactory stimuli relevant for moral decision-making, is related to the unique anatomical features of the olfactory system. Indeed, it is the only sensory system in which receptors project directly to the olfactory bulb and to the primary olfactory cortical areas (Carmichael, Clugnet, & Price, 1994) without the obligatory thalamic relay, that has been implied in conscious awareness (McAlonan, Cavanaugh, & Wurtz, 2008; Plailly, Howard, Gitelman *et al.*, 2008). This makes olfactory stimuli to be good experimental tools to investigate sub-threshold information processing (Li *et al.*, 2007).

Besides opening an experimental window on the study of implicit information processing in the moral domain, the chemical senses are also ideally suited to evaluate the role that arousal and valence play in moral decision-making (Anderson *et al.*, 2003; Winston *et al.*, 2005). If, as we have seen, odour intensity matters, with moral choice being biased towards deontological responses when the odour is presented at a sub-threshold level, Study 2 might suggest that odour valence – contrary to expectations - did not affect participants' moral decisions. We could propose that the odour valence effect may have been hidden by the attentional-grabbing effect of the neutral odour (Bradley, 2009), which may have been more novel to the participants as the pleasant/unpleasant odour. Another hypothesis is that pleasant and unpleasant odours might have the ability to manipulate moral choice only when they are presented in supra-threshold concentrations.

This lack of an effect of the pleasant/unpleasant odour on moral choice seems to be in contrast with previous literature on induced pleasant (Valdesolo & DeSteno, 2006; Eskine, Kacinik, & Prinz, 2011; Pastötter *et al.*, 2013) and unpleasant affective states and moral judgment (Schnall *et al.*, 2008; Horberg, Oveis, Keltner *et al.*, 2009; Harlé & Sanfey, 2010; Moretti & Di Pellegrino, 2010; Eskine *et al.*, 2011; Case, Oaten, & Stevenson, 2012; Ugazio *et al.*, 2012; Cameron, Payne, & Doris, 2013; Cheng, Ottati, & Price, 2013; Seidel & Prinz, 2013; Johnson, Cheung, & Donnellan, 2014; Ong *et al.*, 2014).

However, some considerations are in order. First, previous studies were focused on moral judgment, while in our study participants were asked to make moral decisions. Even though these two labels have been used as synonyms in the past, it has recently been demonstrated that moral judgment and moral decision-making are two distinct psychological constructs, both referring to the system of moral norms (Sood & Forehand, 2005; Tassy, Oullier, Mancini *et al.*, 2013). While in moral judgment tasks participants are asked to evaluate the *appropriateness* or the *permissibility* of certain actions, in moral decision-making

tasks they are the main characters of a dilemma and, as such, they are responsible for the action chosen and for its moral consequences. So, it might be possible that the physical disgust amplification phenomenon theorized for moral judgment, actually it is not valid or not strong enough in the context of moral decision-making.

A third possibility is that some limitations of the present work might have obscured some effects. Although participants were carefully selected, the sample size is rather limited. This may have particularly affected highly variable measures such as IHR. Second, in Study 2 only two odours were tested, suggesting that conclusions should be generalized with caution, while waiting for future studies to investigate the effects of wider samples of pleasant and unpleasant odours on moral choices. Third, dilemmas were designed in a way that the affirmative answer was always the utilitarian options. This could have been introduced a bias toward one option. Future studies should counterbalance the direction of the question.

In conclusion, our study points out that olfactory stimuli affect the processes underlying moral decisions by incrementing deontological choices and that this effect goes beyond the ability of the odour to induce disgust.

CHAPTER 5

The contribution of human body odours in biasing moral choices

Abstract

Recent theories of moral psychology have tried to explain moral choices within the framework of social contexts. Among the most unnoticeable stimuli providing social information, human body odours are powerful social communication tool that is often masked by fragranced hygiene products. Even in these conditions body odours can modulate behavioural and neural processing outside of conscious awareness. In this study, we aimed to investigate whether social odour, unconsciously perceived, might influence people on their moral decisions. On this purpose we designed a behavioural experiment (experiment I) and a combined fMRI (functional magnetic resonance imaging) experiment (experiment II) with two independent samples of volunteers. Participants viewed 64 moral dilemmas, which presented a choice between two actions. While making their choice, participants were exposed to an affectively neutral fragrance (masker) or to a body odour concealed by the same masker, rendering the two odour conditions perceptually not discriminable. Behavioural data of Experiment I revealed that masked social odour increases deontological answers when presented during impersonal dilemmas. Experiment II showed that the masked social odour decreases deontological answers for personal dilemmas. Moreover, in Experiment II the masked social odour increases deontological answers for avoidable dilemmas and it increases them for inevitable dilemmas. Altogether this data advocates for an effect of the social odour to increase deontological answers for the less arousing dilemmas. As

predicted, fMRI data showed that moral dilemmas processed during the masked social odour seem to involve the activation of more areas included in the social brain (fusiform gyrus, caudate nucleus, anterior insula and orbitofrontal cortex) than the moral dilemmas processed during the masker odour. To conclude, this data suggests that social odours, even when unconsciously processed, can increase the saliency of the social context incrementing the dilemmatic nature of the moral choices.

5.1 Introduction

The most influential model proposed to explain moral choices relies on the relative role of only two processes, cognitive and emotions (Greene *et al.*, 2001; 2004; Mendez, Anderson, & Shapira, 2005; Cushman, Young, & Hauser, 2006; Valdesolo & DeSteno, 2006; Ciaramelli *et al.*, 2007; Koenigs *et al.*, 2007; Greene *et al.*, 2008; Greene *et al.*, 2009; Koenigs *et al.*, 2012; Sarlo *et al.*, 2012; Ugazio, Lamm, & Singer, 2012; Van Dillen, van der Wal, & van den Bos, 2012; Youssef *et al.*, 2012; Carmona-Perera *et al.*, 2013; Białek & De Neys, 2016). However, as advocated by Cikara, Farnsworth, Harris *et al.* (2010), "*moral decisions are not made in a vacuum*" but they are usually made in a context and in the interaction with environmental stimuli. The most prominent context in which moral decisions are made is social context. For example, Cikara *et al.* (2010) have showed that participants' moral acceptability of tradeoff scenarios is affected by intergroup biases and stereotypes and that the perception of different social groups influences the neural systems implicated in moral choices. Along the same lines, a new theory, called *Relationship Regulation Theory* (RR) has recently been proposed, as to integrate moral psychology within social-relational contexts (Rai & Fiske, 2011). Such theory suggests that people are led by moral motives to evaluate and guide one's own and others' judgments and behaviours according to moral rules developed inside specific social relationships. In other words, people build a particular moral motive required to live in a specific social context and moral transgression is defined as the circumvention of such relational prescriptions (Rai & Fiske, 2011).

Besides stereotypes and the perception of social groups, many are the mechanisms that can interfere with one's predisposition in making moral decisions. Environmental factors - including irrelevant olfactory stimuli – have shown to significantly change the direction of moral preferences. For example, Schnall et al. (2008) have disclosed that when participants are asked to judge vignettes in which non-moral actions are presented, they are more severe

in the presence of a disgusted odours compared to when such disgusting stimulus was not present. Moreover, in Chapter 4 of the present thesis, we have suggested that even a neutral odour, presented at a very low intensity, can bias moral choices towards options characterized by harm avoidance (deontological options).

However, so far, the moral literature has not considered the possibility of evaluating the effect of social information transmitted via odours. As humans we live in environmental contexts highly characterized by the presence of social related stimuli. In this context human body odours (or chemosignals) are a form of communication among conspecifics that transfers socially relevant information (Wyatt, 2014; Lübke & Pause, 2015; Parma, Gordon, Cecchetto *et al.*, In press). Such form of communication entails that there is a sender, who produces the message, and a recipient who receives and interprets such message (Parma *et al.*, In press). One might think that the effects of human body odours are often consciously neglected because of masked by fragranced hygiene products, nevertheless, it has been shown that, even when not consciously perceived, body odours are able to carry different types of social information regarding individuals' identities (e.g., age, gender, health status, sexual availability and personal predisposition; Jacob, McClintock, Zelano *et al.*, 2002; McClintock, Bullivant, Jacob *et al.*, 2005; Parma *et al.*, In press) and emotional status that can modulate the behaviour and neural processing of the receiver (Lundström, Boyle, Zatorre *et al.*, 2008; Lundström, Boyle, Zatorre *et al.*, 2009; Mujica-Parodi, Strey, Frederick *et al.*, 2009). The evidence that body odours effects persist in the presence of olfactory masking suggests the existence of differentiate neural pathways able to mediate common and body odour messages, as the ones found for social information presented through other modalities, such as visual stimuli (Schupp, Öhman, Junghöfer *et al.*, 2004) or auditory stimuli (Belin, Fecteau, & Bedard, 2004). Indeed, this has been demonstrated by Lundström *et al.* (2008) that the specific neural network for human body odours includes the occipital cortex, which has been

found to be active not only to the presentation of purely visual stimuli but also to the social relevance of the stimuli presented in different modalities (Haxby, Hoffman, & Gobbini, 2002); the angular gyrus, which activates in response to human body related information (Seghier, 2013) but also in response to tasks involving social cognition and multisensory integration; and the anterior and posterior cingulate cortex, which are involved in many processes such as in emotion regulation (Johns, Inzlicht, & Schmader, 2008) and regulation of emotional (Cato, Crosson, Gökçay *et al.*, 2004) as well as in self-reflective processes (van der Meer, Costafreda, Aleman *et al.*, 2010).

So far, the effects of body odours have been examined only in relation of perceptual (Lundström *et al.*, 2008; Lundström *et al.*, 2009; Mitro, Gordon, Olsson *et al.*, 2012; Lundström, Mathe, Schaal *et al.*, 2013) and evaluative tasks that have focused on emotions primarily (Mujica-Parodi *et al.*, 2009; de Groot, Smeets, Kaldewaij *et al.*, 2012; de Groot, Smeets, Rowson *et al.*, 2015). However, we still do not know the effect of body odours on higher cognitive processing such as moral decision-making. A question that arises is whether socially relevant stimuli, unconsciously perceived, as are human chemosignals, might influence moral decisions. Indeed, as suggested by Rai and Fiske (2011), in a social context people should be more ready to behave according to the model created within that social context. The social information sent by a human body odour should make the social context more salient and as a consequence lead individuals to a prosocial behaviour, that usually corresponds to the urge of avoiding harm (Tangney, Stuewig, & Mashek, 2007). In this perspective, we designed two experiments, a behavioural experiment (experiment I) and a combined fMRI experiment (experiment II) with two independent samples of volunteers, to investigate whether the presence of human body odour can affect moral behaviour.

In Experiment I, we employed a behavioural paradigm in which participants were asked to perform a moral decision-making task in which they had to answer to 64 moral dilemmas.

Moral dilemmas presented a choice between two actions, while participants were exposed to an affectively neutral fragrance (masker) or to a body odour concealed by the same fragrance (masked social odour). Our main dependent variable was the type of moral choice made, which could be *utilitarian*, whether participants decided to save people with highly aversive harmful actions, or *deontological,* whether participants decided not to cause harm even if the harm is meant for a greater good (Greene *et al.*, 2001; Koenigs *et al.*, 2007). Our hypothesis is that if the presence of human body odour should increase harm aversion promoting prosocial behaviour so participants should choose more deontological answers for the dilemmas presented in combination with a human body odour compared to a common odour.

Besides the four different conceptual factors used in previous Chapters to differentiate the emotional engagement of moral dilemmas (*Personal force, Intentionality, benefit recipient and evitability*), in this study we inserted another distinction to better explore the effects of the human body odour. Indeed, half of the dilemmas were designed to be congruent, meaning that cognitive and emotional processes converged in the same deontological action, and half to be incongruent dilemmas, in which the two processes diverged (Conway & Gawronski, 2013). Since it has been shown that in incongruent dilemmas people are more willing to gave utilitarian answers compared to congruent dilemmas, we expect that the human body odour are able to increase deontological answer even in the incongruent dilemmas.

To probe the specific effect of body odour on moral behaviour, we contrasted the effect of the body odour condition with those of a common odour condition, cedarwood oil, a neutral common odour that we have previously used with a similar task and population in Chapter 4. In light of the results presented in Chapter 4, showing that a neutral odour can favour deontological choices and based on the evidence that free-choice behaviours can be influenced by non-consciously perceived stimuli (Ocampo, 2015), we decided to mask human body odours with the cedarwood oil, as to implicitly evaluate the effects. This paradigm also

provides sufficient ecological validity in exploring the effects of body odours. Indeed, even though the high level effects of body odours perception have yet to be fully investigated, we know that human body odours can transmit social information even when masked with fragrances (e.g., Saxton, Lyndon, Little *et al.*, 2008; Cecchetto, Cavazzana, Gordon *et al.*, 2016; Parma, Cavazzana, & Lundström, 2016).

To test whether the masking procedure applied to cover the body odour had the expected perceptual impact and was equivalent across olfactory conditions, participants were asked to rate intensity, pleasantness and familiarity of the masker, masked body odour and clean air before and after the moral decision-making task. Overall, masker and masked body odour conditions should be perceived both as neutral odours, so the pleasantness and familiarity ratings are not expected to reveal significant differences across the two odour conditions and clean air, but the two odour conditions should be perceived as more intense than clean air. However, we expect to find differences between sessions: given the dilemmatic nature of the moral decision-making task and the involvement of disturbing actions described, it is possible that the moral decision-making task would lead to aversive experiences on the odours presented in concomitance with it. If this is correct we expect reduced odour pleasantness at the end of the task. Moreover, an adaptation phenomenon (Dalton & Wysocki, 1996; Dalton, 2000) might occur during the moral decision-making task. In this case we expect that participants will rate odours as less intense during the second session.

Moreover, to strengthen the idea that the two odour conditions were not perceptually different, participants performed a three-alternative forced choice (3AFC) task at the end of the experimental session. For each trial of this task, the masked body odour was presented in random order with two presentation of the masker odour and the participants were asked to choose which odour was different. If the two odour conditions were non consciously discriminable, we expect participants to perform this task at chance.

In experiment II, we validated the findings of experiment I and additionally investigated the neural mechanisms that might mediate the body odour modulation of moral behaviour.

Given that participants will be engaged in a moral decision-making task, our first prediction is that regions commonly implicated in this type of task will be found: such as the amygdala and the ventro medial prefrontal cortex (vmPFC; Greene *et al.*, 2004; Shenhav & Greene, 2014), the temporo-parietal junction (which has been related to cognitive processes associated with inferring mental states; Decety & Lamm, 2007) and precuneus (Garrigan, Adlam, & Langdon, 2016). However, we also expect that the presence of the human body odour will stress the social aspects of the dilemmas. So our second prediction is that areas commonly associated with social processing and related also to human body odours processing, such as the angular gyrus, occipital cortex, and the anterior posterior cingulate cortex (Lundström *et al.*, 2008; Parma *et al.*, In press), will be activated for the dilemmas presented during the masked social odour compared to the ones presented during the mask only.

5.2 Materials and Methods

Donors

Four healthy, heterosexual males (henceforth donors) donated their body odours in three different days for Experiments I (Age: M = 26.35 years old; SD = 1.38; range = 28 – 24 years old) and ten healthy, heterosexual males donated their body odours in two different days for Experiments II (Age: M = 26.28 years old; SD = 3.63; range = 20 – 31 years old). Male donors were chosen based on the greater intensity of their body odour axillary secretions (Prokop-Prigge, Greene, Varallo *et al.*, 2016). The donors reported: i) to be non-smokers (Boesveldt, Lindau, McClintock *et al.*, 2011); ii) not to have health issues or undergoing drug treatment known to be related to olfactory alterations; iii) to be heterosexual; iv) to be

between the ages of 18 and 35. Donors provided written consent and agreed to follow behavioural, nutritional (i.e., no alcohol, smoking, food altering the natural body odour) and hygiene instructions throughout the collection session (adapted from Lundström *et al.*, 2008; Lundström *et al.*, 2009; Lundström & Jones-Gotman, 2009; Mitro *et al.*, 2012). The medium of body odour collection was a t-shirt, previously washed with an odourless detergent. T-shirts were worn by donors for 12 consecutive hours during the day, right after having taken a shower using fragrance-free body wash and having dried themselves with towels washed with the same odour-free detergent used to pre-wash the t-shirts. Donors collected their body odours on separate t-shirt for each day of collection. Odourless plastic bags were provided to each donor to store each of their t-shirts before bringing them to the lab, the day after each collection period (Lundström *et al.*, 2008; Lundström *et al.*, 2009). Samples were perceptually evaluated for odour contamination (e.g., alcohol, smoke, fragrance, food) and for body odour detectability by one to three trained experimenters. All samples were then stored in a −80°C freezer to prevent sample deterioration (Lenochova, Roberts, & Havlicek, 2009). All contacts with the pads occurred while the experimenters wore disposable, odourless surgical gloves.

Participants

The original sample was composed of 29 women in Experiment I and 30 women in Experiment II. The rationale for testing only women comes from the evidence that women show a processing advantage for social emotional stimuli (Proverbio, Zani, & Adorni, 2008), also when presented in olfactory form (Pause, Lübke, Laudien *et al.*, 2010). The participants followed the same criteria as the donors, and additionally they had to score at the 16-item Sniffin' Sticks Identification subtest of the Sniffin' Sticks Extended test above 10 (Hummel, Sekinger, Wolf *et al.*, 1997). In experiment I, one participant was removed for technical problems and five were removed because they scored above 50 at the State and Trait Anxiety

Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1968), which means that they had clinically anxiety, a criterion known to interact with both olfactory perception and morality. In experiment II, two participants were removed because of possible clinical problems. No depression or heightened sensitivity to disgust (Disgust Scale; Rozin, Haidt, McCauley *et al.*, 1999) was revealed. The final sample of experiment I 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 score was within the normal range (M = 36.83, SD = 6.84, range= 20-48). The final sample of experiment II included 28 healthy, heterosexual, right-handed women between the ages of 19 and 34 (M = 23.70, SD = 4.19), who were normosmic (M = 13.42, SD = 1.46, range= 11-16), and whose STAI state score before the task was within the normal range (M = 33.70, SD = 4.31, range= 24-42). Participants were instructed to not eat or drink anything but water one hour prior to testing, and to not wear any scented products on the day of testing. All aspects of the two experiments were approved by the local Institutional Review Board and are compliant with the Declaration of Helsinki.

General procedure

Experimental procedures were similar in both studies (Fig. 1). 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; Rozin *et al.*, 1999); the Autism-Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner *et al.*, 2001) and the Odour Awareness Scale (OAS; Smeets, Schifferstein, Boelema *et al.*, 2008). These self-report questionnaires have been included because previous literature has shown that moral decisions are modulated also by individual variability in sensitivity to disgust (Schnall, Haidt, Clore *et al.*, 2008; Choe & Min, 2011; Ugazio *et al.*, 2012) and autistic traits (Moran, Young, Saxe *et al.*, 2011; Buon, Dupoux, Jacob *et al.*, 2013), while the attention that people address to

odours could bias the effects that odours might have on moral choices. Moreover, participants performed the odour identification test (Hummel *et al.*, 1997). In Experiment II participants completed the Interpersonal Reactivity Index (IRI; Albiero, Ingoglia, & Lo Coco, 2006) instead of AQ. Afterwards, participants were asked to seat in front on a computer screen and to complete the State–Trait Anxiety Inventory (STAI-T and STAI-S; Spielberger *et al.*, 1968) and, only for Experiment I, the and the Profile of Mood States (POMS; McNair, Lorr, & Droppleman, 1992). Later, a rating odour task was proposed, followed by the moral decision-making task. After the moral decision-making task STAI-S, POMS (for Experiment I) and rating odour task were repeated. In Experiment I, at the end of the experimental session participants performed a 3AFC on odour stimuli. Participants in Experiment I completed all parts of the experimental session on the same computer screen while participants in Experiment II completed all parts except odour rating task and moral decision making task (which were performed in the MRI scanner) on the same computer screen. Each image was presented to the participants at the center of a 17" monitor (15.16° visual angle), upon a uniform black background. A central black or green fixation cross (0.2° visual angle) was presented before each image. Odour and visual presentation as well as response collection was regulated by the stimulus presentation program E-Prime Professional 2.0 (Psychological Software Tools. Sharpsburg. PA).

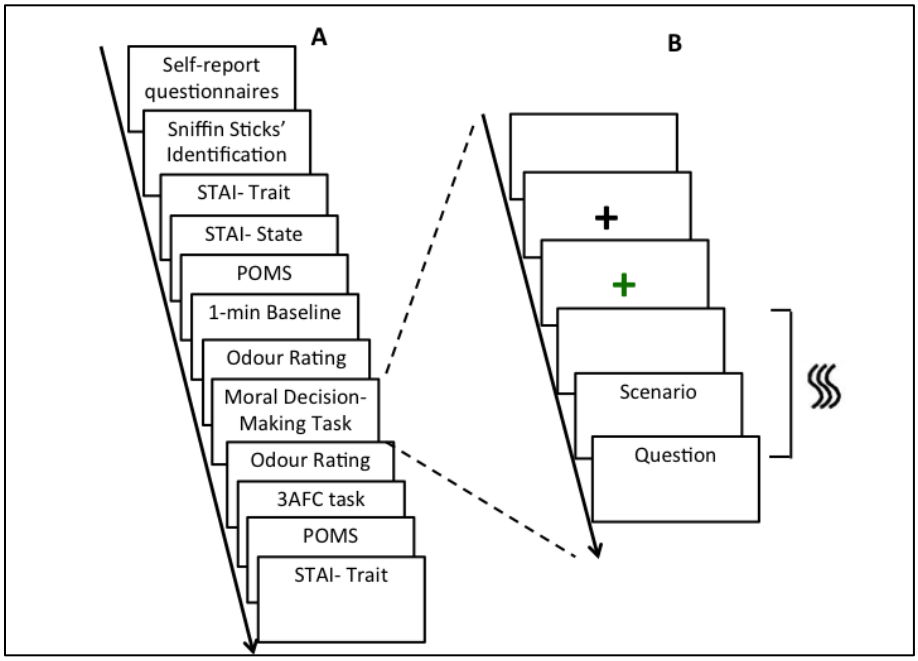

Figure 5.1. *Schematic example of the experimental procedure of Experiment I. A) Overview of the experiment session; B) Overview of a single trial of the moral decision-making task.*

Moral dilemmas

The 4CONFiDE moral set described in Chapter 2 was reshaped for this study. Each dilemma included a combination of the four conceptual factors. However dilemmas were reshaped for in order to include both congruent, in which cognitive and emotional processes converged in the same deontological action, and incongruent dilemmas, in which the two processes diverged (Conway & Gawronski, 2013). This resulted in 13 dilemma types, presented in their congruent and incongruent version. Each dilemma type was presented in two alternative versions to allow for the presentation of the same factors' combination in both odour conditions for a total of 64 dilemmas. The order of presentation of the dilemmas was randomized across subjects to exclude any presentation order effects on moral decision-making. As in Chapters 3 and 4, each dilemma was presented on two subsequent screens. The first screen described the scenario, in which a danger threatens to kill a group of persons, and a hypothetical action would save these people but cause the death of another person. The

second screen presented the question *Do you...[action verb] so that…?* Participants had to choose between four options: "I certainly do it", "I do it", "I do not do it", and "I certainly do not do it". The first two were considered to be utilitarian, as they maximise overall utility (i.e., saving more lives), whereas the second two choices were considered to be non-utilitarian (deontological).

Odour stimuli

Two odour conditions were presented within participants. One set of dilemma alternatives (N = 32) was presented following the exposure to an emotionally neutral, rather unfamiliar odour (200uL of cedarwood oil, Sigma-Aldrich), as determined via pilot studies (N = 53 participants). Such odour was used also in the other odour condition (aka, *social odour*) to perceptually mask the body odour samples. The social odour consisted of the combination of one equally-sized quadrants of t-shirt collected from each of the four donors (Martins, Preti, Crabtree *et al.*, 2005). Each participant smelled the samples of the same four donors, but in order to reduce the stimuli similarity (Mitro *et al.*, 2012), the combination varied in terms of the axilla the sample came from and the day at which it was collected.

Olfactometer

In both experiments, odours were presented bi-rhinally in a temporally-precise, square-shaped manner using a computer-automated olfactometer (Lundström, Gordon, Alden *et al.*, 2010). A low bi-rhinal flow rate of 1.0 L/m (a total of 0.5 L/m per nostril) was used to prevent irritation of the nasal mucosa over time (Lötsch, Ahne, Kunder *et al.*, 1998; Lundström *et al.*, 2010). Odorous air was directed to the nose when the odour was delivered and clean air was presented subsequently for approximately 1.6 (±0.2) sec. After odour presentation, clean air was presented until participant's response to minimize odour

residuals (Seubert, Gregory, Chamberland *et al.*, 2014). Odour stimuli were delivered directly to both participants' nostrils from a nasal manifold, attached to the participant's chest by means of a chest strap, connected to the Olfactometer via Teflon tubing.

Odour rating task

The rating odour task was designed to assess whether the two odour conditions were perceptually different between them and from clean air. Each odour presentation was preceded by a green fixation cross on the screen for 0.5 seconds followed by a black screen while an odour was presented for 4 sec; a white screen followed for an average inter-stimulus interval of 6 sec (± 0.12 sec). Subsequently, three questions were asked in succession and in a random order, namely "How intense was the odour you just smelled?", "How pleasant was the odour you just smelled?", and "How familiar was the odour you just smelled?". In Experiment I, perceptual ratings for odour intensity, pleasantness, and familiarity were collected on a 100-point computerized VAS, while for Experiment II, they were collected on a 10-point computerized VAS, both ranging from "not at all" to "very much". Participants were instructed to answer even if they did not perceive odour.

In Experiment II, odours rating task was performed inside the scanner to reduce the time of the experimental session but without collecting functional MRI data.

Moral decision-making task

Before starting the moral decision-making task, participants performed two practice trials. The instructions were similar to the ones proposed in previous Chapters (2, 3, 4). Each trial began with a white screen presented for 10 sec followed by a black cross that was displayed for 5 sec (jittered randomly ±0.294 sec). Then, a green screen was presented for 4 sec and the odour started to be delivered. Successively the scenario was presented for 25 sec.

The scenario presentation was combined with the odour presentation. Afterwards, the question slide was presented together with the releasing of clean air. The four choices were displayed below the question. Participants had maximum 6 sec to answer. Dilemmas were presented in four blocks of 16 trials. Participants were allowed to take a short break at the end of each block.

In Experiment II, moral decision-making task was divided into four runs. During each run, 16 trails balanced for moral dilemmas types and odour conditions, were presented in randomized order. Each trial began with a black cross that was displayed for 5 sec (jittered randomly ±0.294 sec). Then, a green screen was presented for 1.2 sec (jittered randomly ±0.159 sec) and the odour started to be delivered. In this experiment the scenario presentation was reduced to 22 sec. The scenario presentation was combined with the odour presentation. Afterwards, the question slide was presented together with the releasing of clean air as in Experiment I. Participants had maximum 5 sec to answer. After the answer a black cross was presented for 5 sec. Participants were allowed to take a short break at the end of each run.

3AFC task

The 3AFC was inserted to assess whether the masker body odour were consciously discriminable from the masker alone. Each trial was composed by the presentation of the masked body odour and by two presentation of the masker odour in consecutive and random order, for a total of nine trials. Each odour was presented for 1.7 sec it was followed by 2 sec of clean air. At the end of the trial participants had to answer to the question "Which odour was different?".

Behavioural data analysis

Behavioural data from both Experiments were analyzed with linear mixed-effects models (LMMs) as for Chapters 3 and 4 considering the answers as dichotomic (utilitarian and deontological). Moreover, frequency analysis were performed on the four distinctive options to see whether the number of each option change on odour condition. For odour ratings, models with odour factor and session were tested. For moral choice analyses, models included odour factor, as the main interest of our analysis, and the four conceptual moral factors (*Personal force, Intentionality, Benefit recipient, Evitability*), as factors describing our items. Moreover, for each experiment, at the beginning, all self-report questionnaires, and second-level interactions were included as fixed effects (McLean, Sanders, & Stroup, 1991; Faraway, 2005; Crepaldi, Che, Su *et al.*, 2012; Wehling, Wollschlaeger, Nordin *et al.*, 2016) 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). Final models are described in detail in the results sections.

Outliers with respect to reaction times were determined by means of the outliers-labelling rules. For Experiment I, no outliers were identified leaving a final sample of 1470 trials. For Experiment II, from a sample of 1792, 127 trials were removed for no response (N = 127/1792, 7.08%), and 43 trials were removed because of extremely long choice reaction times (>2.59 seconds; N = 43/1665, 2.58%). Conditions have equivalent final samples of trials (Masker odour = 810, Masked Social Odour = 812; $x^2_1 = 0.0025$, p = 0.96).

MRI data acquisition and pre-processing

A 3 Tesla Philips Achieva whole-body MR Scanner at the Hospital 'Santa Maria della Misericordia' (Udine, Italy), equipped with an 8-channel head coil, was used for MRI scanning. Head movement was minimized through cushioning within the coil. Functional volumes were obtained using a whole-head $T2^*$-weighted echoplanar image (EPI) sequence (repetition time

[TR] = 2.5s, echo time = 35ms, flip angle = 90, 28 transverse axial slices with interleaved acquisition, 3.5×3.59×4mm^3 voxel resolution, field of view = 230 X 230mm^2, acquisition matrix = 68×62, SENSE factors: 2 in the anterior–posterior direction). The number of volumes acquired varied for each participant and run given the task duration based on participants' reaction times (mean volumes per run = 260, SD = 4.60, range 153 – 270). Anatomical images were acquired during the final odour ratings task as 180 T1-weighted transverse images (0.75mm slice thick- ness). Stimuli were viewed through VisuaStim Goggles system (Resonance Technology) mounted to the head coil, which were adjusted on each participant's vision. Responses were made and recorded through one MR-compatible response pads (Lumitouch, Lightwave Medical Industries, Coldswitch technologies, Richmond, CA) using the right hand. Due to technical problems images from the second session of one participant were removed from the analysis.

Data were analyzed with SPM12 (Wellcome Department of Imaging Neuroscience, London, UK). All functional volumes were realigned to the first volume, segmented in gray matter, white matter and cerebrospinal fluid tissues, spatially normalized to the standard EPI template, and smoothed using a Gaussian kernel with full width at half maximum (FWHM) of 10 mm^3 (8 mm smoothing). Movement-related variance was analysed using the Art toolbox (www.nitrc.org/projects/artifact_detect). For each run, outlier scans were identified based on the TR-to-TR composite motion more than 2mm and/or considering whether the scan-to-scan global BOLD signal normalized to z-scores deviated from mean more than z = 3. The time-points identified as outliers were regressed out as separate nuisance covariates in the first-level design matrix. All participants display a percentage of outlier scan inferior to the cut-off (25%), therefore no one was excluded from the analyses.

fMRI data analysis

Based on the behavioural results, we decided to focus the fMRI data analysis on the interaction between personal force and odour conditions, which resulted significant on both behavioural analyses. Moreover, four events within each trial were modelled: presentation of clean air, odour presentation alone, the scenario presentation combined with odour, and question slide. Statistical analysis was performed using a general linear model approach. In the first-level analysis data were analyzed separately for each participants. Sixteen conditions were defined as regressors [Events (4) X Personal Force (2) X Odour conditions (2)] for each run. Six estimated motion parameters for each participant and run were included as regressors of no interest in the design matrix. All regressors were convoluted with a canonical hemodynamic response function. Low frequency signal drifts were filtered using a cutoff period of 128 sec. Whole-brain analyses were thresholded at $p < 0.05$, family-wise error (FEW) corrected at cluster level.

Neural activations related to conditions of interest were assessed by entering images from first-level into a full factorial design.

5.3 Results

5.3.1 Experiment I

The two odour conditions are perceptually equivalent

We first tested whether the masking procedure applied to cover the social odour had the expected perceptual impact and was equivalent across olfactory conditions. A distinction was maintained only for valence rating. The LMM on intensity ratings (Clean air: M = 17.72, SD = 1.62; Mask only: M = 55.17, SD = 2.07; Masked Social odour: M = 48.56, SD = 2.44; Figure 2A) revealed that both masker odour and masked social odour were perceived as significantly more intense than clean air ($p < 0.001$; reference factor: clean air), but no significant differences were found between mask only and masked social odour ($p = 0.15$; reference

factor: mask only). Moreover, no significant differences were found between ratings before and after the moral decision-making task (p = 0.35).

The LMM on familiarity ratings (Clean air: M = 26.79, SD = 1.77; Mask only: M = 47.56, SD = 2.33; Masked Social odour: M = 47.88, SD = 2.46; Figure 2B) showed that both masker odour and masked social odour were perceived as significant more familiar than clean air (p < 0.001; reference factor: clean air), but no significant differences were found between masker odour and masked social odour (p = 0.89; reference factor: mask only). No significant differences were found before and after the moral decision-making task (p = 0.35).

The LMM on valence ratings (Clean air: M = 38.62, SD = 2.15; Mask only: M = 48.70, SD = 2.26; Masked Social odour: M = 46.80, SD = 2.12; Figure 2C) showed that both the masker odour condition was perceived as more pleasant than clean air (p = 0.03) while the masked social odour tends to be perceived as more pleasant than clean air (p = 0.07; reference factor: clean air), but no significant differences were found between mask only and masked social odour (p = 0.72; reference factor: mask only). Moreover, a main effect of session was found: the three odour conditions were considered less pleasant after the moral decision-making task compared to the session performed before the task. This might indicate that the moral decision-making task, since it involved the presentation of stimuli with an highly aversive emotional content, could have acted as aversive stimuli making the two odour being perceived as more unpleasant compared to the ratings before the task. Please refer to Table 1 for descriptive data. Please refer to Table 1 for descriptive data.

To strengthen the idea that the masker and the masked body odour were not perceived as different, the results of the 3AFC test indicate that only 1 out 23 participants was able to discriminate the presence of the body odour among two masker samples in a percentage of cases significantly higher than chance. Following the binomial distribution, chance is set at 67% (6/9 correct discriminations; Figure 5. intercept of the red line on the y axis). 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 odour from the masker. Given that the moral choices of the participants better able to smell the difference between masker and masked body odour superiorly than or at chance level (N=3) were not significantly different from those of the group who could not discriminate the masked body odour, we included them in the final analyses.

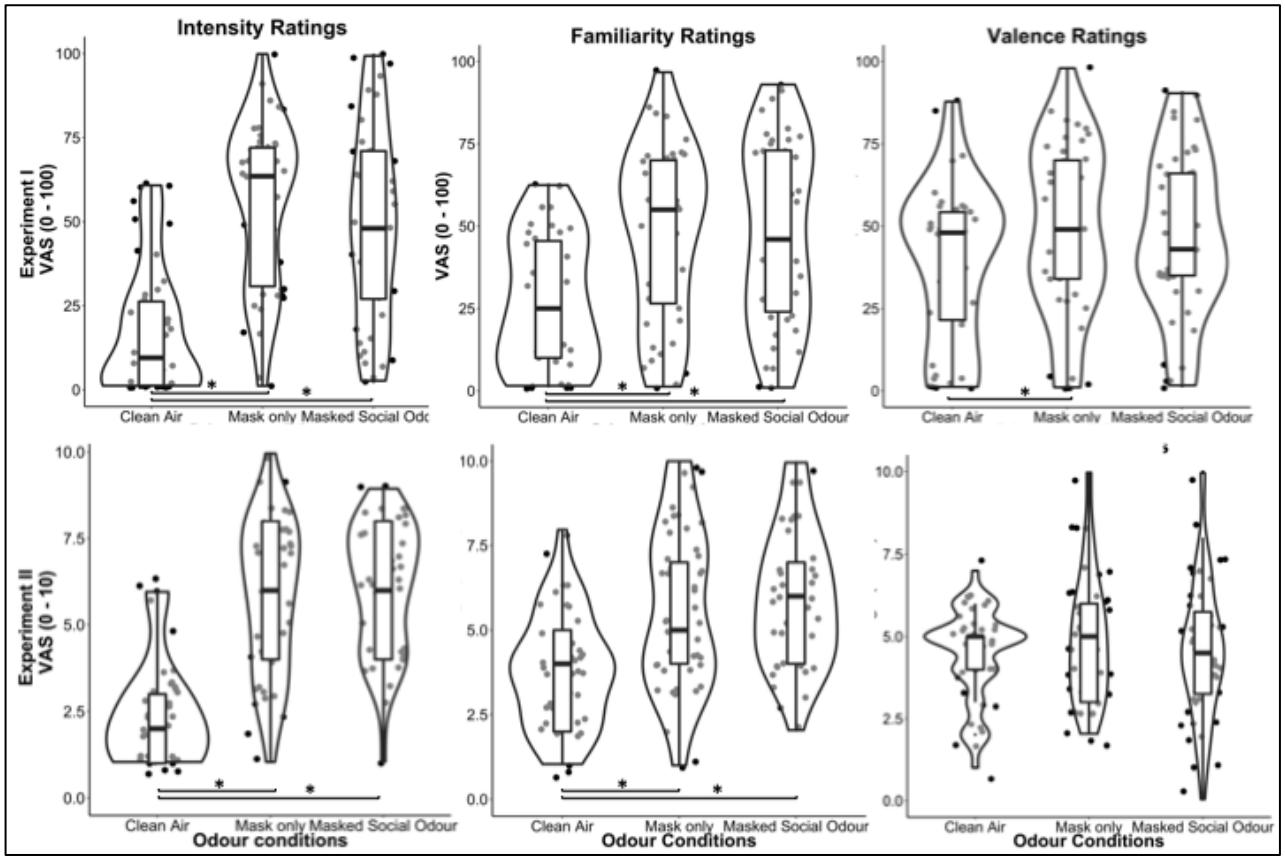

Figure 5.2. *Distribution of participants' odour ratings of Experiment I and Experiment II. The black dots represent single data points, whereas the box-plot represents the interquartile range of each distribution, with the thick black horizontal bar corresponding to the median. Each box-plot is surrounded by a violin plot representing the smoothed distribution of data. Significant differences (p <0.05) are indicated with a star.*

Table 5.1. *Summary of linear mixed effects model on intensity and valence odour ratings of Experiment I.*

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 Social Odour	-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 Social Odour	-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 Social Odour	-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 odour condition "Mask Only" set as reference.

Smelling the social odour increases the number of deontological responses

A frequency analysis confirms that participants are more prone to answer in a deontological manner ($X_{(1)} = 102.41$, $p < 0.0001$) and that they prefer using the central options (both deontological and utilitarian) rather than the extremes (respectively; $X_{(1)} = 43.49$, $p < 0.0001$; $X_{(1)} = 349.77$, $p < 0.0001$), as expected. Interestingly, the frequency analysis on the four options related to odour condition shows that during the exposure to the masked social odour condition participants gave less extreme utilitarian answers ($X_{(1)} = 6.81$, $p = 0.009$; See Figure 3) compared to the masker condition. This might indicate that participants were less confident with the decision of harming someone in the presence of socially relevant information.

The best fitting model for moral choice data (reference factor: utilitarian choice) resulted being the one including the odour factor, personal force, intentionality, benefit

recipient, evitability, the interaction of odour and each of these three factors, and the scores at DS (see Table 2 for descriptive data of single parameters). No effect of single odour conditions on moral choice was retrieved (z = -1.42, p = 0.15). However, the odour significantly interacted with three dilemma factors (personal force, intentionality and benefit recipient). However, post-hoc tests (*lsmeans* function) revealed only meaningful significant results for the interaction odour*personal force (see Figure 4A). Specifically, masked social odour, as compared to the masker condition, significantly increased the number of deontological choices to impersonal dilemmas (p = 0.008). Irrespective of the odour, the likelihood of choosing the deontological option increased when dilemmas were personal (vs. impersonal), instrumental (harm was intentional vs. accidental), self-benefit (vs. other-benefit), congruent, in which cognitive and emotional processes converged in the same deontological action (vs. incongruent), and increased disgust sensitivity (i.e., greater DS scores).

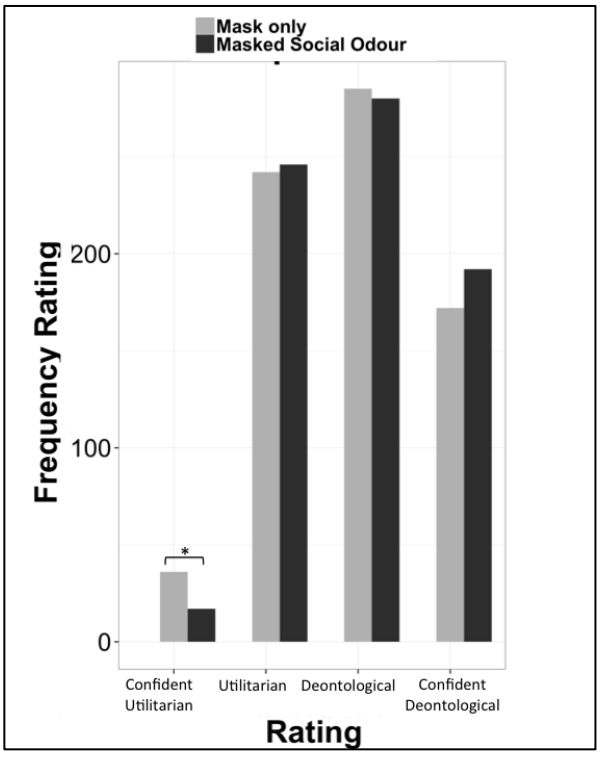

Figure 5.3. *Frequency of the four response options per odour conditions*

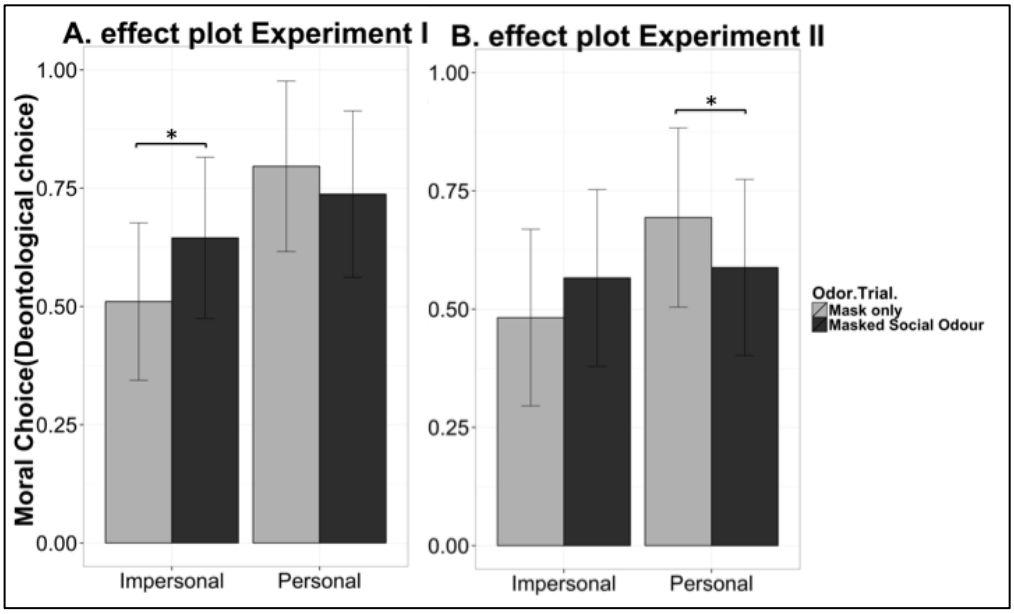

Figure 5.4. Effect plot of the interaction between odour factor and personal force. *Error bars are the Standard Error estimates of the parameter estimates of the model*

Table 5.2. *Summary of the best linear mixed effects model on moral choices for Experiment I.*

Moral choices	***β***	***SE***	***z value***	***p value***	***βexp***	***95%CI***	
Fixed effects						***Lower***	***Upper***
Intercept	0.18	0.57	0.31	0.756	1.193	0.393	3.618
MSocialOd	-0.40	0.28	-1.42	0.154	0.671	0.387	1.162
Personal force (*Personal*)	-1.32	0.18	-7.15	**<0.001**	0.267	0.186	0.383
Intentionality (*Instrumental*)	0.93	0.18	5.08	**<0.001**	2.525	1.766	3.611
Benefit recipient (*Self*)	0.48	0.18	2.68	**0.007**	1.622	1.138	2.311
Evitability (*Inevitable*)	-0.03	0.18	-0.18	0.860	0.969	0.681	1.379
Incongruency (*Incongruent*)	-1.95	0.14	-14.10	**<0.001**	0.143	0.109	0.187
DS	0.08	0.03	2.84	**0.005**	1.088	1.026	1.152
MSocialOd*Personal force(*Personal*)	0.89	0.26	3.44	**0.001**	2.426	1.464	4.018
MSocialOd*Intentionality (*Instrumental*)	0.57	0.26	2.19	**0.028**	1.760	1.062	2.916
MSocialOd*Benefit recipient (*Self*)	-0.54	0.26	-2.10	**0.036**	0.585	0.354	0.965
MSocialOd*Evitability (*Inevitable*)	0.11	0.26	0.43	0.669	1.115	0.676	1.839

Note: β = estimate; SE = standard error; β exp = exponential of β coefficient; 95% CI = confidence interval; MSocialOd = Masked Social Odour; DS = disgust scale. Significant p values are reported in bold. Table shows model with utilitarian choice and mask only odour condition set as references. The contrast condition from the reference for categorical factors is reported in italic in brackets.

The increased stress level at the end of the task suggests the dilemmatic nature of the task

A Wilcoxon test (V = 148801, $p < 0.0001$) 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; see Figure 5A). The Wilcoxon test on POMS (V = 83.5, $p = 0.273$) showed that participants mood overall did not change at the end of the task. However, looking into the single components of POMS questionnaires, we determined that participants' mood was more characterized by confusion (V = 31, $p = 0.032$) and less by vigour (V = 160, $p = 0.009$) at the end of the task (respectively: M = 13.74, SD = 5.93, range = 6-27; M = 21.26, SD = 6.85, range = 10-35) as compared to its beginning (respectively: M = 11.43, SD = 4.67, range = 6-19; M = 24.13, SD = 7.15, range = 11-35).

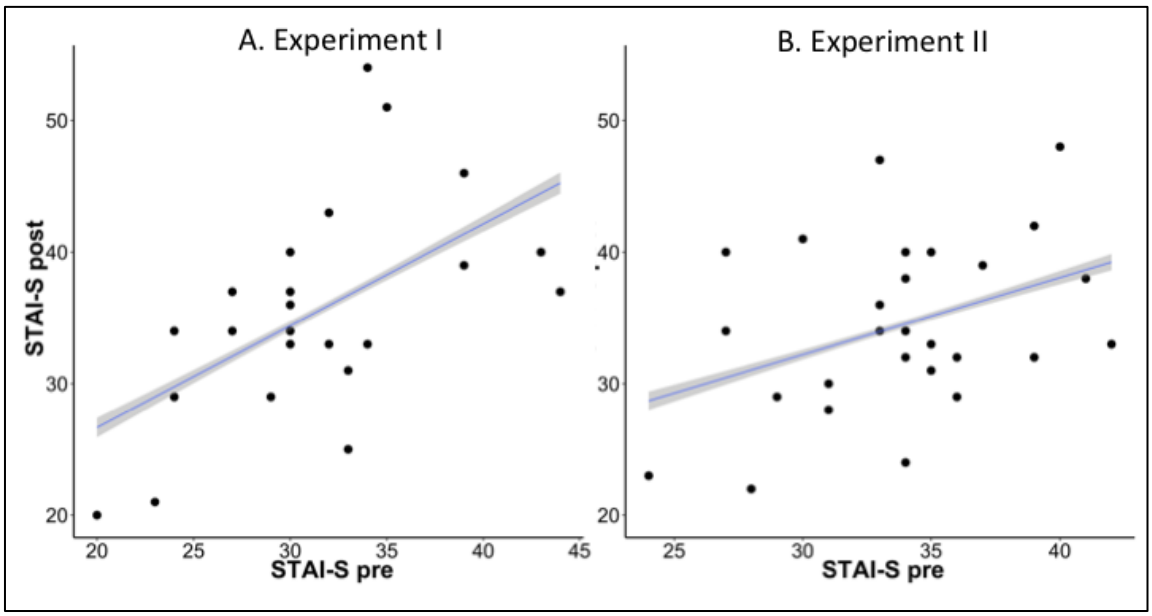

Figure 5.5. *Non-linear relationship between STAI state before and after the moral decision-making task in the two experiments. A) Experiment I; B) Experiment II.*

5.3.2 Experiment II

Odour ratings and anxiety levels confirm results of Experiment I

In line with Experiment I, the LMM on intensity ratings (Clean air: M = 2.45, SD = 0.13; Mask only: M = 5.83, SD = 0.18; Masked Social odour: M = 6.10, SD = 0.16; Figure 2) revealed that both masker odour and masked social odour were perceived as significantly more intense than clean air ($p < 0.001$; reference factor: clean air), but no significant differences were found between mask only and masked social odour ($p = 0.48$; reference factor: mask only). A difference emerged when looking at the effect of session: odours were rated as less intense during the second session compared to the first session suggesting that participants might have adapted during the moral decision-making task (Dalton, 2000).

The LMM on familiarity ratings (Clean air: M = 3.78, SD = 0.14; Mask only: M = 5.61, SD = 0.20; Masked Social odour: M = 5.91, SD = 0.17; Figure 2B) showed, as for Experiment I, that both masker odour and masked social odour were perceived as significantly more familiar than clean air ($p < 0.001$; reference factor: clean air), but no significant differences were found between masker odour and masked social odour ($p = 0.40$; reference factor: mask only). No significant differences were found between the ratings performed before and after the task.

In contrast with Experiment I, the LMM on valence ratings (Clean air: M = 4.48, SD = 0.12; Mask only: M = 4.89, SD = 0.16; Masked Social odour: M = 4.58, SD = 0.18; Figure 2C) showed no significant differences across the three conditions. Moreover, no significant differences were found between sessions. Please refer to Table 2 for descriptive data.

Wilcoxon test (V = 545373, $p = 0.005$) confirmed that participants' state anxiety was increased at the end of the task (M = 34.36, SD = 6.45, range = 22 - 48) as compared to its beginning (M = 33.67, SD = 4.33, range = 24 - 42; see Figure 5B).

***Table 5.2**. Summary of linear mixed effects model on intensity and valence odour ratings of Experiment II.*

Intensity Ratings	***β***	***SE***	***t value***	***p value***	***95%CI***	
Fixed effects					***Lower***	***Upper***
Intercept	6.18	0.32	19.20	**<0.001**	5.546	6.807
Clean Air	-3.31	0.35	-9.28	**<0.001**	-4.016	-2.615
Masked Social Odour	0.24	0.34	0.70	0.484	-0.432	0.914
Session (Post)	-0.66	0.29	-2.28	**0.024**	-1.233	-0.093
Familiarity Ratings	***β***	***SE***	***t value***	***p value***	***95%CI***	
Fixed effects					***Lower***	***Upper***
Intercept	5.76	0.37	15.61	**<0.001**	5.035	6.480
Clean Air	-1.85	0.33	-5.61	**<0.001**	-2.502	-1.207
Masked Social Odour	0.27	0.33	0.83	0.410	-0.370	0.910
Session (Post)	-0.27	0.27	-0.99	0.323	-0.814	0.267
Valence Ratings	***β***	***SE***	***t value***	***p value***	***95%CI***	
Fixed effects					***Lower***	***Upper***
Intercept	5.05	0.32	15.55	**<0.001**	4.416	5.689
Clean Air	-0.47	0.31	-1.51	0.132	-1.079	0.138
Masked Social Odour	-0.38	0.30	-1.26	0.210	-0.976	0.212
Session (Post)	-0.20	0.25	-0.78	0.436	-0.695	0.298

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

Behavioural data confirm the same pattern of results found in Experiment I

The frequency analysis on the number of responses per option showed that even in Experiment II participants gave more deontological answers ($X_{(1)} = 26.16$, $p < 0.0001$) and that they preferentially chose the central options (both deontological and utilitarian) rather than the extremes (respectively; $X_{(1)} = 72.83$, $p < 0.0001$; $X_{(1)} = 399.75$, $p < 0.0001$). However, in contrast with Experiment I, no significant differences emerge among response options in relation to odour condition.

The model resulted for Experiment I fitted also for moral choice data of Experiment II (reference factor: utilitarian choice; see Table 3 for descriptive data of single parameters). No effect of single odour conditions on moral choice was retrieved (z = -0.20, $p = 0.83$). However, the odour conditions significantly interacted with three dilemma factors (personal force, intentionality and evitability), revealing significant results for the interaction odour*personal force (see Figure 3). Specifically, post-hoc tests (*lsmeans* function) revealed that masked social

odour, as compared to masker condition, significantly decreases the number of deontological choices to personal dilemmas ($p = 0.03$). Although no significant differences in post-hoc contrasts were revealed for impersonal dilemmas, greater deontological answers were nominally associated with the masked social odour, as seen in Experiment I (see Figure 3). Additionally, in line with Experiment I, masked social odour significantly decreases the number of deontological choices to self-benefit dilemmas ($p = 0.02$). However, in contrast with Experiment I, a significant interaction between odour conditions and evitability was found: masked social odour has opposite effects for avoidable and inevitable dilemmas: it decreases deontological answer to avoidable dilemmas ($p < 0.001$) but it increases deontological answers to inevitable dilemmas (compared to mask only; $p = 0.01$). As seen for Experiment I, irrespective of the odour, the likelihood of choosing the deontological option increased when dilemmas were personal (vs. impersonal), instrumental (harm was intentional vs. accidental), self-benefit (vs. other-benefit), and increased disgust sensitivity (i.e., greater DS scores) however in Experiment II deontological options significantly increases also when dilemmas were avoidable (vs. inevitable).

As expected, and in line with Experiment I, we found that participants gave more deontological answers for congruent dilemmas compared to incongruent, however, no significant interactions were found with the odour conditions.

Table 5.3. *Summary of the best linear mixed effects model on moral choices for Experiment II.*

Moral choices	***β***	***SE***	***z value***	***p value***	***βexp***	***95%CI***	
Fixed effects						***Lower***	***Upper***
Intercept	0.25	0.62	0.40	0.686	1.283	0.383	4.302
MSocialOd	-0.85	0.26	-3.24	**0.001**	0.427	0.255	0.714
Personal force (*Personal*)	-0.89	0.17	-5.26	**<0.001**	0.411	0.295	0.573
Intentionality (*Instrumental*)	0.78	0.17	4.61	**<0.001**	2.175	1.563	3.026
Benefit recipient (*Self*)	0.51	0.17	3.04	**0.002**	1.668	1.199	2.320
Evitability (*Inevitable*)	-0.80	0.17	-4.71	**<0.001**	0.450	0.323	0.627
Incongruency (*Incongruent*)	-1.64	0.12	-13.30	**<0.001**	0.194	0.152	0.247
DS	0.07	0.04	2.00	**0.045**	1.074	1.002	1.152
MSocialOd*Personal force(*Personal*)	0.80	0.24	3.38	**0.001**	2.223	1.400	3.530
MSocialOd*Intentionality (*Instrumental*)	0.37	0.24	1.57	**0.117**	1.447	0.912	2.295
MSocialOd*Benefit recipient(*Self*)	-0.79	0.24	-3.33	**0.001**	0.455	0.287	0.723
MSocialOd*Evitability (*Inevitable*)	1.17	0.24	4.94	**<0.001**	3.237	2.031	5.159

Note: β = estimate; SE = standard error; β exp = exponential of β coefficient; 95% CI = confidence interval; MSocialOd = Masked Social Odour; DS = disgust scale. Significant p values are reported in bold. Table shows model with utilitarian choice and mask only odour condition set as references. Contrast condition from the reference for categorical factors is reported in italic in brackets.

5.3.3 fMRI data

Masked social odours selectively activate areas of the social brain

To explore the neural activations related to different odour conditions we considered the event corresponding to odour presentation only. We first contrasted the social odour condition with the masker condition. Increased neural activity was found in areas commonly associated to faces processing: the fusiform gyrus (left and right) and right inferior occipital gyrus (face processing; Sato, Kochiyama, Uono *et al.*, 2014). Interestingly the fusiform gyrus, beside face processing, has also been related to the general network of social cognition (Adolphs, 2001; Schultz, Grelotti, Klin *et al.*, 2003). Moreover, activation was found in the anterior cingulate gyrus (previously found by Lundström *et al.* (2008) for human body odour processing) as well as in areas related to the decoding of arousing stimuli (i.e., middle occipital gyrus; Dima, Stephan, Roiser *et al.*, 2011), and to the regulation of emotions (i.e.,

middle cingulate gyrus; Mayberg, 1997). Moreover in the left supramarginal gyrus and precuneus (witch it is usually activated by stimuli evoking disgust; Phillips, Williams, Heining *et al.*, 2004; but also by stranger body odour; Lundström *et al.*, 2008); see Table 1D in Appendix D). The opposite contrast revealed significant greater neural activity in the calcarine cortex and cuneus. Even though these areas are commonly visual areas they have been found in other olfactory neuroimaging studies (Gottfried, Smith, Rugg *et al.*, 2004; Djordjevic, Zatorre, Petrides *et al.*, 2005; Lundström *et al.*, 2008). Moreover activations were found in the right temporal pole and right superior temporal gyrus, areas associated with odour processing and identification (Jones-Gotman, Zatorre, Cendes *et al.*, 1997; Sobel, Prabhakaran, Hartley *et al.*, 1999; Suzuki, Critchley, Suckling *et al.*, 2001) and left supplementary motor cortex (previously found associated also to odour imagery; Djordjevic *et al.*, 2005; see Table 2D in Appendix D; see Figure 5.6).

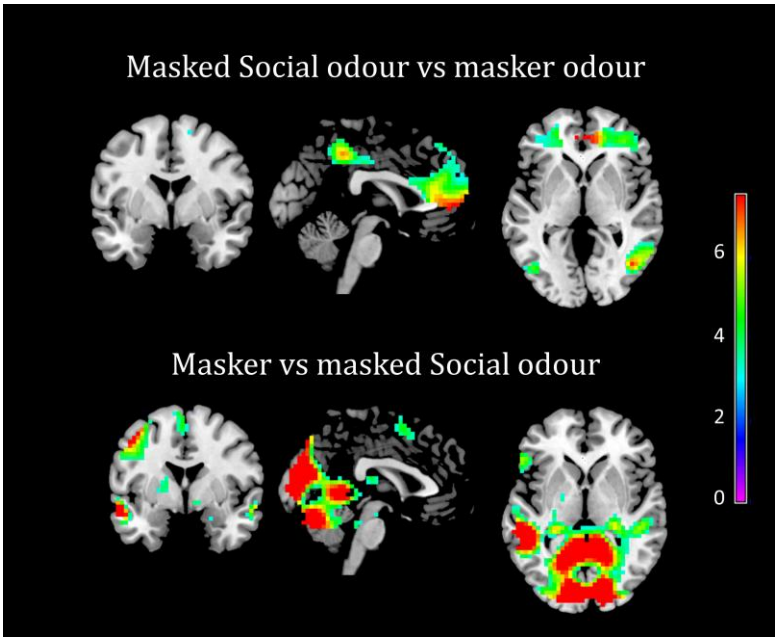

Figure 5.6. *Neural activations for the contrast masked social odour vs. masker odour and masker odour vs. masked social odour.*

***Table 5.4**. Brain regions exhibiting significant differential activity for A: Masked social odour vs. masker odour; B: Masker odour vs. masked social odour.*

A: Masked Social Odour vs. Masker odour						
Regions	Right/Left	Cluster size	t-value	x	y	z
Fusiform gyrus	R	758	11.13	29	-56	-10
Inferior occipital gyrus	R		7.24	43	-66	0
Anterior cingulate gyrus	L	1763	8.54	-6	46	0
Superior frontal gyrus	R		7.65	4	52	4
Supramarginal gyrus	L	116	8.47	-58	-42	42
Fusiform gyrus	L	57	7.04	-27	-52	-10
Precuneus	R	341	6.71	1	-42	46
Middle cingulate gyrus	R		4.71	8	-24	38
Inferior occipital gyrus	L	52	5.20	-41	-70	4
Middle occipitale gyrus	L		4.68	-48	-77	10
B: Masker odour vs. Masked Social odour						
Regions	Right/Left	Cluster size	t-value	x	y	z
Calcarine cortex	R	5167	17.53	15	-84	7
Cuneus	L		16.51	-6	-94	18
Temporal pole	R	56	6.07	54	10	-18
Superior temporal gyrus	R		5.99	60	-4	-10
Supplementary motor cortex	L	64	6.02	-2	7	60

Note: Anatomical labels follow the nomenclature of the Automated Anatomical Labelling (AAL). Peak locations are expressed in MNI coordinates. Voxelwise threshold, $p < 0.001$. FWE corrected $p < 0.05$.

Personal dilemmas, but not impersonal ones, activate areas of the social brain

To explore the different neural activation related to the personal and impersonal dilemmas the event of the scenario presentation was considered. The contrast personal vs impersonal revealed enhanced activity in posterior cingulate gyrus (activated as response to emotional stimuli; Cato *et al.*, 2004; but also found for body odours; Lundström *et al.*, 2008). Activations were also found in the visual areas, lingual gyrus and occipital pole; in social areas such as the left superior temporal gyrus, and in many limbic regions as the parahippocampal gyrus, left thalamus and right caudate, right amygdala and the hippocampus (left and right). In particular amygdala and hippocampus has been commonly related both to the processing of anxiogenic stimuli (McHugh, Deacon, Rawlins *et al.*, 2004), risk-taking task (Ernst, Bolla, Mouratidis *et al.*, 2002) and to olfactory processing (Gottfried & Dolan, 2003; see Table 3D in Appendix D). The opposite contrast, impersonal vs personal, showed increased activation

mostly in visual areas (right lingual gyrus, left occipital fusiform gyrus, left inferior occipital gyrus) and in the left and right thalamus. In previous literature thalamus activation have been found in association to perceiving painful situations (Jackson, Meltzoff, & Decety, 2005; Decety, Michalska, & Kinzler, 2012) and to everyday moral dilemma evaluation (Sommer, Rothmayr, Döhnel *et al.*, 2010; Pascual, Rodrigues, & Gallardo-Pujol, 2013; see Table 4D in Appendix D).

Table 5.5*. Brain regions exhibiting significant differential activity for A: Personal dilemmas vs. Impersonal dilemmas; B: Impersonal dilemmas vs. personal dilemmas.*

A: Personal vs. Impersonal						
Regions	Right/Left	Cluster size	t-value	x	y	z
Posterior cingulate gyrus	L	816	8.11	-10	-46	0
Lingual gyrus	L		6.62	-27	-60	7
Occipital pole	R		6.50	15	-98	7
Hippocampus	L	63	6.21	-30	-18	-18
Parahippocampal gyrus	L		5.61	-20	-18	-21
Superior temporal gyrus	L	70	5.72	-55	-7	-14
Hippocampus	R	67	5.38	26	-18	-18
Amygdala	R		3.33	22	4	-18
Thalamus	L	112	5.09	-16	-21	24
Right Caudate	R		4.34	12	-4	24
B: Impersonal vs. Personal						
Regions	Right/Left	Cluster size	t-value	x	y	z
Lingual gyrus	R	10580	17.95	29	-60	-10
Occipital fusiform gyrus	L		13.23	-27	-63	-10
Inferior occipital gyrus	L		12.70	-41	-74	4
Thalamus	L	88	5.57	-13	-21	10
Thalamus	R		4.44	12	-18	10

Note: Anatomical labels follow the nomenclature of the Automated Anatomical Labelling (AAL). Peak locations are expressed in MNI coordinates. Voxelwise threshold, $p < 0.001$. FWE corrected $p < 0.05$.

Processing the interaction between odour and type of dilemma

Comparison of hemodynamic responses associated with personal vs. impersonal trials in the social odour condition revealed enhanced neural activity in the fusiform gyrus (both sides), left posterior cingulate gyrus, hippocampus (both sides) and left caudate (see Table 5.4a). Impersonal dilemmas contrasted to personal dilemmas during the social odour were

related to increased activity in the occipital fusiform gyrus (both sides), right precentral gyrus, left supplementary motor cortex, orbital part of inferior frontal gyrus, right middle frontal gyrus, left anterior insula, frontal operculum, left thalamus and the caudate (an area involved in affective feedback; Delgado, Frank, & Phelps, 2005; see Table 5.4b).

Considering the scenario presentation during the masker odour condition, areas commonly involved in visual processing, the left calcarine cortex, right occipital pole, right cuneus, were significantly activated were significantly activated when personal dilemmas were contrasted to impersonal dilemmas. Moreover the left and right superior temporal gyrus (which is related to social perception (Allison, Puce, & McCarthy, 2000; Hein & Knight, 2008)) and hippocampus (both sides) were found (see Table 5.5c). The opposite contrast, impersonal vs. personal, was associated with activation mainly in visual areas: right lingual gyrus, left and right inferior occipital gyrus, right middle occipital gyrus, left and right superior parietal lobule, left supramarginal gyrus. Moreover, activations were found in the left postcentral gyrus, in the supplementary motor cortex and left thalamus (see Table 5.6d; see Figure 5.7).

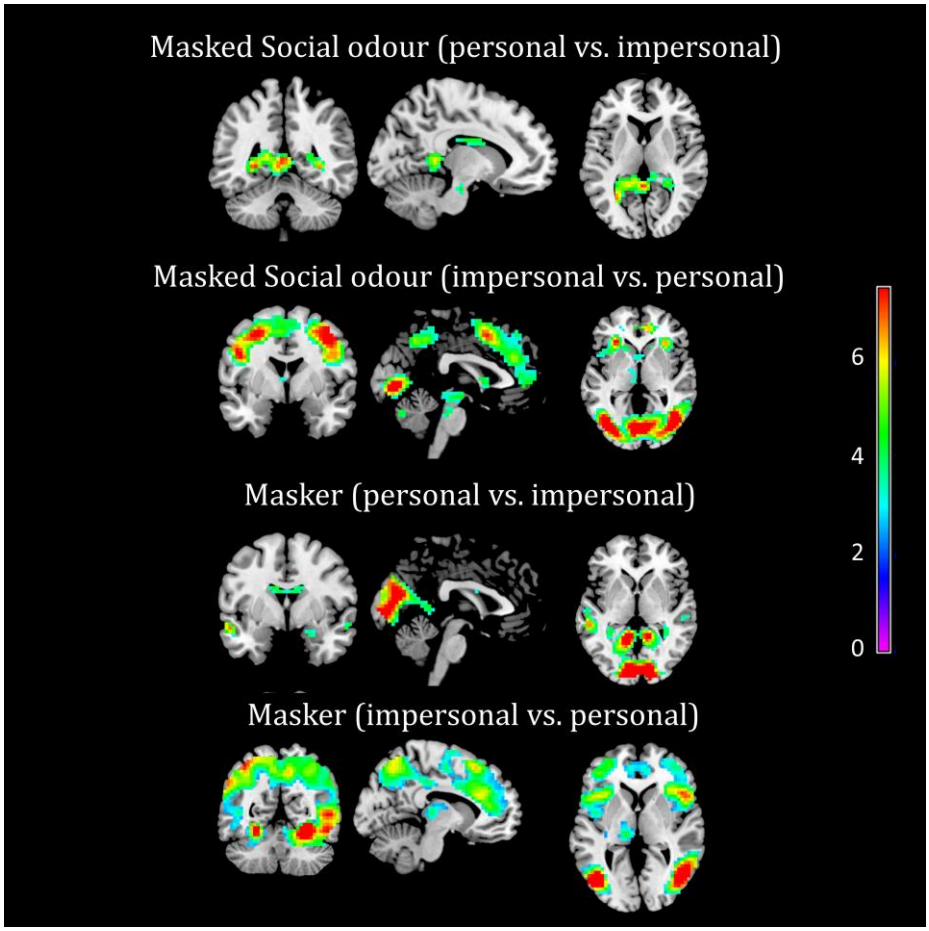

Figure 5.7. *Neural activations for masked social odour (Personal dilemmas vs. Impersonal dilemmas), masked social odour (Impersonal dilemmas vs. personal dilemmas), masker odour (Personal dilemmas vs. Impersonal dilemmas), masker odour (Impersonal dilemmas vs. personal dilemmas).*

Table 5.6*. Brain regions exhibiting significant differential activity for A: Masked social odour (Personal dilemmas vs. Impersonal dilemmas); B: Masked social odour (Impersonal dilemmas vs. personal dilemmas); c: Masker odour (Personal dilemmas vs. Impersonal dilemmas); B: Masker odour (Impersonal dilemmas vs. personal dilemmas).*

A: Masked social odour (Personal vs. Impersonal)						
Regions	Right/Left	Cluster size	t-value	x	y	z
Fusiform Gyrus	L	221	6.03	-30	-49	0
Posterior cingulate gyrus	L		5.80	-2	-46	7
Fusiform Gyrus	R	50	5.37	32	-46	0
Hippocampus	R		4.43	22	-42	10
Hippocampus	L	40	5.30	-16	-18	-21
Caudate	L	39	4.12	-16	-10	24
B: Masked social odour (Impersonal vs. Personal)						
Regions	Right/Left	Cluster size	t-value	x	y	z
Occipital fusiform gyrus	R	4882	14.85	29	-63	-10
Occipital fusiform gyrus	L		12.42	-27	-66	-10
Precentral gyrus	R	2283	8.17	40	7	24
Supplementary motor cortex	L		7.45	-6	10	49
Anterior insula	L	143	6.58	-27	28	0
Frontal operculum	L		3.66	-48	14	0
Orbital part of inferior frontal gyrus	R	76	5.76	32	28	0
Thalamus	L	169	4.91	-10	-18	10
Caudate	L	60	4.91	-6	7	7
Caudate	R		3.85	12	14	10
Middle frontal gyrus	R	93	4.64	29	35	28
B: Masker odour (Personal vs. Impersonal)						
Regions	Right/Left	Cluster size	t-value	x	y	z
Calcarine cortex	L	1691	12.68	-10	-91	0
Occipital pole	R		11.65	15	-98	7
Cuneus	R		9.65	8	-74	18
Superior temporal gyrus	L	134	8.96	-55	-7	-10
Superior temporal gyrus	R	42	6.56	60	-7	-10
Hippocampus	L	63	6.27	-30	-18	-18
Hippocampus	R	98	5.58	26	-24	-7
B: Masker odour (Impersonal vs. Personal)						
Regions	Right/Left	Cluster size	t-value	x	y	z
Lingual gyrus	R	10563	16.97	29	-60	-10
Inferior occipital gyrus	L		13.43	-44	-70	4
supramarginal gyrus	L		12.74	-52	-35	49
Inferior occipital gyrus	R		12.58	43	-66	0
Superior parietal lobule	R		10.42	32	-42	38
Inferior temporal gyrus	R		10.20	46	-60	-14
Supplementary motor cortex	L		10.18	-2	24	52
Superior parietal lobule	L		10.17	-38	-52	56
Postcentral gyrus	L		10.09	-38	-38	63
Middle occipital gyrus	R		9.28	32	-77	21
Thalamus	L	77	5.39	-13	-24	7

Note: Anatomical labels follow the nomenclature of the Automated Anatomical Labelling (AAL). Peak locations are expressed in MNI coordinates. Voxelwise threshold, $p < 0.001$. FWE corrected $p < 0.05$.

5.4 Discussion

The goal of this study was to examine whether human body odours can affect moral decisions by providing a social context in an implicit manner. As human body odours are powerful messengers for socially relevant information (Wyatt, 2014) able to modulate the behaviour and neural processing of the receiver (Jacob *et al.*, 2002; McClintock *et al.*, 2005; Lundström *et al.*, 2008; Lundström *et al.*, 2009; Mujica-Parodi *et al.*, 2009; Parma *et al.*, In press), we hypothesized that body odours might modulate moral behavioural choices by increasing prosocial behavioural and increasing harm avoidance. With this in mind, we asked participants to select their course of action to moral dilemmas while exposed to a neutral fragrance (masker) or to a body odour hidden by the same masker, rendering the two odour conditions perceptually not discriminable.

As the analysis of odour ratings reveals, mask only and the masked social odour were perceptually equivalent for intensity, valence and familiarity, indicating that the masking procedure succeeded. Therefore, differential effects of the odour factor on moral choice should not be attributed to perceptual differences across conditions. Indeed, this is an important aspect, since we previously demonstrated that intensity and pleasantness are odour dimensions able to induce confounders in the pattern of moral choices (see Chapter 4), in line with the data suggested by Schnall *et al.* (2008). Furthermore, the results from the 3AFC data of Experiment I, showing that participants performed this task below chance probability, strengthen the idea that the two odour conditions were not consciously discriminable.

As expected, in both experiments, the two odour conditions were rated as more intense compared to clean air, showing that participants were indeed perceiving the odours. Additionally, in contrast with our predictions, mask only and masked social odour conditions were perceived as more familiar than clean air. This result could be explained by the ambiguous nature of clean air condition, indeed participants, not smelling an actual odour,

were not able to identify the subject of the rating. Finally, even though in Experiment I participants rated the mask only condition as significantly more pleasant compared to clean air, however in Experiment II this result is not replicated and both graphs show that the median points are around the middle of the pleasantness scales, supporting the idea that cedarwood oil odour is considered hedonically neutral.

Considering the odour ratings between sessions, results of Experiment I seem to support the hypothesis of a potential aversive experience occurred during the moral decision-making task: indeed, the odours were rated as less pleasant during the second session. However, results of Experiment II did not confirm this hypothesis, instead the reduced intensity ratings resulted from the analysis of the second session seems to indicate that participants experienced olfactory adaptation. However, we cannot exclude that these differences between the Experiments may be due by the different experimental settings (only behavioural for Experiment I and in the MRI scanner for Experiment II).

Behavioural data showed that the human body odour modulates moral behaviour in interaction with the emotional content of the dilemmas. First, both Experiment I and II showed a significant interaction between personal force and odour. Experiment I revealed that masked social odour increases deontological answers when presented during impersonal dilemmas. Experiment II showed that the masked social odour decreases deontological answers for personal dilemmas. Even though these results seem in contrast with each other, the graphs of the two effects display the same modulatory pattern. The same pattern is present in Experiment II with the significant interaction between odour and the evitability factor: the masked social odour increases deontological answers for avoidable dilemmas and it increases them for inevitable dilemmas. Altogether this data seems to be in contrast with our hypothesis that social odour increases harm avoidance. Indeed, they advocate for an effect of the social odour to increase deontological answers only for the less arousing dilemmas (impersonal, inevitable; Christensen, Flexas, Calabrese *et al.*, 2014) and to decrease

deontological answers for the more arousing ones (personal, avoidable; Christensen *et al.*, 2014). One possible alternative hypothesis is that the social odour might induce participants to unconsciously perceive individuals described in the dilemmas as more concrete, real. In this way the social odour gave to the moral dilemma a concrete and more salient social context in a way similar to the mechanisms seen for virtual reality. Virtual reality is a task paradigm, usually used to simulate life-threatening situations, that provides a visually contextually rich environment (Zanon, Novembre, Zangrando *et al.*, 2014) and makes the task more ecologically valid (Patil, Cogoni, Zangrando *et al.*, 2014; Zanon *et al.*, 2014). Previous studies have shown that participants tend to give more utilitarian answers (Patil *et al.*, 2014) for the virtual-reality dilemmas compared to textual descriptions of the same dilemmas. We suggest that the social odour makes the social context richer and more salient incrementing the dilemmatic nature of the question and making the internal differences between personal and impersonal dilemmas (and between inevitable avoidable dilemmas) less noteworthy, as seen by the pattern of utilitarian and deontological answers for the two types of dilemmas in the social odour condition. This hypothesis is supported by the significantly reduced number of confident utilitarian responses chosen during the masked social odour condition in Experiment I. Indeed, participants might be less confident when they decide to harm someone when they perceive the presence of a real person.

Moreover, this hypothesis seems to be reinforced also by the fMRI data. Indeed as expected the moral dilemmas processed together with the masked social odour seems to involve more social areas than the moral dilemmas processed during the masker odour. As an example, the fusiform gyrus has been generally involved in social cognition (Adolphs, 2001; Schultz *et al.*, 2003), even though it is mostly associated with the perception and recognition of human faces (Harris, Rice, Young *et al.*, 2015). In our study we found the activation of this area for the masked social odour alone and while deciding on both personal and impersonal dilemmas. Another area that was activated for both personal and impersonal dilemmas when

presented in the masked social odour condition, but not during the masker odour, is the caudate nucleus. The caudate nucleus, previously found only for personal dilemmas in contrast to personal dilemmas (Greene *et al.*, 2004), is involved in decisions about reciprocity (Delgado *et al.*, 2005) and social cooperation (Rilling, Gutman, Zeh *et al.*, 2002; Rilling, King-Casas, & Sanfey, 2008). Moreover, the masked social odour increased activations in social areas for impersonal dilemmas that are not activated for the same type of dilemma during the masker only condition: the left anterior insula, and the orbital part of the inferior frontal gyrus, which is part of the so-called orbitofrontal cortex. The anterior insula is connected to an extensive range of functions, from interoception to subjective feeling and consciousness (Craig, 2009). However, it is particularly interesting for our study because it is an area labelled as secondary olfactory cortex (Soudry, Lemogne, Malinvaud *et al.*, 2011) and it is implicated in emotional awareness (Craig, 2009) and feeling of disgust (Wicker, Keysers, Plailly *et al.*, 2003): it controls visceral disgust sensations and the related autonomic responses (Wicker *et al.*, 2003). The orbitofrontal cortex is another complex area labelled as secondary olfactory cortex (Kadohisa, 2013) but involved also in other functions such as cognitive emotion regulation (Cunningham & Zelazo, 2007), experience of emotions that follow choices (Levens, Larsen, Bruss *et al.*, 2014) and response selection (Badre & Wagner, 2004). More in general the orbitofrontal cortex is implicated in the neural system sub-serving decision-making (Bechara, Damasio, & Damasio, 2000) and integrates cognitive and emotional information, as well as olfactory information, to choose the better option (Bechara *et al.*, 2000). So the activation of these two regions during the impersonal dilemmas might support the hypothesis that the masked social odour increased the aversive emotional reactions for these dilemmas making the impersonal dilemmas as high-conflict as the personal dilemmas. This evidence is in line with the results of the pleasantness ratings, which showed that after the moral decision making task odours were perceived as less pleasant.

It is worth noting that activations in occipital areas, commonly associated with vision, have been found in mainly all the contrast: both the one in which the scenario was presented (visual areas here are explained by the processing of the dilemmas) but also when only the odour was presented. These visual areas have been previously found activated in other neuroimaging studies exploring olfactory processing (Gottfried *et al.*, 2004; Djordjevic *et al.*, 2005; Lundström *et al.*, 2008) and it has been suggested that these visual areas could be activated by additional processes elicited by olfactory stimuli (Lundström *et al.*, 2008). However, an interesting difference comes up between visual areas activated during in the masked social odour conditions and the masker only condition: while in the former visual areas with higher social involvement are activated, such as the fusiform face area as seen before, in the latter we found activations in visual areas mainly involved in primary visual processing (calcarine cortex; Wandell, Dumoulin, & Brewer, 2007), discrimination of visual stimuli (cuneus; Pernet, Franceries, Basan *et al.*, 2004) and objects/words processing (lingual gyrus, left supramarginal gyrus; Mechelli, Humphreys, Mayall *et al.*, 2000; Oberhuber, Hope, Seghier *et al.*, 2016).

In conclusion, we demonstrate that body odours increased deontological answers when presented during impersonal dilemmas and decrease them for personal dilemmas. The same pattern was found for the evitability factor: masked social odour increases deontological answers for avoidable dilemmas and it increases them for inevitable dilemmas. Moreover, fMRI data showed that moral dilemmas processed during the masked social odour seem to involve the activation of more areas included in the social brain than the moral dilemmas processed during the masker odour. In summary, our data suggests that social odour, when unconsciously processed, is able to make more salient the social context incrementing the dilemmatic nature of the question.

CHAPTER 6

General Discussion

The past decade has seen a flourishing of studies investigating cognitive and emotional processing underlying moral choices. This is understandable thinking of the critical role that morality plays in human societies. Indeed, everyday we are asked to make decisions, more or less puzzling, that refer to the moral norms of our community. Nevertheless, the majority of previous studies have considered moral choices as if they were made in a vacuum. Particularly, the role of sensory information has been neglected. Nevertheless, all our moral choices are processed within a context and in interaction with environmental factors. This aspect becomes particularly interesting when considering evidence such as that proposed by Landy and Goodwin (2015), showing that olfactory stimuli strongly predict moral behaviour. However, in the studies revised by Landy and Goodwin (2015) several paradigms focusing on various aspects of morality have been used: different tasks might have introduced confounds in the investigations of the effects of olfactory stimuli on moral choices.

The experimental work included in this thesis aimed at extending the knowledge on the several ways in which contextual variables play a role in modulating moral choices, with a specific focus on olfactory perception. With the goal of contributing to this question, I first capitalized on some of the many confounding variables that shape our moral decisions. In particular, I created a set of stimuli in Italian in which all the four conceptual factors (*Personal force, intentionality, benefit recipient and evitability*) proposed by previous literature (Christensen et al. 2014; and Lotto et al. 2014) were considered (**Chapter 2**). These factors are designed around different aspects (whether the harm is direct or mediated by objects, whether the harm is intended or it is just an unintended consequence of the choice, who will

benefit from the harm and whether the sacrificed life would be lost in any case or not) that previous literature has shown to significantly modulate the choice of utilitarian and deontological responses beyond personal tendencies. However, many of the previous moral dilemmas databases have been developed in English speaking countries, whereas I will study the Italian population: previous studies have shown that the language in which a question is posed and the participants' cultural background could alter moral decision processes (Costa *et al.*, 2014; Cipolletti, McFarlane, & Weissglass, 2016; Gump, Baker, & Roll, 2000; Ahlenius & Tännsjö, 2012; Cowell *et al.*, 2016). To evaluate whether culture and language have effects on moral choices, I tested whether English dilemmas produce the same effects in the Italian population when they are translated. Additionally, we have also tried to fix some problems reported in the dilemma literature through the standardization of the dilemmas with respect to the word count, the type of moral transgression, the decision maker's perspective, the type of question, the use of the word *kill* and *save* and the description of the antecedent situation. As described in **Chapter 2**, moral choices were made irrespective of participants' native language (Study 1), suggesting that my translation was consistent between the two version of the dilemma set, allowing for direct comparison, moreover (Study 2) moral choices were made considering the four moral concepts (or the interaction between them) that constituted the moral dilemmas confirming that the information given through the dilemma is effective to modulate moral decisions.

Subsequently, I evaluated which are the interindividual features that may contribute to the processing of the moral dilemmas that I developed in the first chapter. Results of **Chapter 3** showed that individual differences in empathy and alexithymia shaped emotional reactions to moral decisions, but did not bias moral choices. The more empathic the participants, the more the dilemmas were perceived as unpleasant and arousing, and the greater the increase in skin conductance. Such results seem to suggest that, even though individual differences in

empathy or alexithymia might not affect moral choices in the context of moral decision making tasks, they do influence emotional reactions to moral dilemmas; moreover, they might indicate that, in contrast to what has been suggested for moral judgment, moral choice seems to be highly dependent on the contextual information provided by the moral dilemmas, rather than the participant's emotional tendencies. Based on this hypothesis, I focused on the study of how olfactory stimuli - in virtue of their preferential link with the emotional areas in the brain – may unbalance the participants' moral choices towards emotional decisions.

Considering the role that sensory stimuli play in moral decisions, as highlighted by (Landy & Goodwin, 2015), olfaction is a potent moral decision modulator. However, previous literature pairing odours with moral judgments has not carefully evaluated aspects of these stimuli that are known to generally modulate behaviour. Besides the use of olfactory stimuli to induce disgust, in **Chapter 4** we evaluated whether the mere presence of a neutral odour plays a role in modulating moral decisions and to which extent a negative odour pleasantness is required. In detail, we focused on odour intensity, based on the comparison between the findings by Schnall *et al.* (2008) and Ugazio *et al.* (2012), and pleasantness, to investigate whether the effects of odours on moral decisions go beyond negative valence. The results showed that, olfactory stimuli are effective in biasing moral choices towards a deontological tendency only when they were presented in a sub-threshold concentration, suggesting that olfactory stimuli affect the processes underlying moral decisions by incrementing deontological choices and that this effect goes beyond the ability of the odour to induce disgust. Also, pleasant and unpleasant odours might not differentially affect moral choices, opening to the possibility of using a wide range of olfactory stimuli in the study of moral choice and stemming away from disgust theories.

Finally, since most of moral decisions are made within a social context, in **Chapter 5** we explored whether human social odours, which are powerful signals to communicate social

information, are able to influence people on their moral decisions and which neural mechanisms are involved in such process. Behavioural data revealed that masked social odour interacted with some conceptual factors (personal force and evitability): it increased deontological answers for the less arousing dilemmas and it decreased them for the more arousing dilemmas. To investigate the neural mechanisms of the social odour effects in moral choices, the neural activations of moral dilemmas processed at the present of masked social odours were contrasted to the ones of moral dilemmas processed at the present of a common odour (the same odour used in Chapter 4). The networks of areas activated in response to each odour suggests that social odour, when unconsciously processed, involved more social areas (fusiform gyrus, caudate nucleus, anterior insula and orbitofrontal cortex) than the moral dilemmas processed during the masker only, supporting the hypothesis that human social odours can increase the saliency of the social context incrementing the dilemmatic nature of the moral choices.

The results of the individual experimental works have been discussed in their corresponding chapters. In the paragraphs below I will focus on three main points, which will describe some of the most relevant implications of the studies presented in this thesis, as well as questions that are still open.

6.1 Moral dilemmas: a critical view

The experimental works presented in this thesis were all designed around the same moral decision-making paradigm based on the presentation of moral dilemmas. Many criticisms have been raised against such stimuli, because they have been claimed to be unrealistic and unrepresentative of the moral situations people can face (Bauman *et al.*, 2014; Kahane, 2015; Kahane, Everett, Earp *et al.*, 2015) and because they lack of reliability and internal consistency (Borg *et al.*, 2006; McGuire *et al.*, 2009; Rosas & Koenigs, 2014; Kahane *et*

al., 2015; Christensen & Gomila, 2012). Despite these critics, I still consider moral dilemmas a useful and legitimate experimental method because rather than being unrealistic these dilemmas has a low likelihood of occurrence: circumstances similar to those described in these scenarios are become more and more usual in a world shattered by natural calamity, assaults and wars and moral dilemmas are the first step to clarify how people could behave when forced in these contexts; nevertheless, they are also a useful tool for understanding everyday moral decisions because they allow to evaluate moral choices without the confounding effect of different levels of experience across participants since they represent events with low probability of occurrence that participants are unlikely to have previously experienced (Hauser *et al.*, 2007). Moreover, when the potential confounding variables are addressed, then the methodology seems to produce valid and reliable results, as evident by the Cronbach's alpha test applied on the dilemmas in Chapter 2 and indicating high consistency among them, and by the similar rates utilitarian and deontological answers for the same conceptual factors across the studies.

However, some considerations are needed with respect to the results that emerged from the studies presented here. First, even though the careful and analytic work presented in Chapter 2 for creating a standardized set of moral dilemmas based on the four factors proposed by previous literature (Christensen & Gomila, 2012; Lotto et al. 2014), the results of Chapters 3, 4 and 5 did not present the a consistent effect that we were expecting. Indeed, while in Chapter 3, in study 1a of Chapter 4 and in Experiment I of Chapter 5 the conceptual factors that resulted as significant factors in shaping moral choices are personal force, intentionality and benefit recipient, the other studies did not present the same results. In studies 1b and 2 of Chapter 4 only personal force and evitability contributed to the moral choices, and in Experiment II of Chapter 5 moral choices are the results of the contribution of all the four conceptual factors. This might be due to the interindividual differences across the

samples of participants, which I have tried to contrast with the application of random intercept for participants in the analysis. However, the reduced sample size in the Study 2 of Chapter 4 may require additional studies to strengthen that point. Another option could be that the inconsistency between studies might be the results of the complex relationship between the conceptual factors and the different variables included in the studies. Moreover, this inconsistency across studies might be due by a problem embodied in dilemmas structure: indeed, dilemmas are described in lengthy written texts, which increase the time needed by the participants to process each stimulus; furthermore to make dilemmas credible they cannot be repeated the factors have to be intermingled along the dilemmas. These aspects reduce the possibility to present paradigms with large numbers of trials, therefore limiting the power of the study.

Alternatives to these problems, which are central to the moral dilemma literature, have been proposed. For instance, Lotto, Manfrinati, and Sarlo (2014) reduced the factors to be considered based on a theory driven approach (Intentionality and benefit recipient). However, since the present thesis represents the first attempt to thoroughly explore the olfactory effects on moral decision-making with a new dilemma set that has been highly controlled, I have preferred no to use the database proposed by Lotto *et al.* (2014) but to use a database that includes all conceptual factors so far known to have better control on the minimal effects that odour could have had. Indeed, our results showed that the effects of odours depended on the interaction with some of the conceptual factors; in particular personal force, the first that emerged in literature (Greene, Sommerville, Nystrom *et al.*, 2001; Greene, Nystrom, Engell *et al.*, 2004), was the one more consistent across the five studies in which the effects of odours were investigated. This evidence confirms that olfactory stimuli modulation acts through specific features of the dilemma.

In the light of the findings stemming from my thesis, I would suggest that future studies assess the role of olfactory contexts in moral choice to focus on the *personal force*, *intentionality* and *benefit recipient* conceptual factors, which have been shown to be more sensitive to olfactory modulation. In particular, I would advise to consider only personal force and intentionality factors: the first because is the factor that has shown the majority of the significant interactions with odours across the studies; the second because, after personal force, is the more consistent looking at the significant modulators of moral choices in our studies (Chapter 3, Chapter 4 study 1a, and both experiments of Chapter 5).

Second, even though it is clear that it is not acceptable to study moral decisions in real-life-threatening situations, the hypothetical moral dilemmas could be presented in a way that is more ecologically valid. One example is the application of virtual reality, which provides to the participants a visually rich environment (Zanon, et al., 2014). Here, I have tried to induce such contextual richness by capitalizing on a different sensory modality – olfaction - which can stress the social aspects of the decision. We applied this paradigm in Chapter 5 with the presentation of social odour, which have triggered a social context in our participants, but the same paradigm could be applied with dangerous signals, such as the smell of smoke or hazardous gas, which could triggered threating messages.

6.2 The olfactory effects on morality from disgust to social context

The starting point of this thesis was the meta-analysis published by Landy and Goodwin (2015a). The authors examined published and unpublished studies in which incidental disgust was induced in participants before they made moral choices. Even though the number of studies inducing disgust through visual stimuli was disproportionately bigger than the number of studies in which disgust was induced through chemosensory stimuli, the

meta-analysis revealed that the chemosensory induction of disgust (gustatory and olfactory) produced the stronger amplification effect in moral choice.

Following Landy and Goodwin's advice, we further investigated the special effects of olfactory stimuli with special attention of the chemosensory confounding effects neglected in the previous moral literature (Schnall *et al.*, 2008; Ugazio *et al.*, 2012). Our results extended previous literature in a fascinating way: even a neutral odour significantly modulates moral choices towards deontological answers. Moreover, we understand that the intensity of the olfactory stimulation is relevant for the success of the moral choices modulation: indeed, we found the modulatory effects only when the neutral odour was presented in sub-threshold concentration. We proposed that this effect is the sum of two favourable features: the novelty effect specific of the neutral odour (Bradley, 2009), which was cedarwood oil, an odour probably not familiar for our participants, and the minimal sensory information that can escape strategic inhibitory control (e.g., Li *et al.* 2007). Odours, in this case, constitute irrelevant information to be processed during the moral decision-making task. Nevertheless, such distracting information biases the moral choice towards a more emotional tendency, possibly through the activation of limbic areas, as seen in Chapter 5, given that cognitive resources have been taxed by the presence of the irrelevant stimulus (Greene et al., 2008). This phenomenon is not new: indeed odours irrelevant to the task (i.e. reach to grasp movement) can facilitate action planning and execution possibly through the reactivation of the action system (i.e., Parma et al., 2012; Parma et al., 2013).

However, the very innovative aspect of the present thesis is that we explored the moral decision-making inside a social context triggered by human social odours. Starting from the theory proposed by Rai and Fiske (2011), which advanced the hypothesis that actions and outcomes should be considered in the context of specific social relationships, indeed any action - including violence and impure acts - can be perceived as morally acceptable

depending on the social relationships in it takes place (Rai & Fiske, 2011), I wondered whether it was possible to make the social context more salient. Our study in this sense did not take the social perspective of Rai and Fiske: it was not meant to investigate the social relationships inside a group and the consequences of these social boundaries on the moral behaviour. The human body odours were only a means for triggering the social context and for making more salient the social norms.

In our study (Chapter 5) the human body odour was masked by a neutral odour. This masker was applied to simulate the hygiene product usually applied to cove body odours and to make the paradigm more ecologically valid (Saxton, Lyndon, Little *et al.*, 2008). However this paradigm has also other advantages: it allowed studying the effects of the human body odour when they are unconsciously perceived, as seen by the Chapter 4 this seemed to be one necessary condition for the odour modulation effect; and it also limited the intensity and valence biases that we have previously identified in Chapter 4.

6.3 The relevance of social odours on moral decisions

The results of Chapter 5 pointed out the special effects of human social odours on modulating moral choices both at behavioural level and at the level of neural activations.

To our knowledge this is the first study that the effect of social odour on moral decision-making is investigated and it is also the first study in which the effects of human body odours were investigated in relations to high-cognitive functions, such as decision-making. Indeed, so far, the evidence examined the body odour effects with reference to perceptual (Lundström et al., 2008; 2009; Mitro et al., 2012; Lundström et al., 2013) or evaluative tasks, primarily focused on discrete emotions and indirect measures (de Groot et al., 2012; de Groot et al., 2015). The value of these results is highlighted by the consideration that most of the moral decisions, from everyday choices to choices that we are forced to make

under unexpected circumstances, are made in the presence of other people. Our results indicate that human body odours could effectively bias high-level decisions, such as moral decisions, towards one option. However, although it provides new insights into the mechanisms of moral decision-making and the effects of human body odours, it also poses some questions. We here only contrasted the dilemma responses, olfactory ratings and neural activations of women, who were smelling male body odours. Based on the gender differences that are being highlighted in body odour literature recently (Mutic *et al.*, 2015) these results cannot be fully generalized to the overall population. Would the effects of body odours be different if we had women or males smelling women's body odours or males smelling males' body odours? Additionally, considering the role that familiarity plays in modulating body odors responses (Weisfeld, Czilli, Phillips *et al.*, 2003; Lundström *et al.*, 2008; 2009), Would the modulation be different if the body odours presented are from a friend or from a kin instead of from strangers? Previous studies have shown that the processing of olfactory stimuli from a stranger or a friend or a kin recruits different neural networks (Lundström et al., 2008; 2009) suggesting that they can differently affect moral behaviour. Would the response change if the emotional tone of the body odors was characterized by a specific emotion? Previous literature revealed that that humans behaviour can be affected by the anxiety signal transmitted from the body odours of others individuals (Pause et al., 2004; Chen et al., 2006; Pause et al., 2009; Prehn-Kristensen et al., 2009a; Zhou & Chen, 2009; Haegler et al., 2010; Zernecke et al., 2010; Albrecht et al., 2011) and the same results was found for disgust (de Groot et al., 2012), happiness (de Groot et al., 2015) and aggression (Mutic et al., 2015). Would emotions transmitted through social odours be able to biasing also moral decisions? If so, which will be the direction of these effects? Further research exploring the effect of human body odours on moral decision-making will help to clarify these aspects.

6.4 Epilogue

Although the majority of the studies investigating morality have focused on cognitive and emotional influences, in this thesis I have tried to uncover how contextual variables can impact moral choices, with a specific focus on olfactory perception. This thesis is an ideal continuum from the meta-analysis of Landy and Goodwin (2015), that has shown that the effect of incidental disgust on moral judgement would be maximal when disgust is elicited through the chemical senses, to social-bounded theories proposed to explain morality (Cikara *et al.*, 2010; Rai & Fiske, 2011). The take-home message of this work is that the context in which the decisions are made is relevant for understanding how that decision is made.

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References

Adams, R. P. (1991). Cedar wood oil—Analyses and properties. In Essential oils and waxes (pp. 159-173). Springer Berlin Heidelberg.

Adolphs, R. (2001). The neurobiology of social cognition. *Current opinion in neurobiology, 11*(2), 231-239.

Ahlenius, H., & Tännsjö, T. (2012). Chinese and Westerners respond differently to the trolley dilemmas. *Journal of Cognition and Culture, 12*(3-4), 195-201.

Alaoui-Ismaïli, O., Robin, O., Rada, H., Dittmar, A., & Vernet-Maury, E. (1997). Basic emotions evoked by odorants: comparison between autonomic responses and self-evaluation. *Physiology & behavior, 62*(4), 713-720.

Alaoui-Ismaili, O., Vernet-Maury, E., Dittmar, A., Delhomme, G., & Chanel, J. (1997). Odor hedonics: connection with emotional response estimated by autonomic parameters. *Chemical senses, 22*(3), 237-248.

Albiero, P., Ingoglia, S., & Lo Coco, A. (2006). Contributo all'adattamento italiano dell'Interpersonal Reactivity Index. *TPM, 13*, 107-125.

Albrecht, J., Demmel, M., Schöpf, V., Kleemann, A. M., Kopietz, R., May, J., . . . Wiesmann, M. (2011). Smelling chemosensory signals of males in anxious versus nonanxious condition increases state anxiety of female subjects. *Chemical senses, 36*(1), 19-27.

Allison, T., Puce, A., & McCarthy, G. (2000). Social perception from visual cues: role of the STS region. *Trends in cognitive sciences, 4*(7), 267-278.

Allman, J. M., Watson, K. K., Tetreault, N. A., & Hakeem, A. Y. (2005). Intuition and autism: a possible role for Von Economo neurons. *Trends in cognitive sciences, 9*(8), 367-373.

Anderson, A., Christoff, K., Stappen, I., Panitz, D., Ghahremani, D., Glover, G., . . . Sobel, N. (2003). Dissociated neural representations of intensity and valence in human olfaction. *Nature neuroscience, 6*(2), 196-202.

Anderson, S., Bechara, A., Damasio, H., Tranel, D., & Damasio, A. (1999). Impairment of social and moral behavior related to early damage in human prefrontal cortex. *Nature neuroscience, 2*(11), 1032-1037.

Aquinas, T. (1947). Summa theologica (Fathers of the English Dominican Province, Trans.). *New York: Benziger Brothers*.

Aquinas, T. (1965). *Introduction to Saint Thomas Aquinas*: McGraw-Hill Humanities/Social Sciences/Languages.

Arzi, A., Holtzman, Y., Samnon, P., Eshel, N., Harel, E., & Sobel, N. (2014). Olfactory Aversive Conditioning during Sleep Reduces Cigarette-Smoking Behavior. *The Journal of Neuroscience, 34*(46), 15382-15393.

Badre, D., & Wagner, A. D. (2004). Selection, integration, and conflict monitoring: assessing the nature and generality of prefrontal cognitive control mechanisms. *Neuron, 41*(3), 473-487.

Bargh, J. A., & Chartrand, T. L. (1999). The unbearable automaticity of being. *American psychologist, 54*(7), 462.

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The autism-spectrum quotient (AQ): Evidence from asperger syndrome/high-functioning autism, malesand females, scientists and mathematicians. *Journal of autism and developmental disorders, 31*(1), 5-17.

Baron, J., Gürçay, B., Moore, A. B., & Starcke, K. (2012). Use of a Rasch model to predict response times to utilitarian moral dilemmas. *Synthese, 189*(1), 107-117.

Batson, C. D. (2014). *The altruism question: Toward a social-psychological answer*: Psychology Press.
Bauman, C. W., McGraw, A. P., Bartels, D. M., & Warren, C. (2014). Revisiting external validity: Concerns about trolley problems and other sacrificial dilemmas in moral psychology. *Social and Personality Psychology Compass, 8*(9), 536-554.
Bechara, A., Damasio, H., & Damasio, A. R. (2000). Emotion, decision making and the orbitofrontal cortex. *Cerebral Cortex, 10*(3), 295-307.
Beck, A. T., Steer, R. A., & Brown, G. K. (1996). Beck depression inventory-II. *San Antonio*.
Belin, P., Fecteau, S., & Bedard, C. (2004). Thinking the voice: neural correlates of voice perception. *Trends in cognitive sciences, 8*(3), 129-135.
Bensafi, M., Brown, W., Khan, R., Levenson, B., & Sobel, N. (2004). Sniffing human sex-steroid derived compounds modulates mood, memory and autonomic nervous system function in specific behavioral contexts. *Behavioural brain research, 152*(1), 11-22.
Bensafi, M., Rouby, C., Farget, V., Bertrand, B., Vigouroux, M., & Holley, A. (2002). Autonomic nervous system responses to odours: the role of pleasantness and arousal. *Chemical senses, 27*(8), 703-709.
Bermond, B., & Oosterveld, P. (1994). Bermond-Vorst Alexithymia Questionnaire; construction, reliability, validity and uni-dimensionality: Internal Report. University of Amsterdam: Faculty of Psychology. Department of Psychological Methods.
Bermond, B., Bierman, D. J., Cladder, M. A., Moormann, P. P., & Vorst, H. C. (2010). The cognitive and affective alexithymia dimensions in the regulation of sympathetic responses. *International Journal of Psychophysiology, 75*(3), 227-233.
Bermond, B., Clayton, K., Liberova, A., Luminet, O., Maruszewski, T., Ricci Bitti, P. E., . . . Wicherts, J. (2007). A cognitive and an affective dimension of alexithymia in six languages and seven populations. *Cognition and Emotion, 21*(5), 1125-1136.
Bermond, B., Vorst, H., C. M., & Moormann, P. P. (2006). Cognitive neuropsychology of alexithymia: implications for personality typology. *Cogntive neuropsychiatry, 11*(3), 332-360.
Berthoz, S., Pouga, L., & Wessa, M. (2011). Alexithymia from the social neuroscience perspective. *Handbook of Social Neuroscience*, 906-934.
Białek, M., & De Neys, W. (2016). Conflict detection during moral decision-making: evidence for deontic reasoners' utilitarian sensitivity. *Journal of Cognitive Psychology*, 1-9.
Bird, G., & Cook, R. (2013). Mixed emotions: the contribution of alexithymia to the emotional symptoms of autism. *Translational psychiatry, 3*.
Bird, G., Silani, G., Brindley, R., White, S., Frith, U., & Singer, T. (2010). Empathic brain responses in insula are modulated by levels of alexithymia but not autism. *Brain*, awq060.
Blair, R. J. R. (2005). Responding to the emotions of others: dissociating forms of empathy through the study of typical and psychiatric populations. Consciousness and cognition, 14(4), 698-718.
Bloomfield, P. (2007). *Morality and Self-interest*: Oxford University Press.
Boesveldt, S., Lindau, S. T., McClintock, M. K., Hummel, T., & Lundström, J. N. (2011). Gustatory and olfactory dysfunction in older adults: a national probability study. *Rhinology, 49*(3), 324.
Bonini, N., Hadjichristidis, C., Mazzocco, K., Demattè, M. L., Zampini, M., Sbarbati, A., & Magon, S. (2011). Pecunia olet: The role of incidental disgust in the ultimatum game. *Emotion, 11*(4), 965-969.
Borg, J. S., Hynes, C., Van Horn, J., Grafton, S., & Sinnott-Armstrong, W. (2006). Consequences, action, and intention as factors in moral judgments: An fMRI investigation. *Journal of cognitive neuroscience, 18*(5), 803-817.

Boucsein, W. (2012). *Electrodermal activity*: Springer Science & Business Media.
Bradley, M. M. (2009). Natural selective attention: Orienting and emotion. *Psychophysiology, 46*(1), 1-11.
Bradley, M. M., Codispoti, M., Cuthbert, B. N., & Lang, P. J. (2001). Emotion and motivation I: defensive and appetitive reactions in picture processing. Emotion, 1(3), 276.
Bradley, M. M., Greenwald, M. K., & Hamm, A. O. (1993). Affective picture processing. The structure of emotion, 25(1), 48-65.
Bressi, C., Taylor, G., Parker, J., Bressi, S., Brambilla, V., Aguglia, E., . . . Bucca, M. (1996). Cross validation of the factor structure of the 20-item Toronto Alexithymia Scale: an Italian multicenter study. *Journal of Psychosomatic Research, 41*(6), 551-559.
Brewer, R., Marsh, A. A., Catmur, C., Cardinale, E. M., Stoycos, S., Cook, R., & Bird, G. (2015). The impact of autism spectrum disorder and alexithymia on judgments of moral acceptability. *Journal of abnormal psychology, 124*(3), 589.
Buon, M., Dupoux, E., Jacob, P., Chaste, P., Leboyer, M., & Zalla, T. (2013). The role of causal and intentional judgments in moral reasoning in individuals with high functioning autism. *Journal of autism and developmental disorders, 43*(2), 458-470.
Bussani, M., & Infantino, M. (2015). Tort law and legal cultures. *American Journal of Comparative Law, 63*, 301-332.
Cacioppo, J. T., Berntson, G. G., Larsen, J. T., Poehlmann, K. M., & Ito, T. A. (2000). The psychophysiology of emotion. *Handbook of emotions, 2*, 173-191.
Cameron, C. D., Payne, B. K., & Doris, J. M. (2013). Morality in high definition: Emotion differentiation calibrates the influence of incidental disgust on moral judgments. *Journal of Experimental Social Psychology, 49*(4), 719-725.
Carmichael, S. T., Clugnet, M. C., & Price, J. L. (1994). Central olfactory connections in the macaque monkey. *Journal of Comparative Neurology, 346*(3), 403-434.
Carmona-Perera, M., Martí-García, C., Pérez-García, M., & Verdejo-García, A. (2013). Valence of emotions and moral decision-making: increased pleasantness to pleasant images and decreased unpleasantness to unpleasant images are associated with utilitarian choices in healthy adults. *Frontiers in Human Neuroscience, 7*.
Case, T. I., Oaten, M. J., & Stevenson, R. J. (2012). Disgust and moral judgment. *Emotions, Imagination and Moral Reasoning*, 191-214.
Castiello, U., Zucco, G. M., Parma, V., Ansuini, C., & Tirindelli, R. (2006). Cross-modal interactions between olfaction and vision when grasping. *Chemical senses, 31*(7), 665-671.
Cato, M. A., Crosson, B., Gökçay, D., Soltysik, D., Wierenga, C., Gopinath, K., . . . Fischler, I. S. (2004). Processing words with emotional connotation: an FMRI study of time course and laterality in rostral frontal and retrosplenial cortices. *Journal of cognitive neuroscience, 16*(2), 167-177.
Cecchetto, C., Cavazzana, A., Gordon, A., Rebeschini, V., Parma, V., & Lundström, J. (2016). Chemosensory Threat Signals: The Case of Strangers' Body Odor. In t. A. M. Association for Chemoreception Sciences (AChemS), April 20-23, 2016, Bonita Springs, Florida (Ed.), *Chemical senses* (Vol. 41(7), pp. e1-e110).
Chapman, H. A., & Anderson, A. K. (2013). Things rank and gross in nature: a review and synthesis of moral disgust. *Psychological bulletin, 139*(2), 300.
Chapman, H., Kim, D., Susskind, J., & Anderson, A. (2009). In bad taste: evidence for the oral origins of moral disgust. *Science (New York, N.Y.), 323*(5918), 1222-1226.
Chebat, J.-C., & Michon, R. (2003). Impact of ambient odors on mall shoppers' emotions, cognition, and spending. *Journal of Business Research, 56*(7), 529-539.
Chen, D., & Haviland-Jones, J. (1999). Rapid mood change and human odors. *Physiology & behavior, 68*(1), 241-250.

Chen, D., Katdare, A., & Lucas, N. (2006). Chemosignals of fear enhance cognitive performance in humans. *Chemical senses, 31*(5), 415-423.
Cheng, J. S., Ottati, V. C., & Price, E. D. (2013). The arousal model of moral condemnation. *Journal of Experimental Social Psychology, 49*(6), 1012-1018.
Choe, S. Y., & Min, K.-H. (2011). Who makes utilitarian judgments? The influences of emotions on utilitarian judgments. *Judgment and Decision Making, 6*(7), 580-592.
Christensen, J. F., & Gomila, A. (2012). Moral dilemmas in cognitive neuroscience of moral decision-making: A principled review. *Neuroscience & Biobehavioral Reviews, 36*(4), 1249-1264.
Christensen, J. F., Flexas, A., Calabrese, M., Gut, N. K., & Gomila, A. (2014). Moral Judgment Reloaded: A Moral Dilemma validation study. *Emotion Science, 5*, 607.
Ciaramelli, E., Muccioli, M., Làdavas, E., & di Pellegrino, G. (2007). Selective deficit in personal moral judgment following damage to ventromedial prefrontal cortex. *Social cognitive and affective neuroscience, 2*(2), 84-92.
Cikara, M., Farnsworth, R. A., Harris, L. T., & Fiske, S. T. (2010). On the wrong side of the trolley track: Neural correlates of relative social valuation. *Social cognitive and affective neuroscience, 5*(4), 404-413.
Cipolletti, H., McFarlane, S., & Weissglass, C. (2016). The moral foreign-language effect. *Philosophical Psychology, 29*(1), 23-40.
Conway, P., & Gawronski, B. (2013). Deontological and utilitarian inclinations in moral decision making: A process dissociation approach. *Journal of personality and social psychology, 104*(2), 216.
Costa, A., Foucart, A., Hayakawa, S., Aparici, M., Apesteguia, J., Heafner, J., & Keysar, B. (2014). Your morals depend on language. *PloS one, 9*(4), e94842.
Cowell, J. M., Lee, K., Malcolm‐Smith, S., Selcuk, B., Zhou, X., & Decety, J. (2016). The development of generosity and moral cognition across five cultures. *Developmental science*.
Craig, A. D. (2009). How do you feel—now? the anterior insula and human awareness. *Nature reviews neuroscience, 10*(1).
Crepaldi, D., Che, W.-C., Su, I., & Luzzatti, C. (2012). Lexical-semantic variables affecting picture and word naming in Chinese: A mixed logit model study in aphasia. *Behavioural neurology, 25*(3), 165-184.
Crockett, M. J. (2013). Models of morality. *Trends in cognitive sciences, 17*(8), 363-366.
Crockett, M. J. (2014). Moral bioenhancement: a neuroscientific perspective. *Journal of medical ethics, 40*(6), 370-371.
Crockett, M. J., Clark, L., Hauser, M. D., & Robbins, T. W. (2010). Serotonin selectively influences moral judgment and behavior through effects on harm aversion. *Proceedings of the National Academy of Sciences, 107*(40), 17433-17438.
Crockett, M. J., Siegel, J. Z., Kurth-Nelson, Z., Ousdal, O. T., Story, G., Frieband, C., . . . Dolan, R. J. (2015). Dissociable effects of serotonin and dopamine on the valuation of harm in moral decision making. *Current Biology, 25*(14), 1852-1859.
Cunningham, W. A., & Zelazo, P. D. (2007). Attitudes and evaluations: A social cognitive neuroscience perspective. *Trends in cognitive sciences, 11*(3), 97-104.
Cushman, F. (2013). Action, outcome, and value a dual-system framework for morality. *Personality and Social Psychology Review, 17*(3), 273-292.
Cushman, F. (2014). The Psychological Origins of the Doctrine of Double Effect. *Criminal Law and Philosophy*, 1-14.
Cushman, F., & Greene, J. D. (2012). Finding faults: How moral dilemmas illuminate cognitive structure. *Social neuroscience, 7*(3), 269-279.

Cushman, F., Sheketoff, R., Wharton, S., & Carey, S. (2013). The development of intent-based moral judgment. *Cognition, 127*(1), 6-21.
Cushman, F., Young, L., & Hauser, M. (2006). The Role of Conscious Reasoning and Intuition in Moral Judgment: Testing Three Principles of Harm. *Psychological science, 17*.
Dalton, P. (2000). Psychophysical and behavioral characteristics of olfactory adaptation. *Chemical senses, 25*(4), 487-492.
Dalton, P., & Wysocki, C. J. (1996). The nature and duration of adaptation following long-term odor exposure. *Perception & Psychophysics, 58*(5), 781-792.
Damasio, A. (1994). Descartes' Error; Emotion, Reason and lhe Human Brain, New York. *NY, Grosset/Putnam*.
Davis, M. H., & Association, A. P. (1980). A multidimensional approach to individual differences in empathy.
de Araujo, I. E., Rolls, E. T., Velazco, M. I., Margot, C., & Cayeux, I. (2005). Cognitive modulation of olfactory processing. *Neuron, 46*(4), 671-679.
de Groot, J. H., Smeets, M. A., Kaldewaij, A., Duijndam, M. J., & Semin, G. R. (2012). Chemosignals communicate human emotions. *Psychological science, 23*(11), 1417-1424.
de Groot, J. H., Smeets, M. A., Rowson, M. J., Bulsing, P. J., Blonk, C. G., Wilkinson, J. E., & Semin, G. R. (2015). A sniff of happiness. Psychological science, 0956797614566318.
Decety, J., & Batson, C. D. (2009). *Empathy and morality: Integrating social and neuroscience approaches*: Springer.
Decety, J., & Cowell, J. M. (2014). The complex relation between morality and empathy. *Trends in cognitive sciences, 18*(7), 337-339.
Decety, J., & Cowell, J. M. (2014b). Friends or Foes Is Empathy Necessary for Moral Behavior? *Perspectives on psychological science, 9*(5), 525-537.
Decety, J., & Jackson, P. L. (2004). The functional architecture of human empathy. *Behavioral and cognitive neuroscience reviews, 3*(2), 71-100.
Decety, J., & Lamm, C. (2007). The role of the right temporoparietal junction in social interaction: how low-level computational processes contribute to meta-cognition. *The Neuroscientist*.
Decety, J., Michalska, K. J., & Kinzler, K. D. (2012). The contribution of emotion and cognition to moral sensitivity: a neurodevelopmental study. *Cerebral Cortex, 22*(1), 209-220.
Delgado, M. R., Frank, R. H., & Phelps, E. A. (2005). Perceptions of moral character modulate the neural systems of reward during the trust game. *Nature neuroscience, 8*(11), 1611-1618.
Devine, P. G. (1989). Stereotypes and prejudice: their automatic and controlled components. *Journal of personality and social psychology, 56*(1), 5.
Dima, D., Stephan, K. E., Roiser, J. P., Friston, K. J., & Frangou, S. (2011). Effective connectivity during processing of facial affect: evidence for multiple parallel pathways. *The Journal of Neuroscience, 31*(40), 14378-14385.
Djordjevic, J., Zatorre, R. J., Petrides, M., Boyle, J., & Jones-Gotman, M. (2005). Functional neuroimaging of odor imagery. *NeuroImage, 24*(3), 791-801.
Doty, R. L. (1991). Psychophysical measurement of odor perception in humans *The human sense of smell* (pp. 95-134): Springer.
Efron, B., & Tibshirani, R. J. (1994). *An introduction to the bootstrap*: CRC press.
Ehrlichman, H., & Halpern, J. N. (1988). Affect and memory: effects of pleasant and unpleasant odors on retrieval of happy and unhappy memories. *Journal of personality and social psychology, 55*(5), 769.
Eisenberg, N. (2000). Emotion, regulation, and moral development. *Annual review of psychology, 51*(1), 665-697.

Ernst, M., Bolla, K., Mouratidis, M., Contoreggi, C., Matochik, J. A., Kurian, V., . . . London, E. D. (2002). Decision-making in a risk-taking task: a PET study.
Eskine, K., Kacinik, N., & Prinz, J. (2011). A bad taste in the mouth: gustatory disgust influences moral judgment. *Psychological science, 22*(3), 295-299.
Faraway, J. J. (2005). *Extending the linear model with R: generalized linear, mixed effects and nonparametric regression models*: CRC press.
Feinberg, M., Willer, R., Antonenko, O., & John, O. P. (2012). Liberating reason from the passions overriding intuitionist moral judgments through emotion reappraisal. *Psychological science, 23*(7), 788-795.
FeldmanHall, O., Mobbs, D., Evans, D., Hiscox, L., Navrady, L., & Dalgleish, T. (2012). What we say and what we do: the relationship between real and hypothetical moral choices. *Cognition, 123*(3), 434-441.
Ferry, B., Ferreira, G., Traissard, N., & Majchrzak, M. (2006). Selective involvement of the lateral entorhinal cortex in the control of the olfactory memory trace during conditioned odor aversion in the rat. *Behavioral neuroscience, 120*(5), 1180.
Figner, B., & Murphy, R. O. (2011). Using skin conductance in judgment and decision making research. *A handbook of process tracing methods for decision research*, 163-184.
Fischer, J. M., & Ravizza, M. (1992). *Ethics: Problems and principles*: Harcout Brace Jovanovich College Publishers.
Flack, J. C., & de Waal, F. B. M. (2000). Any animal whatever': Darwinian building blocks of morality in monkeys and apes. In L. D. Katz (Ed.), *Evolutionary Origins of Morality* (Imprint Academic ed., pp. 1-29).
Foot, P. (1967). Theories of ethics.
Franz, M., Schaefer, R., & Schneider, C. (2003). Psychophysiological response patterns of high and low alexithymics under mental and emotional load conditions. *Journal of Psychophysiology, 17*(4), 203-213.
Frith, C. D., & Allen, H. A. (1983). The skin conductance orienting response as an index of attention. *Biological psychology, 17*(1), 27-39.
Fukunishi, I., Sei, H., Morita, Y., & Rahe, R. H. (1999). Sympathetic activity in alexithymics with mother's low care. *Journal of Psychosomatic Research, 46*(6), 579-589.
Fumagalli, M., & Priori, A. (2012). Functional and clinical neuroanatomy of morality. *Brain, 135*(7), 2006-2021.
Fumagalli, M., Ferrucci, R., Mameli, F., Marceglia, S., Mrakic-Sposta, S., Zago, S., . . . Pravettoni, G. (2010). Gender-related differences in moral judgments. *Cognitive processing, 11*(3), 219-226.
Gao, Y., & Tang, S. (2013). Psychopathic personality and utilitarian moral judgment in college students. *Journal of Criminal Justice, 41*(5), 342-349.
Garrigan, B., Adlam, A. L., & Langdon, P. E. (2016). The neural correlates of moral decision-making: A systematic review and meta-analysis of moral evaluations and response decision judgements. Brain and Cognition, 108, 88-97.
Garrigan, B., Adlam, A. L., & Langdon, P. E. (2016). The neural correlates of moral decision-making: A systematic review and meta-analysis of moral evaluations and response decision judgements. *Brain and cognition*.
Gleichgerrcht, E., & Young, L. (2013). Low levels of empathic concern predict utilitarian moral judgment. *PloS one, 8*(4), e60418.
Gleichgerrcht, E., Tomashitis, B., & Sinay, V. (2015). The relationship between alexithymia, empathy and moral judgment in patients with multiple sclerosis. *European Journal of neurology*.
Glenn, A. L., Koleva, S., Iyer, R., Graham, J., & Ditto, P. H. (2010). Moral identity in psychopathy. *Judgment and Decision Making, 5*(7), 497-505.

Goerlich-Dobre, K. S., Bruce, L., Martens, S., Aleman, A., & Hooker, C., I. . (2014). Distinct associations of insula and cingulate volume with the cognitive and affective dimensions of alexithymia. *Neuropsychologia, 53*.
Goerlich-Dobre, K. S., Lamm, C., Pripfl, J., Habel, U., & Votinov, M. (2015). The left amygdala: A shared substrate of alexithymia and empathy. *NeuroImage, 122*, 20-32.
Goerlich-Dobre, K. S., Votinov, M., Habel, U., Pripfl, J., & Lamm, C. (2015). Neuroanatomical profiles of alexithymia dimensions and subtypes. *Human brain mapping*.
Gottfried, J. A., Smith, A. P., Rugg, M. D., & Dolan, R. J. (2004). Remembrance of odors past: human olfactory cortex in cross-modal recognition memory. *Neuron, 42*(4), 687-695.
Gottfried, J., & Dolan, R. (2003). The nose smells what the eye sees: crossmodal visual facilitation of human olfactory perception. *Neuron, 39*(2), 375-386.
Greene, J. D. (2009). Dual-process morality and the personal/impersonal distinction: A reply to McGuire, Langdon, Coltheart, and Mackenzie. *Journal of Experimental Social Psychology, 45*(3), 581-584.
Greene, J. D., Cushman, F. A., Stewart, L. E., Lowenberg, K., Nystrom, L. E., & Cohen, J. D. (2009). Pushing moral buttons: The interaction between personal force and intention in moral judgment. *Cognition, 111*(3), 364-371.
Greene, J. D., Morelli, S. A., Lowenberg, K., Nystrom, L. E., & Cohen, J. D. (2008). Cognitive load selectively interferes with utilitarian moral judgment. *Cognition, 107*(3), 1144-1154.
Greene, J., & Haidt, J. (2002). How (and where) does moral judgment work? *Trends in cognitive sciences, 6*(12), 517-523.
Greene, J., Nystrom, L., Engell, A., Darley, J., & Cohen, J. (2004). The neural bases of cognitive conflict and control in moral judgment. *Neuron, 44*(2), 389-400.
Greene, J., Sommerville, R., Nystrom, L., Darley, J., & Cohen, J. (2001). An fMRI investigation of emotional engagement in moral judgment. *Science (New York, N.Y.), 293*(5537), 2105-2108.
Grynberg, D., Luminet, O., Corneille, O., Grèzes, J., & Berthoz, S. (2010). Alexithymia in the interpersonal domain: A general deficit of empathy? *Personality and Individual Differences, 49*(8), 845-850.
Gump, L. S., Baker, R. C., & Roll, S. (2000). Cultural and gender differences in moral judgment: A study of Mexican Americans and Anglo-Americans. *Hispanic Journal of Behavioral Sciences, 22*(1), 78-93.
Guttman, H., & Laporte, L. (2002). Alexithymia, empathy, and psychological symptoms in a family context. *Comprehensive Psychiatry, 43*(6), 448-455.
Haegler, K., Zernecke, R., Kleemann, A. M., Albrecht, J., Pollatos, O., Brückmann, H., & Wiesmann, M. (2010). No fear no risk! Human risk behavior is affected by chemosensory anxiety signals. *Neuropsychologia, 48*(13), 3901-3908.
Haidt, J. (2001). The emotional dog and its rational tail: a social intuitionist approach to moral judgment. *Psychological review, 108*(4), 814.
Haidt, J. (2007). The new synthesis in moral psychology. *science, 316*(5827), 998-1002.
Haidt, J. (2008). Morality. *Perspectives on psychological science, 3*(1), 65-72.
Harenski, C. L., & Hamann, S. (2006). Neural correlates of regulating negative emotions related to moral violations. *NeuroImage, 30*(1), 313324.
Harlé, K. M., & Sanfey, A. G. (2010). Effects of approach and withdrawal motivation on interactive economic decisions. *Cognition and Emotion, 24*(8), 1456-1465.
Harris, R. J., Rice, G. E., Young, A. W., & Andrews, T. J. (2015). Distinct but overlapping patterns of response to words and faces in the fusiform gyrus. *Cerebral Cortex*, bhv147.
Hatfield, E., Cacioppo, J. T., & Rapson, R. L. (1994). Emotional contagion: Studies in emotion and social interaction. *Editions de la Maison des sciences de l'homme*.

Hauser, M., Cushman, F., Young, L., Kang‐Xing Jin, R., & Mikhail, J. (2007). A dissociation between moral judgments and justifications. *Mind & language, 22*(1), 1-21.
Haxby, J. V., Hoffman, E. A., & Gobbini, M. I. (2002). Human neural systems for face recognition and social communication. *Biological psychiatry, 51*(1), 59-67.
Heekeren, H. R., Wartenburger, I., Schmidt, H., Prehn, K., Schwintowski, H.-P., & Villringer, A. (2005). Influence of bodily harm on neural correlates of semantic and moral decision-making. *NeuroImage, 24*(3), 887-897.
Heekeren, H. R., Wartenburger, I., Schmidt, H., Schwintowski, H.-P., & Villringer, A. (2003). An fMRI study of simple ethical decision-making. *Neuroreport, 14*(9), 1215-1219.
Hein, G., & Knight, R. T. (2008). Superior temporal sulcus—it's my area: or is it? *Journal of cognitive neuroscience, 20*(12), 2125-2136.
Hein, G., & Singer, T. (2008). I feel how you feel but not always: the empathic brain and its modulation. *Current opinion in neurobiology, 18*(2), 153-158.
Herz, R. S. (2000). Verbal coding in olfactory versus nonolfactory cognition. *Memory & Cognition, 28*(6), 957-964.
Herz, R. S. (2006). I know what i like: understanding odor preferences. *The smell culture reader*, 190-203.
Herz, R. S., & von Clef, J. (2001). The influence of verbal labeling on the perception of odors: evidence for olfactory illusions? *Perception, 30*(3), 381-391.
Herz, R. S., Eliassen, J., Beland, S., & Souza, T. (2004). Neuroimaging evidence for the emotional potency of odor-evoked memory. *Neuropsychologia, 42*(3), 371-378.
Hilbe, J. M. (2009). *Logistic regression models*: CRC Press.
Hoaglin, D. C., Iglewicz, B., & Tukey, J. W. (1986). Performance of some resistant rules for outlier labeling. *Journal of the American Statistical Association, 81*(396), 991-999.
Hoffman, M. L. (1994). The contribution of empathy to justice and moral judgment. *Reaching out: Caring, altruism, and prosocial behavior, 7*, 161-194.
Horberg, E., Oveis, C., Keltner, D., & Cohen, A. B. (2009). Disgust and the moralization of purity. *Journal of personality and social psychology, 97*(6), 963.
Hosmer Jr, D. W., & Lemeshow, S. (2004). *Applied logistic regression*: John Wiley & Sons.
Hummel, T., & Nordin, S. (2005). Olfactory disorders and their consequences for quality of life. *Acta oto-laryngologica, 125*(2), 116-121.
Hummel, T., Sekinger, B., Wolf, S., Pauli, E., & Kobal, G. (1997). 'Sniffin'sticks': olfactory performance assessed by the combined testing of odor identification, odor discrimination and olfactory threshold. *Chemical senses, 22*(1), 39-52.
Inbar, Y., Pizarro, D. A., & Bloom, P. (2012). Disgusting smells cause decreased liking of gay men. *Emotion, 12*(1), 23.
Jackson, P. L., Meltzoff, A. N., & Decety, J. (2005). How do we perceive the pain of others? A window into the neural processes involved in empathy. *NeuroImage, 24*(3), 771-779.
Jacob, S., McClintock, M. K., Zelano, B., & Ober, C. (2002). Paternally inherited HLA alleles are associated with women's choice of male odor. *Nature genetics, 30*(2), 175-179.
Johns, M., Inzlicht, M., & Schmader, T. (2008). Stereotype threat and executive resource depletion: examining the influence of emotion regulation. *Journal of Experimental Psychology: General, 137*(4), 691.
Johnson, D. J., Cheung, F., & Donnellan, M. B. (2014). Does cleanliness influence moral judgments? A direct replication of Schnall, Benton, and Harvey (2008). *Social Psychology, 45*(3), 209.
Jones-Gotman, M., Zatorre, R., Cendes, F., Olivier, A., Andermann, F., McMackin, D., . . . Wieser, H. (1997). Contribution of medial versus lateral temporal-lobe structures to human odour identification. *Brain, 120*(10), 1845-1856.

Judd, C. M., Westfall, J., & Kenny, D. A. (2012). Treating stimuli as a random factor in social psychology: a new and comprehensive solution to a pervasive but largely ignored problem. *Journal of personality and social psychology*, *103*(1), 54.
Kadohisa, M. (2013). Effects of odor on emotion, with implications. *Frontiers in systems neuroscience, 7*, 66.
Kahane, G. (2015). Sidetracked by trolleys: Why sacrificial moral dilemmas tell us little (or nothing) about utilitarian judgment. *Social neuroscience*(ahead-of-print), 1-10.
Kahane, G., Everett, J. A., Earp, B. D., Farias, M., & Savulescu, J. (2015). 'Utilitarian'judgments in sacrificial moral dilemmas do not reflect impartial concern for the greater good. *Cognition, 134*, 193-209.
Kahane, G., Wiech, K., Shackel, N., Farias, M., Savulescu, J., & Tracey, I. (2012). The neural basis of intuitive and counterintuitive moral judgment. *Social cognitive and affective neuroscience, 7*(4), 393-402.
Kamm, F. (1998). Précis of morality, mortality, vol. 1: death and whom to save from it: JSTOR.
Kant, I. (2005). *The moral law: Groundwork of the metaphysic of morals*: Psychology Press.
Keller, A., Zhuang, H., Chi, Q., Vosshall, L. B., & Matsunami, H. (2007). Genetic variation in a human odorant receptor alters odour perception. *Nature, 449*(7161), 468-472.
Keltner, D., & Kring, A. M. (1998). Emotion, social function, and psychopathology. *Review of General Psychology, 2*(3), 320.
Kemp, S. E., & Gilbert, A. N. (1997). Odor intensity and color lightness are correlated sensory dimensions. *The American journal of psychology, 110*(1), 35.
Kirk-Smith, M., Van Toller, C., & Dodd, G. (1983). Unconscious odour conditioning in human subjects. *Biological psychology, 17*(2-3), 221-231.
Koenigs, M., Kruepke, M., Zeier, J., & Newman, J. P. (2012). Utilitarian moral judgment in psychopathy. *Social cognitive and affective neuroscience, 7*(6), 708-714.
Koenigs, M., Young, L., Adolphs, R., Tranel, D., Cushman, F., Hauser, M., & Damasio, A. (2007). Damage to the prefrontal cortex increases utilitarian moral judgements. *Nature, 446*(7138), 908-911.
Kohlberg, L. (1963). The development of children's orientations toward a moral order. *Human Development, 6*(1-2), 11-33.
Kohlberg, L. (1984). *Essays on moral development. Vol. 2, The psychology of moral development: the nature and validity of moral stages*: Harper & Row.
Koven, N. (2011). Specificity of meta-emotion effects on moral decision-making. *Emotion (Washington, D.C.), 11*(5), 1255-1261.
Krusemark, E. A., Novak, L. R., Gitelman, D. R., & Li, W. (2013). When the sense of smell meets emotion: anxiety-state-dependent olfactory processing and neural circuitry adaptation. *The Journal of Neuroscience, 33*(39), 15324-15332.
Kunda, Z. (1990). The case for motivated reasoning. *Psychological bulletin, 108*(3), 480.
Kurzban, R., DeScioli, P., & Fein, D. (2012). Hamilton vs. Kant: Pitting adaptations for altruism against adaptations for moral judgment. *Evolution and Human Behavior, 33*(4), 323-333.
Kvaran, T., & Sanfey, A. G. (2010). Toward an integrated neuroscience of morality: the contribution of neuroeconomics to moral cognition. *Topics in cognitive science, 2*(3), 579-595.
Landy, J. F., & Goodwin, G. P. (2015). Does incidental disgust amplify moral judgment? A meta-analytic review of experimental evidence. *Perspectives on psychological science*.
Landy, J. F., & Goodwin, G. P. (2015b). Our Conclusions Were Tentative, But Appropriate A Reply to Schnall et al.(2015). *Perspectives on psychological science, 10*(4), 539-540.
Lang, P. J. (1995). The emotion probe: Studies of motivation and attention. *American psychologist, 50*(5), 372.

Langdon, R., & Delmas, K. (2012). Moral reasoning and psychopathic tendencies in the general community. *Emotions, imagination, and moral reasoning: Macquarie Monographs in Cognitive Science*, 91-118.
Larsen, J., K. , Brand, N., Bermond, B., & Hijman, R. (2003). Cognitive and emotional characteristics of alexithymia. *Journal of Psychosomatic Research, 54*, 533-541.
Lenochova, P., Roberts, S. C., & Havlicek, J. (2009). Methods of human body odor sampling: the effect of freezing. *Chemical senses, 34*(2), 127-138.
Levens, S. M., Larsen, J. T., Bruss, J., Tranel, D., Bechara, A., & Mellers, B. A. (2014). What might have been? The role of the ventromedial prefrontal cortex and lateral orbitofrontal cortex in counterfactual emotions and choice. *Neuropsychologia, 54*, 77-86.
Li, W. (2014). Learning to smell danger: acquired associative representation of threat in the olfactory cortex. *Frontiers in Behavioral Neuroscience, 8*.
Li, W., Moallem, I., Paller, K., & Gottfried, J. (2007). Subliminal smells can guide social preferences. *Psychological science, 18*(12), 1044-1049.
Lorig, T. S. (1999). On the similarity of odor and language perception. *Neuroscience & Biobehavioral Reviews, 23*(3), 391-398.
Lorig, T. S., Herman, K. B., Schwartz, G. E., & Cain, W. S. (1990). EEG activity during administration of low-concentration odors. *Bulletin of the Psychonomic Society, 28*(5), 405-408.
Lötsch, J., Ahne, G., Kunder, J., Kobal, G., & Hummel, T. (1998). Factors affecting pain intensity in a pain model based upon tonic intranasal stimulation in humans. *Inflammation research, 47*(11), 446-450.
Lotto, L., Manfrinati, A., & Sarlo, M. (2014). A new set of moral dilemmas: norms for moral acceptability, decision times, and emotional salience. *Journal of Behavioral Decision Making, 27*(1), 57-65.
Lübke, K. T., & Pause, B. M. (2015). Always follow your nose: The functional significance of social chemosignals in human reproduction and survival. *Hormones and behavior, 68*, 134-144.
Lundström, J. N., & Jones-Gotman, M. (2009). Romantic love modulates women's identification of men's body odors. *Hormones and behavior, 55*(2), 280-284.
Lundström, J. N., Boyle, J. A., Zatorre, R. J., & Jones-Gotman, M. (2008). Functional neuronal processing of body odors differs from that of similar common odors. *Cerebral Cortex, 18*(6), 1466-1474.
Lundström, J. N., Boyle, J. A., Zatorre, R. J., & Jones‐Gotman, M. (2009). The neuronal substrates of human olfactory based kin recognition. *Human brain mapping, 30*(8), 2571-2580.
Lundström, J. N., Mathe, A., Schaal, B., Frasnelli, J., Nitzsche, K., Gerber, J., & Hummel, T. (2013). Maternal status regulates cortical responses to the body odor of newborns. *Frontiers in psychology, 4*.
Lundström, J. N., McClintock, M. K., & Olsson, M. J. (2006). Effects of reproductive state on olfactory sensitivity suggest odor specificity. *Biological psychology, 71*(3), 244-247.
Lundström, J., Gordon, A., Alden, E., Boesveldt, S., & Albrecht, J. (2010). Methods for building an inexpensive computer-controlled olfactometer for temporally-precise experiments. *International journal of psychophysiology : official journal of the International Organization of Psychophysiology, 78*(2), 179-189.
Mainland, J. D., Keller, A., Li, Y. R., Zhou, T., Trimmer, C., Snyder, L. L., . . . Zhuang, H. (2014). The missense of smell: functional variability in the human odorant receptor repertoire. *Nature neuroscience, 17*(1), 114-120.
Mainland, J. D., Lundström, J. N., Reisert, J., & Lowe, G. (2014). From molecule to mind: an integrative perspective on odor intensity. *Trends in neurosciences, 37*(8), 443-454.

Martins, A. T., Faísca, L., Esteves, F., Muresan, A., & Reis, A. (2012). Atypical moral judgment following traumatic brain injury.
Martins, Y., Preti, G., Crabtree, C. R., Runyan, T., Vainius, A. A., & Wysocki, C. J. (2005). Preference for human body odors is influenced by gender and sexual orientation. *Psychological science, 16*(9), 694-701.
Mayberg, H. S. (1997). Limbic-cortical dysregulation: a proposed model of depression. *The Journal of neuropsychiatry and clinical neurosciences*.
McAlonan, K., Cavanaugh, J., & Wurtz, R. H. (2008). Guarding the gateway to cortex with attention in visual thalamus. *Nature, 456*(7220), 391-394.
McClintock, M. K., Bullivant, S., Jacob, S., Spencer, N., Zelano, B., & Ober, C. (2005). Human body scents: Conscious perceptions and biological effects. *Chemical senses, 30*(suppl 1), i135-i137.
McCulloch, C. E. (1997). Maximum likelihood algorithms for generalized linear mixed models. *Journal of the American Statistical Association, 92*(437), 162-170.
McGuire, J., Langdon, R., Coltheart, M., & Mackenzie, C. (2009). A reanalysis of the personal/impersonal distinction in moral psychology research. *Journal of Experimental Social Psychology, 45*(3), 577-580.
McHugh, S., Deacon, R., Rawlins, J., & Bannerman, D. M. (2004). Amygdala and ventral hippocampus contribute differentially to mechanisms of fear and anxiety. *Behavioral neuroscience, 118*(1), 63.
McLean, R. A., Sanders, W. L., & Stroup, W. W. (1991). A unified approach to mixed linear models. *The American Statistician, 45*(1), 54-64.
McNair, D. M., Lorr, M., & Droppleman, L. (1992). POMS: profile of mood states. *North Tonawanda, NY: Multi-Health Systems Inc*.
Mechelli, A., Humphreys, G. W., Mayall, K., Olson, A., & Price, C. J. (2000). Differential effects of word length and visual contrast in the fusiform and lingual gyri during. *Proceedings of the Royal Society of London B: Biological Sciences, 267*(1455), 1909-1913.
Mendez, M. F., Anderson, E., & Shapira, J. S. (2005). An investigation of moral judgement in frontotemporal dementia. *Cognitive and behavioral neurology, 18*(4), 193-197.
Mikhail, J. (2007). Universal moral grammar: Theory, evidence and the future. *Trends in cognitive sciences, 11*(4), 143-152.
Mitro, S., Gordon, A. R., Olsson, M. J., & Lundström, J. N. (2012). The smell of age: perception and discrimination of body odors of different ages. *PloS one, 7*(5), e38110.
Moll, J., de Oliveira-Souza, R., & Eslinger, P. J. (2003). Morals and the human brain: a working model. *Neuroreport, 14*(3), 299-305.
Moll, J., de Oliveira-Souza, R., Bramati, I. E., & Grafman, J. (2002). Functional networks in emotional moral and nonmoral social judgments. *NeuroImage, 16*(3), 696-703.
Moll, J., de Oliveira-Souza, R., Eslinger, P., Bramati, I., Mourão-Miranda, J., Andreiuolo, P., & Pessoa, L. (2002). The neural correlates of moral sensitivity: a functional magnetic resonance imaging investigation of basic and moral emotions. *The Journal of neuroscience : the official journal of the Society for Neuroscience, 22*(7), 2730-2736.
Moll, J., Oliveira‐Souza, D., & Zahn, R. (2008). The neural basis of moral cognition. *Annals of the New York Academy of Sciences, 1124*(1), 161-180.
Monin, B., Pizarro, D. A., & Beer, J. S. (2007). Deciding versus reacting: Conceptions of moral judgment and the reason-affect debate. *Review of General Psychology, 11*(2), 99.
Moore, A. B., Clark, B. A., & Kane, M. J. (2008). Who shalt not kill? Individual differences in working memory capacity, executive control, and moral judgment. *Psychological science, 19*(6), 549-557.
Moore, A. B., Lee, N. L., Clark, B. A., & Conway, A. R. (2011). In defense of the personal/impersonal distinction in moral psychology research: Cross-cultural

validation of the dual process model of moral judgment. *Judgment and Decision Making, 6*(3), 186.
Moran, J. M., Young, L. L., Saxe, R., Lee, S. M., O'Young, D., Mavros, P. L., & Gabrieli, J. D. (2011). Impaired theory of mind for moral judgment in high-functioning autism. *Proceedings of the National Academy of Sciences, 108*(7), 2688-2692.
Moretti, L., & Di Pellegrino, G. (2010). Disgust selectively modulates reciprocal fairness in economic interactions. *Emotion, 10*(2), 169.
Moretto, G., Làdavas, E., Mattioli, F., & Di Pellegrino, G. (2009). A psychophysiological investigation of moral judgment after ventromedial prefrontal damage. *Journal of cognitive neuroscience, 22*(8), 1888-1899.
Moriguchi, Y., Decety, J., Ohnishi, T., Maeda, M., Mori, T., Nemoto, K., . . . Komaki, G. (2007). Empathy and judging other's pain: an fMRI study of alexithymia. *Cerebral Cortex, 17*(9), 2223-2234.
Mujica-Parodi, L. R., Strey, H. H., Frederick, B., Savoy, R., Cox, D., Botanov, Y., . . . Weber, J. (2009). Chemosensory cues to conspecific emotional stress activate amygdala in humans. *PloS one, 4*(7), e6415.
Mutic, S., Moellers, E. M., Wiesmann, M., & Freiherr, J. (2015). Chemosensory Communication of Gender Information: Masculinity Bias in Body Odor Perception and Femininity Bias Introduced by Chemosignals During Social Perception. *Frontiers in psychology, 6*.
Mutic, S., Parma, V., Brünner, Y. F., & Freiherr, J. (2015). You Smell Dangerous: Communicating Fight Responses Through Human Chemosignals of Aggression. *Chemical senses, Accepted*.
Navarrete, C. D., McDonald, M. M., Mott, M. L., & Asher, B. (2012). Virtual morality: Emotion and action in a simulated three-dimensional "trolley problem". *Emotion, 12*(2), 364.
Nemiah, J., Freyberger, H., & Sifneos, P. (1976). Alexithymia: a view of the psychosomatic process. *Modern trends in psychosomatic medicine, 3*, 430-439.
Neufeld, J., Ioannou, C., Korb, S., Schilbach, L., & Chakrabarti, B. (2015). Spontaneous Facial Mimicry is Modulated by Joint Attention and Autistic Traits. *Autism Research*.
Neumann, D., Zupan, B., Malec, J., & Hammond, F. (2013). Relationships Between Alexithymia, Affect Recognition, and Empathy After Traumatic Brain Injury. *The Journal of head trauma rehabilitation*.
Neumann, S. A., Sollers, J. J., Thayer, J. F., & Waldstein, S. R. (2004). Alexithymia predicts attenuated autonomic reactivity, but prolonged recovery to anger recall in young women. *International Journal of Psychophysiology, 53*(3), 183-195.
Nisbett, R. E., & Wilson, T. D. (1977). Telling more than we can know: Verbal reports on mental processes. *Psychological review, 84*(3), 231.
Nucci, L. P., & Gingo, M. (2010). The development of moral reasoning. *The Wiley-Blackwell Handbook of Childhood Cognitive Development, Second edition*, 420-445.
O'Neill, P., & Petrinovich, L. (1998). A preliminary cross-cultural study of moral intuitions. *Evolution and Human Behavior, 19*(6), 349-367.
Oberhuber, M., Hope, T., Seghier, M. L., Jones, O. P., Prejawa, S., Green, D. W., & Price, C. J. (2016). Four Functionally Distinct Regions in the Left Supramarginal Gyrus Support Word Processing. *Cerebral Cortex*.
Ocampo, B. (2015). Unconscious manipulation of free choice by novel primes. *Consciousness and cognition, 34*, 4-9.
Ong, H. H., O'Dhaniel, A., Kwok, K., & Lim, J. (2014). Moral judgment modulation by disgust is bi-directionally moderated by individual sensitivity. *Frontiers in psychology, 5*.
Öngür, D., & Price, J. L. (2000). The organization of networks within the orbital and medial prefrontal cortex of rats, monkeys and humans. Cerebral cortex, 10(3), 206-219.

Overman, W. H., Boettcher, L., Watterson, L., & Walsh, K. (2011). Effects of dilemmas and aromas on performance of the Iowa Gambling Task. *Behavioural brain research, 218*(1), 64-72.
Palomba, D., Angrilli, A., & Mini, A. (1997). Visual evoked potentials, heart rate responses and memory to emotional pictorial stimuli. International journal of psychophysiology, 27(1), 55-67.
Palomba, D., Sarlo, M., Angrilli, A., Mini, A., & Stegagno, L. (2000). Cardiac responses associated with affective processing of unpleasant film stimuli. *International Journal of Psychophysiology, 36*(1), 45-57.
Parma, V., Bulgheroni, M., Scaravilli, T., Tirindelli, R., & Castiello, U. (2013). Implicit olfactory processing attenuates motor disturbances in idiopathic Parkinson's disease. *Cortex, 49*(5), 1241-1251.
Parma, V., Bulgheroni, M., Tirindelli, R., & Castiello, U. (2013). Body odors promote automatic imitation in autism. *Biological psychiatry, 74*(3), 220-226.
Parma, V., Cavazzana, A., & Lundström, J. (2016). Stranger's Body Odor Selectively Reduces Response Time to Threatening Faces. In t. A. M. Association for Chemoreception Sciences (AChemS), April 20-23, 2016, Bonita Springs, Florida (Ed.), *Chemical senses* (Vol. 41(7), pp. e1-e110).
Parma, V., Ferraro, S., Miller, S. S., Åhs, F., & Lundström, J. N. (2015). Enhancement of odor sensitivity following repeated odor and visual fear conditioning. *Chemical senses, 40*(7), 497-506.
Parma, V., Gordon, A., Cecchetto, C., Cavazzana, A., Lundström, J., & Olsson, M. J. (In press). Central Processing of Human Body Odors. In I. A. B. (Ed.) (Ed.), *Handbook of Odors*: Springer.
Parma, V., Straulino, E., Zanatto, D., Cantagallo, A., Tirindelli, R., & Castiello, U. (2012). Implicit olfactory abilities in traumatic brain injured patients. *Journal of clinical and experimental neuropsychology, 34*(9), 977-988.
Parma, V., Zanatto, D., & Castiello, U. (2013). Visuo-olfactory integration during action observation and execution of reach-to-grasp movements. *Neuroreport, 24*(14), 768-772.
Pascual, L., Rodrigues, P., & Gallardo-Pujol, D. (2013). How does morality work in the brain? A functional and structural perspective of moral behavior. *Frontiers in Integrative Neuroscience, 7*.
Pastötter, B., Gleixner, S., Neuhauser, T., & Bäuml, K.-H. T. (2013). To push or not to push? Affective influences on moral judgment depend on decision frame. *Cognition, 126*(3), 373-377.
Patil, I., & Silani, G. (2014a). Alexithymia increases moral acceptability of accidental harms. *Journal of Cognitive Psychology, 26*(5), 597-614.
Patil, I., & Silani, G. (2014b). Reduced empathic concern leads to utilitarian moral judgments in trait alexithymia. *Frontiers in psychology, 5*.
Patil, I., Cogoni, C., Zangrando, N., Chittaro, L., & Silani, G. (2014). Affective basis of judgment-behavior discrepancy in virtual experiences of moral dilemmas. *Social neuroscience, 9*(1), 94-107.
Patil, I., Melsbach, J., Hennig-Fast, K., & Silani, G. (2016). Divergent roles of autistic and alexithymic traits in utilitarian moral judgments in adults with autism. *Scientific Reports, 6*.
Paulus, M. P., & Stein, M. B. (2006). An insular view of anxiety. *Biological psychiatry, 60*(4), 383-387.

Pause, B. M., Adolph, D., Prehn-Kristensen, A., & Ferstl, R. (2009). Startle response potentiation to chemosensory anxiety signals in socially anxious individuals. *International Journal of Psychophysiology, 74*(2), 88-92.
Pause, B. M., Lübke, K., Laudien, J. H., & Ferstl, R. (2010). Intensified neuronal investment in the processing of chemosensory anxiety signals in non-socially anxious and socially anxious individuals. *PloS one, 5*(4), e10342.
Pause, B. M., Ohrt, A., Prehn, A., & Ferstl, R. (2004). Positive emotional priming of facial affect perception in females is diminished by chemosensory anxiety signals. *Chemical senses, 29*(9), 797-805.
Paxton, J. M., & Greene, J. D. (2010). Moral reasoning: Hints and allegations. *Topics in cognitive science, 2*(3), 511-527.
Peasley-Miklus, C. E., Panayiotou, G., & Vrana, S. R. (2016). Alexithymia predicts arousal-based processing deficits and discordance between emotion response systems during emotional imagery. Emotion, 16(2), 164.
Penn, D. J., Oberzaucher, E., Grammer, K., Fischer, G., Soini, H. A., Wiesler, D., ... & Brereton, R. G. (2007). Individual and gender fingerprints in human body odour. Journal of the Royal society interface, 4(13), 331-340.
Pernet, C., Franceries, X., Basan, S., Cassol, E., Demonet, J., & Celsis, P. (2004). Anatomy and time course of discrimination and categorization processes in vision: an fMRI study. *NeuroImage, 22*(4), 1563-1577.
Petrinovich, L., & O'Neill, P. (1996). Influence of wording and framing effects on moral intuitions. *Ethology and Sociobiology, 17*(3), 145-171.
Petrinovich, L., O'Neill, P., & Jorgensen, M. (1993). An empirical study of moral intuitions: Toward an evolutionary ethics. *Journal of personality and social psychology, 64*(3), 467.
Phillips, M. L., Drevets, W. C., Rauch, S. L., & Lane, R. (2003). Neurobiology of emotion perception I: The neural basis of normal emotion perception. *Biological psychiatry, 54*(5), 504-514.
Phillips, M. L., Williams, L. M., Heining, M., Herba, C. M., Russell, T., Andrew, C., . . . Morgan, M. (2004). Differential neural responses to overt and covert presentations of facial expressions of fear and disgust. *NeuroImage, 21*(4), 1484-1496.
Piaget, J. (1932). Le jugement moral chez l'enfant.
Piaget, J. (1965). The moral judgment of the child (1932). *New York: The Free*.
Piaget, J. (1997). *The moral judgement of the child*: Simon and Schuster.
Pizarro, D. (2000). Nothing more than feelings? The role of emotions in moral judgment. *Journal for the Theory of Social Behaviour, 30*(4), 355-375.
Pizarro, D. A., & Bloom, P. (2003). The intelligence of the moral intuitions: A comment on Haidt (2001). *Psychological review, 110*(1), 193-196.
Pizarro, D., Inbar, Y., & Helion, C. (2011). On disgust and moral judgment. *Emotion Review, 3*(3), 267-268.
Plailly, J., Howard, J. D., Gitelman, D. R., & Gottfried, J. A. (2008). Attention to odor modulates thalamocortical connectivity in the human brain. *The Journal of Neuroscience, 28*(20), 5257-5267.
Pollatos, O., Werner, N. S., Duschek, S., Schandry, R., Matthias, E., Traut-Mattausch, E., & Herbert, B. M. (2011). Differential effects of alexithymia subscales on autonomic reactivity and anxiety during social stress. *Journal of Psychosomatic Research, 70*(6), 525-533.
Powell, M. J. (2009). The BOBYQA algorithm for bound constrained optimization without derivatives. Cambridge NA Report NA2009/06, University of Cambridge, Cambridge.

Prehn-Kristensen, A., Wiesner, C., Bergmann, T. O., Wolff, S., Jansen, O., Mehdorn, H. M., . . . Pause, B. M. (2009b). Induction of empathy by the smell of anxiety. *PloS one, 4*(6), e5987.
Prehn, A., Ohrt, A., Sojka, B., Ferstl, R., & Pause, B. M. (2006). Chemosensory anxiety signals augment the startle reflex in humans. *Neuroscience letters, 394*(2), 127-130.
Prehn, K., Wartenburger, I., Mériau, K., Scheibe, C., Goodenough, O. R., Villringer, A., . . . Heekeren, H. R. (2008). Individual differences in moral judgment competence influence neural correlates of socio-normative judgments. *Social cognitive and affective neuroscience, 3*(1), 33-46.
Prokop-Prigge, K. A., Greene, K., Varallo, L., Wysocki, C. J., & Preti, G. (2016). The Effect of Ethnicity on Human Axillary Odorant Production. *Journal of chemical ecology, 42*(1), 33-39.
Proverbio, A. M., Zani, A., & Adorni, R. (2008). Neural markers of a greater female responsiveness to social stimuli. *BMC neuroscience, 9*(1), 56.
Rai, T. S., & Fiske, A. P. (2011). Moral psychology is relationship regulation: moral motives for unity, hierarchy, equality, and proportionality. *Psychological review, 118*(1), 57.
Ree, M. J., French, D., MacLeod, C., & Locke, V. (2008). Distinguishing cognitive and somatic dimensions of state and trait anxiety: Development and validation of the State-Trait Inventory for Cognitive and Somatic Anxiety (STICSA). *Behavioural and Cognitive Psychotherapy, 36*(03), 313-332.
Rilling, J. K., & Sanfey, A. G. (2011). The neuroscience of social decision-making. *Annual review of psychology, 62*, 23-48.
Rilling, J. K., Gutman, D. A., Zeh, T. R., Pagnoni, G., Berns, G. S., & Kilts, C. D. (2002). A neural basis for social cooperation. *Neuron, 35*(2), 395-405.
Rilling, J. K., King-Casas, B., & Sanfey, A. G. (2008). The neurobiology of social decision-making. *Current opinion in neurobiology, 18*(2), 159-165.
Rolls, E. T. (2000). The orbitofrontal cortex and reward. Cerebral cortex, 10(3), 284-294.
Rosas, A., & Koenigs, M. (2014). Beyond "utilitarianism": Maximizing the clinical impact of moral judgment research. *Social neuroscience, 9*(6), 661-667.
Roth, W. T., Dawson, M. E., & Filion, D. L. (2012). Publication recommendations for electrodermal measurements. Psychophysiology, 49, 1017-1034.
Royzman, E. B., & Baron, J. (2002). The preference for indirect harm. *Social Justice Research, 15*(2), 165-184.
Rozin, P., & Fallon, A. E. (1987). A perspective on disgust. *Psychological review, 94*(1), 23.
Rozin, P., Haidt, J., & Fincher, K. (2009). From oral to moral. *science*.
Rozin, P., Haidt, J., & McCauley, C. R. (2008). Disgust.
Rozin, P., Haidt, J., McCauley, C., Dunlop, L., & Ashmore, M. (1999). Individual differences in disgust sensitivity: Comparisons and evaluations of paper-and-pencil versus behavioral measures. *Journal of Research in Personality, 33*(3), 330-351.
Rozin, P., Haidt, J., McCauley, C., Dunlop, L., & Ashmore, M. (1999). Individual differences in disgust sensitivity: Comparisons and evaluations of paper-and-pencil versus behavioral measures. *Journal of Research in Personality, 33*(3), 330-351.
Rozin, P., Lowery, L., Imada, S., & Haidt, J. (1999). The CAD triad hypothesis: a mapping between three moral emotions (contempt, anger, disgust) and three moral codes (community, autonomy, divinity). *Journal of personality and …*.
Salminen, J. K., Saarijärvi, S., Äärelä, E., Toikka, T., & Kauhanen, J. (1999). Prevalence of alexithymia and its association with sociodemographic variables in the general population of Finland. *Journal of Psychosomatic Research, 46*(1), 75-82.

Sarlo, M., Lotto, L., Manfrinati, A., Rumiati, R., Gallicchio, G., & Palomba, D. (2012). Temporal dynamics of cognitive-emotional interplay in moral decision-making. *Journal of cognitive neuroscience, 24*(4), 1018-1029.
Sarlo, M., Lotto, L., Rumiati, R., & Palomba, D. (2014). If it makes you feel bad, don't do it! Egoistic rather than altruistic empathy modulates neural and behavioral responses in moral dilemmas. *Physiology & behavior, 130*, 127-134.
Sartori, L., Betti, S., & Castiello, U. (2013). When mirroring is not enough: that is, when only a complementary action will do (the trick). *Neuroreport, 24*(11), 601-604.
Sato, W., Kochiyama, T., Uono, S., Matsuda, K., Usui, K., Inoue, Y., & Toichi, M. (2014). Rapid, high-frequency, and theta-coupled gamma oscillations in the inferior occipital gyrus during face processing. *Cortex, 60*, 52-68.
Saxton, T. K., Lyndon, A., Little, A. C., & Roberts, S. C. (2008). Evidence that androstadienone, a putative human chemosignal, modulates women's attributions of men's attractiveness. *Hormones and behavior, 54*(5), 597-601.
Schiffman, S. S., Suggs, M. S., & Sattely-Miller, E. A. (1995). Effect of pleasant odors on mood of males at midlife: Comparison of African-American and European-American men. *Brain Research Bulletin, 36*(1), 31-37.
Schnall, S., Haidt, J., Clore, G. L., & Jordan, A. H. (2015). Landy and Goodwin (2015) Confirmed Most of Our Findings Then Drew the Wrong Conclusions. *Perspectives on psychological science, 10*(4), 537-538.
Schnall, S., Haidt, J., Clore, G., & Jordan, A. (2008). Disgust as embodied moral judgment. *Personality & social psychology bulletin, 34*(8), 1096-1109.
Schnall, S., Haidt, J., Clore, G., & Jordan, A. (2008). Disgust as embodied moral judgment. *Personality & social psychology bulletin, 34*(8), 1096-1109.
Schultz, R. T., Grelotti, D. J., Klin, A., Kleinman, J., Van der Gaag, C., Marois, R., & Skudlarski, P. (2003). The role of the fusiform face area in social cognition: implications for the pathobiology of autism. *Philosophical Transactions of the Royal Society B: Biological Sciences, 358*(1430), 415-427.
Schupp, H. T., Öhman, A., Junghöfer, M., Weike, A. I., Stockburger, J., & Hamm, A. O. (2004). The facilitated processing of threatening faces: an ERP analysis. *Emotion, 4*(2), 189.
Seghier, M. L. (2013). The angular gyrus multiple functions and multiple subdivisions. *The Neuroscientist, 19*(1), 43-61.
Seidel, A., & Prinz, J. (2013). Sound morality: Irritating and icky noises amplify judgments in divergent moral domains. *Cognition, 127*(1), 1-5.
Seubert, J., Gregory, K. M., Chamberland, J., Dessirier, J.-M., & Lundström, J. N. (2014). Odor Valence Linearly Modulates Attractiveness, but Not Age Assessment, of Invariant Facial Features in a Memory-Based Rating Task. *PloS one, 9*(5), e98347.
Seubert, J., Kellermann, T., Loughead, J., Boers, F., Brensinger, C., Schneider, F., & Habel, U. (2010). Processing of disgusted faces is facilitated by odor primes: a functional MRI study. *NeuroImage, 53*(2), 746-756.
Seubert, J., Rea, A. F., Loughead, J., & Habel, U. (2009). Mood induction with olfactory stimuli reveals differential affective responses in males and females. *Chemical senses, 34*(1), 77-84.
Shenhav, A., & Greene, J. (2014). Integrative moral judgment: dissociating the roles of the amygdala and ventromedial prefrontal cortex. *The Journal of neuroscience : the official journal of the Society for Neuroscience, 34*(13), 4741-4749.
Sifneos, P. E. (1973). The prevalence of 'alexithymic' characteristics in psychosomatic patients. *Psychotherapy and psychosomatics, 22*(2-6), 255-262.
Singer, T., & Lamm, C. (2009). The social neuroscience of empathy. *Annals of the New York Academy of Sciences, 1156*(1), 81-96.

Smeets, M. A., Schifferstein, H. N., Boelema, S. R., & Lensvelt-Mulders, G. (2008). The Odor Awareness Scale: a new scale for measuring positive and negative odor awareness. *Chemical senses, 33*(8), 725-734.
Sobel, N., Prabhakaran, V., Hartley, C. A., Desmond, J. E., Glover, G. H., Sullivan, E. V., & Gabrieli, J. D. (1999). Blind smell: brain activation induced by an undetected air-borne chemical. *Brain, 122*(2), 209-217.
Sommer, M., Rothmayr, C., Döhnel, K., Meinhardt, J., Schwerdtner, J., Sodian, B., & Hajak, G. (2010). How should I decide? The neural correlates of everyday moral reasoning. *Neuropsychologia, 48*(7), 2018-2026.
Sood, S., & Forehand, M. (2005). On self-referencing differences in judgment and choice. *Organizational Behavior and Human Decision Processes, 98*(2), 144-154.
Soudry, Y., Lemogne, C., Malinvaud, D., Consoli, S.-M., & Bonfils, P. (2011). Olfactory system and emotion: common substrates. *European annals of otorhinolaryngology, head and neck diseases, 128*(1), 18-23.
Spielberger, C., Gorsuch, R., & Lushene, R. (1968). Self-Evaluation Questionnaire: STAI Form X-1.
Staples, L. G., Hunt, G. E., Cornish, J. L., & McGregor, I. S. (2005). Neural activation during cat odor-induced conditioned fear and 'trial 2'fear in rats. *Neuroscience & Biobehavioral Reviews, 29*(8), 1265-1277.
Staples, L., McGregor, I., Apfelbach, R., & Hunt, G. (2008). Cat odor, but not trimethylthiazoline (fox odor), activates accessory olfactory and defense-related brain regions in rats. *Neuroscience, 151*(4), 937-947.
Starcke, K., Polzer, C., Wolf, O., & Brand, M. (2011). Does stress alter everyday moral decision-making? *Psychoneuroendocrinology, 36*(2), 210-219.
Starcke, K., Wolf, O. T., Markowitsch, H. J., & Brand, M. (2008). Anticipatory stress influences decision making under explicit risk conditions. *Behavioral neuroscience, 122*(6), 1352.
Stevenson, R. (2010). An initial evaluation of the functions of human olfaction. *Chemical senses, 35*(1), 3-20.
Stevenson, R. J., Boakes, R. A., & Prescott, J. (1998). Changes in odor sweetness resulting from implicit learning of a simultaneous odor-sweetness association: An example of learned synesthesia. *Learning and Motivation, 29*(2), 113-132.
Sturm, V., & Levenson, R. (2011). Alexithymia in neurodegenerative disease. *Neurocase, 17*(3), 242-250.
Suter, R. S., & Hertwig, R. (2011). Time and moral judgment. *Cognition, 119*(3), 454-458.
Suzuki, Y., Critchley, H. D., Suckling, J., Fukuda, R., Williams, S. C., Andrew, C., . . . Swift, C. G. (2001). Functional Magnetic Resonance Imaging of Odor Identification The Effect of Aging. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 56*(12), M756-M760.
Szekely, R. D., & Miu, A. C. (2014). Incidental emotions in moral dilemmas: The influence of emotion regulation. *Cognition & Emotion*(ahead-of-print), 1-12.
Tangney, J. P., Stuewig, J., & Mashek, D. J. (2007). Moral emotions and moral behavior. *Annual review of psychology, 58*, 345.
Tassy, S., Deruelle, C., Mancini, J., Leistedt, S., & Wicker, B. (2013a). High levels of psychopathic traits alters moral choice but not moral judgment. *Frontiers in Human Neuroscience, 7*.
Tassy, S., Oullier, O., Mancini, J., & Wicker, B. (2013). Discrepancies between judgment and choice of action in moral dilemmas. *Frontiers in psychology, 4*.
Taylor, G. J., Bagby, R. M., & Parker, J. D. (1999). *Disorders of affect regulation: Alexithymia in medical and psychiatric illness*: Cambridge University Press.
Terrizzi, J. A., Shook, N. J., & McDaniel, M. A. (2013). The behavioral immune system and social conservatism: A meta-analysis. *Evolution and Human Behavior, 34*(2), 99-108.

Thomas, B. C., Croft, K. E., & Tranel, D. (2011). Harming Kin to Save Strangers: Further Evidence for Abnormally Utilitarian Moral Judgments after Ventromedial Prefrontal Damage. *Journal of cognitive neuroscience, 23*(9), 2186-2196.
Thomson, J. (1976). Aristotle: Ethics: Harmondsworth, UK: Penguin.
Trivers, R. L. (1971). The evolution of reciprocal altruism. *Quarterly review of biology*, 35-57.
Tybur, J. M., Lieberman, D., Kurzban, R., & DeScioli, P. (2013). Disgust: Evolved function and structure. *Psychological review, 120*(1), 65.
Ugazio, G., Lamm, C., & Singer, T. (2012). The role of emotions for moral judgments depends on the type of emotion and moral scenario. *Emotion, 12*(3), 579.
Ugazio, G., Majdandzic, J., & Lamm, C. (2014). Are empathy and morality linked? Insights from moral psychology, social and decision neuroscience, and philosophy. *Empathy in morality*, 155-171.
Valdesolo, P., & DeSteno, D. (2006). Manipulations of emotional context shape moral judgment. *Psychological science, 17*(6), 476-477.
van der Meer, L., Costafreda, S., Aleman, A., & David, A. S. (2010). Self-reflection and the brain: a theoretical review and meta-analysis of neuroimaging studies with implications for schizophrenia. *Neuroscience & Biobehavioral Reviews, 34*(6), 935-946.
Van Dillen, L. F., van der Wal, R. C., & van den Bos, K. (2012). On the Role of Attention and Emotion in Morality Attentional Control Modulates Unrelated Disgust in Moral Judgments. *Personality and Social Psychology Bulletin, 38*(9), 1222-1231.
Vorst, H. C., & Bermond, B. (2001). Validity and reliability of the Bermond–Vorst alexithymia questionnaire. *Personality and Individual Differences, 30*(3), 413-434.
Waldmann, M. R., & Dieterich, J. H. (2007). Throwing a bomb on a person versus throwing a person on a bomb intervention myopia in moral intuitions. *Psychological science, 18*(3), 247-253.
Wandell, B. A., Dumoulin, S. O., & Brewer, A. A. (2007). Visual field maps in human cortex. *Neuron, 56*(2), 366-383.
Wang, Y., Deng, Y., Sui, D., & Tang, Y.-Y. (2014). Neural correlates of cultural differences in moral decision making: a combined ERP and sLORETA study. *Neuroreport, 25*(2), 110-116.
Wehling, E. I., Wollschlaeger, D., Nordin, S., & Lundervold, A. J. (2016). Longitudinal changes in odor identification performance and neuropsychological measures in aging individuals. *Neuropsychology, 30*(1), 87.
Weisfeld, G. E., Czilli, T., Phillips, K. A., Gall, J. A., & Lichtman, C. M. (2003). Possible olfaction-based mechanisms in human kin recognition and inbreeding avoidance. *Journal of experimental child psychology, 85*(3), 279-295.
Weiss, T., Snitz, K., Yablonka, A., Khan, R. M., Gafsou, D., Schneidman, E., & Sobel, N. (2012). Perceptual convergence of multi-component mixtures in olfaction implies an olfactory white. Proceedings of the National Academy of Sciences, 109(49), 19959-19964.
Whalen, P. J., Rauch, S. L., Etcoff, N. L., McInerney, S. C., Lee, M. B., & Jenike, M. A. (1998). Masked presentations of emotional facial expressions modulate amygdala activity without explicit knowledge. *The Journal of Neuroscience, 18*(1), 411-418.
Wicker, B., Keysers, C., Plailly, J., Royet, J., Gallese, V., & Rizzolatti, G. (2003). Both of us disgusted in My insula: the common neural basis of seeing and feeling disgust. *Neuron, 40*(3), 655-664.
Williams, B. (1973). Morality and the emotions *Problems of the self*: Cambridge University Press.

Winston, J. S., Gottfried, J. A., Kilner, J. M., & Dolan, R. J. (2005). Integrated neural representations of odor intensity and affective valence in human amygdala. *The Journal of Neuroscience, 25*(39), 8903-8907.
Wood, A., Rychlowska, M., Korb, S., & Niedenthal, P. (2016). Fashioning the Face: Sensorimotor Simulation Contributes to Facial Expression Recognition. *Trends in cognitive sciences, 20*(3), 227-240.
Woodward, J., & Allman, J. (2007). Moral intuition: its neural substrates and normative significance. *Journal of Physiology-Paris, 101*(4), 179-202.
Wyatt, T. D. (2014). *Pheromones and animal behavior: chemical signals and signatures*: Cambridge University Press.
Yeshurun, Y., & Sobel, N. (2010). An odor is not worth a thousand words: from multidimensional odors to unidimensional odor objects. *Annual review of psychology, 61*, 219-241.
Young, L., Bechara, A., Tranel, D., Damasio, H., Hauser, M., & Damasio, A. (2010). Damage to ventromedial prefrontal cortex impairs judgment of harmful intent. *Neuron, 65*(6), 845-851.
Young, L., Koenigs, M., Kruepke, M., & Newman, J. P. (2012). Psychopathy increases perceived moral permissibility of accidents. *Journal of abnormal psychology, 121*(3), 659.
Youssef, F., Dookeeram, K., Basdeo, V., Francis, E., Doman, M., Mamed, D., . . . Legall, G. (2012a). Stress alters personal moral decision making. *Psychoneuroendocrinology, 37*(4), 491-498.
Zahn, R., Moll, J., Paiva, M., Garrido, G., Krueger, F., Huey, E. D., & Grafman, J. (2009). The neural basis of human social values: evidence from functional MRI. *Cerebral Cortex, 19*(2), 276-283.
Zald, D. H., & Pardo, J. V. (1997). Emotion, olfaction, and the human amygdala: amygdala activation during aversive olfactory stimulation. *Proceedings of the National Academy of Sciences, 94*(8), 4119-4124.
Zanon, M., Novembre, G., Zangrando, N., Chittaro, L., & Silani, G. (2014). Brain activity and prosocial behavior in a simulated life-threatening situation. *NeuroImage, 98*, 134-146.
Zernecke, R., Kleemann, A., Haegler, K., Albrecht, J., Vollmer, B., Linn, J., . . . Wiesmann, M. (2010). Chemosensory properties of human sweat. *Chemical senses, 35*(2), 101-108.
Zhou, W., & Chen, D. (2009). Sociochemosensory and Emotional Functions Behavioral Evidence for Shared Mechanisms. *Psychological science, 20*(9), 1118-1124.
Zucco, G. M., Paolini, M., & Schaal, B. (2009). Unconscious odour conditioning 25 years later: revisiting and extending 'Kirk-Smith, Van Toller and Dodd'. *Learning and Motivation, 40*(4), 364-375.

Appendix A

Supplemental results of Chapter 2

Table 1A. *Summary of dilemmas*

N° Dilemma	Name Dilemma	Personal Force	Intentionality	Benefit Recipient	Evitability	English Word Count	Italian Word Count
1	Burning Building (a)	Personal	Instrumental	Self	Avoidable	116	105
2	Burning Building(b)	Impersonal	Accidental	Self	Avoidable	128	114
3	Modified Crying Baby (a)	Personal	Accidental	Self	Avoidable	146	147
4	Modified Crying Baby (b)	Impersonal	Accidental	Self	Avoidable	139	134
5	Modified Submarine (a)	Personal	Accidental	Self	Avoidable	150	118
6	Modified Submarine (b)	Impersonal	Accidental	Self	Avoidable	150	116
7	Shark Attack (a)	Personal	Instrumental	Self	Avoidable	132	119
8	Shark Attack (b)	Impersonal	Instrumental	Self	Avoidable	148	129
9	Orphanage (a)	Personal	Instrumental	Self	Inevitable	147	128
10	Orphanage (b)	Impersonal	Instrumental	Self	Inevitable	149	138
11	Preventing Cholera (a)	Personal	Instrumental	Self	Avoidable	154	125
12	Preventing Cholera (b)	Impersonal	Instrumental	Self	Avoidable	149	129
13	Rescue 911 (a)	Personal	Instrumental	Self	Inevitable	141	122
14	Rescue 911 (b)	Impersonal	Instrumental	Self	Inevitable	153	140
15	Space Station (a)	Personal	Accidental	Self	Inevitable	158	122
16	Space Station (b)	Impersonal	Accidental	Self	Inevitable	159	128
17	Nuclear reactor (a)	Personal	Instrumental	Self	Inevitable	124	115
18	Nuclear reactor (b)	Impersonal	Accidental	Self	Inevitable	135	124

19	Cinderblock (a)	Personal	Instrumental	Self	Inevitable	119	110
20	Cinderblock (b)	Impersonal	Instrumental	Self	Inevitable	130	109
21	Cliffhanger (a)	Personal	Instrumental	Self	Inevitable	143	131
22	Cliffhanger (b)	Impersonal	Instrumental	Self	Inevitable	137	126
23	Bus plunge (a)	Personal	Accidental	Self	Inevitable	155	134
24	Bus plunge (b)	Impersonal	Accidental	Self	Inevitable	143	128
25	Modified Transplant (a)	Personal	Instrumental	Other	Avoidable	114	90
26	Modified Transplant (b)	Impersonal	Instrumental	Other	Avoidable	113	106
27	On the waterfront (a)	Personal	Accidental	Other	Avoidable	151	139
28	On the waterfront (b)	Impersonal	Accidental	Other	Avoidable	158	129
29	Modified vaccine Test (a)	Personal	Accidental	Other	Avoidable	128	120
30	Modified vaccine Test (b)	Impersonal	Accidental	Other	Avoidable	135	116
31	Modified Footbridge	Personal	Instrumental	Other	Avoidable	106	85
32	Modified Bridge	Impersonal	Accidental	Other	Avoidable	130	108
33	Nobel Prize (a)	Personal	Instrumental	Other	Avoidable	139	127
34	Nobel Prize (b)	Impersonal	Instrumental	Other	Avoidable	151	134
35	Bike week (a)	Personal	Instrumental	Other	Avoidable	136	119
36	Bike week (b)	Impersonal	Instrumental	Other	Avoidable	130	111
37	Modified Euthanasia (a)	Personal	Instrumental	Other	Inevitable	155	134
38	Modified Euthanasia (b)	Impersonal	Instrumental	Other	Inevitable	169	146
39	Modified Fumes (a)	Personal	Accidental	Other	Inevitable	117	110
40	Modified Fumes (b)	Impersonal	Accidental	Other	Avoidable	136	128
41	Modified Rowboat (a)	Persona	Instrumental	Other	Inevitable	135	126
42	Modified Rowboat (b)	Impersonal	Accidental	Other	Inevitable	145	132
43	Mine Shaft (a)	Personal	Instrumental	Other	Inevitable	131	111
44	Mine Shaft (b)	Impersonal	Accidental	Other	Inevitable	133	112
45	Tycoon (a)	Personal	Instrumental	Other	Inevitable	133	119
46	Tycoon (b)	Impersonal	Instrumental	Other	Inevitable	137	130
47	Enemy Spy (a)	Personal	Instrumental	Other	Inevitable	129	114
48	Enemy Spy (b)	Impersonal	Instrumental	Other	Inevitable	142	122
49	Missile (a)	Personal	Instrumental	Other	Avoidable	119	111
50	Missile (b)	Impersonal	Instrumental	Other	Avoidable	122	108

51	Bomb in the Bank (a)	Personal	Accidental	Self	Inevitable	144	134
52	Bomb in the Bank (b)	Impersonal	Accidental	Self	Inevitable	142	138

Table 2A. *Summary of Chi-square tests comparisons between English and Italian native speakers for each dilemma*

N° Dilemma	Dilemma name	Comparison between English and Italian native speakers		Comparison between dilemma versions	
		X^2	*p*	X^2	*p*
1	Burning Building (a)	3.66	0.31	3.95	0.27
2	Burning Building (b)	5.12	0.16	0.40	0.94
3	Modified Crying Baby (a)	2.27	0.52	1.91	0.59
4	Modified Submarine (a)	3.19	0.36	0.81	0.85
5	Modified Submarine (b)	0.89	0.83	0.69	0.87
6	Shark Attack (a)	3.00	0.39	1.62	0.65
7	Shark Attack (b)	4.24	0.24	1.05	0.79
8	Orphanage (a)	0.54	0.91	0.48	0.92
9	Orphanage (b)	4.86	0.18	0.38	0.94
10	Preventing Cholera (a)	6.84	0.08	3.53	0.32
11	Preventing Cholera (b)	0.78	0.85	0.39	0.94
12	Rescue 911 (a)	6.49	0.09	0.51	0.92
13	Rescue 911 (b)	**9.62**	**0.02**	2.51	0.47
14	Space Station (a)	3.82	0.28	1.02	0.79
15	Space Station (b)	2.03	0.56	0.78	0.85
16	Nuclear reactor (a)	2.61	0.45	0.78	0.85
17	Nuclear reactor (b)	1.70	0.63	0.65	0.88
18	Cinderblock (a)	1.67	0.64	1.93	0.59
19	Cinderblock (b)	0.75	0.86	1.25	0.74
20	Cliff-hanger (a)	2.53	0.47	1.35	0.72
21	Cliff-hanger (b)	7.41	0.06	0.23	0.97
22	Bus plunge (a)	**11.28**	**0.01**	2.50	0.47
23	Bus plunge (b)	4.82	0.18	7.56	0.06
24	Modified Transplant (a)	2.17	0.54	0.89	0.83
25	Modified Transplant (b)	1.00	0.80	2.06	0.56
26	On the waterfront (a)	0.65	0.72	0.08	0.96
27	On the waterfront (b)	3.99	0.26	1.80	0.61
28	Modified vaccine Test (a)	0.69	0.87	1.57	0.66
29	Modified vaccine Test (b)	0.93	0.82	2.14	0.54
30	Modified Footbridge	6.33	0.09	1.78	0.62
31	Modified Bridge	0.95	0.81	3.27	0.35
32	Nobel Prize (a)	0.94	0.81	0.42	0.93
33	Nobel Prize (b)	1.98	0.58	1.92	0.59
34	Bike week (a)	0.99	0.80	1,95	0.58
35	Bike week (b)	1.59	0.66	1.31	0.73
36	Modified Euthanasia (a)	3.79	0.28	2.19	0.53
37	Modified Euthanasia (b)	1.58	0.66	0.38	0.94
38	Modified Fumes (a)	1.55	0.67	0.10	0.99
39	Modified Fumes (b)	0.57	0.90	3.22	0.36
40	Modified Rowboat (a)	2.32	0.51	0.99	0.80
41	Modified Rowboat (b)	3.79	0.28	1.95	0.58
42	Mine Shaft (a)	2.06	0.56	1.33	0.72
43	Mine Shaft (b)	3.49	0.32	1.69	0.64

44	Tycoon (a)	2.96	0.39	0.39	0.94
45	Tycoon (b)	3.72	0.29	2.69	0.44
46	Enemy Spy (a)	3.43	0.33	0.82	0.84
47	Enemy Spy (b)	4.70	0.19	2.34	0.50
48	Missile (a)	1.68	0.64	5.19	0.16
49	Modified Crying Baby (b)	1.89	0.59	1.49	0.68
50	Missile (b)	2.33	0.50	0.74	0.86
51	Bomb in the Bank (a)	0.31	0.96	**<0.001**	**1.00**
52	Bomb in the Bank (b)	0.62	0.89	0.13	0.99

Note: X^2 = Chi-square; p = p value.

Table 3A. *Normative data for arousal, valence, familiarity ratings and utilitarian choices for the Italian 4CONFiDe dilemma set*

Dilemma Name	Valence		Arousal		Familiarity		Utilitarian response rate	
	M	SD	M	SD	M	SD	M	SD
Bike week (a)	1.54	1.05	3.98	1.62	1.69	1.13	0.48	0.50
Bike week (b)	1.83	1.13	2.80	1.77	2.53	1.52	0.33	0.47
Bomb in the Bank (a)	1.90	1.60	3.04	1.89	1.46	0.87	0.71	0.46
Bomb in the Bank (b)	1.63	1.12	2.61	1.83	2.42	1.64	0.63	0.49
Burning Building (a)	1.41	0.77	4.14	1.68	1.67	1.20	0.34	0.48
Burning Building(b)	1.56	1.07	3.58	1.82	1.58	1.01	0.69	0.47
Bus plunge (a)	2.38	2.16	3.83	2.06	1.69	1.26	0.50	0.51
Bus plunge (b)	1.28	0.79	4.38	1.87	1.59	1.06	0.53	0.50
Cinderblock (a)	1.56	1.05	3.79	1.70	1.50	1.03	0.69	0.47
Cinderblock (b)	1.41	0.92	3.88	1.69	1.67	1.10	0.78	0.42
Cliffhanger (a)	1.75	1.10	2.95	1.92	2.77	1.89	0.34	0.48
Cliffhanger (b)	1.48	1.03	3.90	1.90	1.44	0.90	0.52	0.50
Enemy Spy (a)	2.08	1.60	4.06	1.96	1.75	1.36	0.73	0.45
Enemy Spy (b)	2.63	1.80	2.94	1.99	1.63	1.02	0.77	0.43
Mine Shaft (a)	2.08	1.71	3.08	1.92	1.40	0.76	0.52	0.50
Mine Shaft (b)	1.61	1.06	2.77	1.79	2.34	1.73	0.42	0.50
Missile (a)	1.58	0.96	3.73	1.78	1.59	1.08	0.56	0.50
Missile (b)	1.77	1.45	3.71	1.83	1.79	1.13	0.77	0.42
Modified Bridge	1.40	0.87	3.79	1.91	1.48	0.95	0.65	0.48
Modified Crying Baby (a)	1.35	0.98	4.83	1.73	1.67	1.19	0.17	0.38
Modified Crying Baby (b)	2.77	2.11	3.56	2.14	1.34	1.03	0.16	0.37
Modified Euthanasia (a)	1.52	1.13	4.09	1.98	1.39	0.73	0.59	0.50
Modified Euthanasia (b)	1.73	1.32	3.65	1.82	1.60	1.16	0.69	0.47
Modified Footbridge	1.80	1.14	3.83	1.69	2.00	1.39	0.05	0.21
Modified Fumes (a)	2.44	1.69	2.89	2.06	1.63	1.15	0.38	0.49
Modified Fumes (b)	1.88	1.48	3.33	1.87	1.58	0.96	0.67	0.48
Modified Rowboat (a)	2.59	2.03	3.38	2.16	1.31	0.85	0.20	0.41
Modified Rowboat (b)	1.29	0.74	4.15	2.05	1.63	1.23	0.54	0.50
Modified Submarine (a)	2.41	1.49	2.80	1.74	1.38	0.83	0.77	0.43
Modified Submarine (b)	1.90	1.57	3.65	1.90	1.58	1.18	0.69	0.47
Modified Transplant (a)	1.83	1.46	4.22	1.85	2.00	1.33	0.05	0.21
Modified Transplant (b)	1.60	1.14	3.90	2.03	1.90	1.31	0.17	0.38
Modified vaccine Test (a)	1.79	1.35	4.06	1.87	2.08	1.38	0.58	0.50
Modified vaccine Test (b)	2.50	1.59	3.11	1.96	2.41	1.42	0.83	0.38
Nobel Prize (a)	2.25	1.63	3.15	1.73	2.02	1.47	0.38	0.49
Nobel Prize (b)	1.56	0.94	3.94	1.70	2.25	1.60	0.31	0.47
Nuclear reactor (a)	2.73	1.90	2.77	1.84	1.64	1.10	0.50	0.50
Nuclear reactor (b)	2.02	1.51	3.19	1.88	1.58	1.18	0.90	0.31
On the waterfront (a)	1.69	0.92	3.81	1.61	1.67	1.18	0.66	0.48
On the waterfront (b)	3.06	1.93	1.81	1.45	1.44	0.92	0.58	0.50

Orphanage (a)	2.42	2.18	3.60	2.18	1.63	1.28	0.23	0.42
Orphanage (b)	1.69	1.25	3.17	2.15	2.94	2.02	0.23	0.43
Preventing Cholera (a)	1.58	1.11	3.94	2.04	1.75	1.21	0.69	0.47
Preventing Cholera (b)	2.36	1.59	2.78	1.96	1.92	1.29	0.77	0.43
Rescue 911 (a)	1.47	0.96	2.98	2.01	2.80	1.72	0.41	0.50
Rescue 911 (b)	1.48	1.11	3.98	1.88	1.60	1.09	0.73	0.45
Shark Attack (a)	1.42	0.89	4.02	1.80	1.47	0.91	0.34	0.48
Shark Attack (b)	2.06	1.56	3.19	1.92	1.50	1.15	0.46	0.50
Space Station (a)	2.06	1.67	3.31	1.84	1.60	1.03	0.81	0.39
Space Station (b)	1.55	0.97	3.84	1.82	1.59	1.12	0.80	0.41
Tycoon (a)	1.96	1.25	2.90	1.65	2.04	1.35	0.15	0.36
Tycoon (b)	1.66	1.12	3.72	1.64	1.77	1.23	0.14	0.35

Appendix B

Supplemental results of Chapter 3

Table 1B. *Summary of the best fitting LMM for valence rating.*

Valence rating	***β***	***SE***	***t value***	***p value***	***95%CI***	
Fixed effects					***Lower***	***Upper***
Gender (*Male*)	0.456	0.337	1.350	0.186	-0.206	1.117
Affective component (BVAQ)	-0.048	0.035	-1.374	0.178	-0.117	0.020
Cognitive component (BVAQ)	0.043	0.026	1.619	0.115	-0.009	0.095
TAS-20	-0.036	0.021	-1.695	0.099	-0.078	0.006
PT (IRI)	-0.052	0.044	-1.177	0.248	-0.139	0.035
FS (IRI)	-0.103	0.041	-2.524	**0.016**	-0.183	-0.023
PD (IRI)	-0.048	0.029	-1.657	0.107	-0.105	0.009
EC (IRI)	-0.087	0.041	-2.116	**0.042**	-0.167	-0.006
Personal force (*Impersonal*)	0.125	0.061	2.040	**0.041**	0.005	0.244
Benefit recipient (*Self*)	-0.197	0.060	-3.277	**0.001**	-0.315	-0.079
Intentionality (*Instrumental*)	0.219	0.065	3.342	**0.001**	0.090	0.347
Moral choice (*Utilitarian*)	-0.250	0.068	-3.682	**< 0.001**	-0.383	-0.117

Note: β = estimate; SE = standard error; 95% CI = confidence interval; BVAQ = Bermond–Vorst Alexithymia Questionnaire; TAS-20 = 20-items Toronto Alexithymia Scale; IRI = Interpersonal Reactivity Index; PT = Perspective taking; FS = Fantasy; EC = Empathic concern; PD = Personal distress. Significant p values are in bold. Reference condition for categorical factors is reported in italic inside bracket.

Table 2B. *Summary of the best fitting LMM for arousal rating.*

Arousal rating	***β***	***SE***	***t value***	***p value***	***95%CI***	
Fixed effects					***Lower***	***Upper***
Gender (*Male*)	-1.198	0.691	-1.734	0.092	-2.552	0.156
Affective component (BVAQ)	0.073	0.072	1.007	0.321	-0.069	0.214
Cognitive component (BVAQ)	-0.020	0.054	-0.376	0.709	-0.126	0.086
TAS-20	0.047	0.043	1.091	0.283	-0.038	0.133
PT (IRI)	0.021	0.091	0.233	0.817	-0.157	0.199
FS (IRI)	0.096	0.083	1.157	0.255	-0.067	0.259
EC (IRI)	0.198	0.084	2.357	**0.024**	0.033	0.362
PD (IRI)	0.106	0.060	1.776	0.085	-0.011	0.223
Personal force (*Impersonal*)	-0.098	0.078	-1.249	0.212	-0.251	0.056
Benefit recipient (*Self*)	0.270	0.077	3.501	**< 0.001**	0.119	0.421
Intentionality (*Instrumental*)	-0.234	0.084	-2.791	**0.005**	-0.398	-0.069
Moral choice (*Utilitarian*)	0.293	0.087	3.359	**0.001**	0.122	0.464

Note: β = estimate; SE = standard error; 95% CI = confidence interval; BVAQ = Bermond–Vorst Alexithymia Questionnaire; TAS-20 = 20-items Toronto Alexithymia Scale; IRI = Interpersonal Reactivity Index; PT = Perspective taking; FS = Fantasy; EC = Empathic concern; PD = Personal distress. Significant p values are in bold. Reference condition for categorical factors is reported in italic inside bracket.

Table 3B. *Summary of the best fitting LMM for SCR.*

SCR	***β***	***SE***	***t value***	***p value***	***95%CI***	
Fixed effects					***Lower***	***Upper***
Gender (*Male*)	0.019	0.028	0.659	0.516	-0.037	0.074
Age	-0.002	0.003	-0.560	0.580	-0.008	0.004
Education	0.003	0.006	0.435	0.667	-0.009	0.014
Affective component (BVAQ)	-0.003	0.003	-1.017	0.318	-0.008	0.003
Cognitive component (BVAQ)	0.003	0.002	1.315	0.200	-0.001	0.007
TAS-20	-0.003	0.001	-2.099	**0.045**	-0.006	-0.001
PT (IRI)	-0.001	0.003	-0.298	0.768	-0.007	0.005
PD (IRI)	0.007	0.002	2.953	**0.006**	0.002	0.012
FS (IRI)	-0.001	0.003	-0.292	0.772	-0.008	0.006
EC (IRI)	-0.005	0.003	-1.795	0.084	-0.011	0.001
Personal force (*Impersonal*)	-0.045	0.029	-1.538	0.124	-0.103	0.012
Benefit recipient (*Self*)	-0.035	0.030	-1.158	0.247	-0.093	0.024
Intentionality (*Instrumental*)	-0.023	0.025	-0.881	0.378	-0.074	0.028
Moral choice (*Utilitarian*)	-0.006	0.012	-0.495	0.621	-0.029	0.017
Personal force*Benefit recipient	0.081	0.038	2.139	**0.033**	0.007	0.156
Personal force*Intentionality	0.026	0.026	0.762	0.446	-0.041	0.094
Benefit recipient*Intentionality	0.024	0.034	0.697	0.486	-0.043	0.091
Personal force*Benefit recipient*Intentionality	-0.014	0.046	-0.302	0.763	-0.104	0.076

Note: β = estimate; SE = standard error; 95% CI = confidence interval; BVAQ = Bermond–Vorst Alexithymia Questionnaire; TAS-20 = 20-items Toronto Alexithymia Scale; IRI = Interpersonal Reactivity Index; PT = Perspective taking; FS = Fantasy; EC = Empathic concern; PD = Personal distress. Significant p values are in bold. Reference condition for categorical factors is reported in italic inside bracket.

Table 4B. *Summary of the best fitting LMM for rise-time of SCR.*

Rise-time of SCR	***β***	***SE***	***t value***	***p value***	***95%CI***	
Fixed effects					***Lower***	***Upper***
Gender (*Male*)	756.04	1253.82	0.603	0.551	-1701.452	3213.529
Age	-192.43	137.94	-1.395	0.174	-462.797	77.931
Education	297.46	275.10	1.081	0.289	-241.739	836.668
Affective component (BVAQ)	-206.31	129.88	-1.588	0.123	-460.871	48.248
Cognitive component (BVAQ)	-10.33	96.63	-0.107	0.916	-199.720	179.060
TAS-20	67.29	72.51	0.928	0.361	-74.821	209.415
PT (IRI)	-256.40	150.29	-1.706	0.099	-358.876	64.111
PD (IRI)	-147.38	107.90	-1.366	0.183	17.392	561.269
FS (IRI)	-123.96	144.31	-0.859	0.398	-406.806	158.895
EC (IRI)	289.33	138.74	2.085	**0.046**	-550.976	38.174
Personal force (*Impersonal*)	-2702.04	1842.54	-1.466	0.143	-6313.428	909.339
Benefit recipient (*Self*)	-2998.63	1833.22	-1.636	0.102	-6591.754	594.486
Intentionality (*Instrumental*)	-2408.87	1624.21	-1.483	0.138	-5592.317	774.571
Moral choice (*Utilitarian*)	1240.93	668.45	1.856	0.064	-69.237	2551.106
Personal force*Benefit recipient	2513.28	2295.03	1.095	0.274	-1984.981	7011.552
Personal force*Intentionality	1295.41	2110.25	0.614	0.539	-2840.667	5431.497
Benefit recipient*Intentionality	2979.41	2074.50	1.436	0.151	-1086.623	7045.438
Personal force*Benefit recipient*Intentionality	988.62	2755.99	0.359	0.720	-4413.114	6390.355

Note: β = estimate; SE = standard error; 95% CI = confidence interval; BVAQ = Bermond–Vorst Alexithymia Questionnaire; TAS-20 = 20-items Toronto Alexithymia Scale; IRI = Interpersonal Reactivity Index; PT = Perspective taking; FS = Fantasy; EC = Empathic concern; PD = Personal distress; Inf = Infinity. Significant p values are in bold. Reference condition for categorical factors is reported in italic inside bracket.

Table 5B. *Summary of the best fitting LMM for IHR.*

IHR	***β***	***SE***	***t value***	***p value***	***95%CI***	
Fixed effects					***Lower***	***Upper***
Time window 2	-0.533	0.140	-3.806	**< 0.001**	-0.808	-0.259
Time window 3	-1.257	0.140	-8.972	**< 0.001**	-1.531	-0.982
Time window 4	-1.698	0.140	-12.121	**< 0.001**	-1.972	-1.423
Time window 5	-1.577	0.140	-11.262	**< 0.001**	-1.852	-1.303
Time window 6	-1.304	0.140	-9.307	**< 0.001**	-1.578	-1.029
Time window 7	-1.197	0.140	-8.546	**< 0.001**	-1.471	-0.922
Time window 8	-0.901	0.140	-6.432	**< 0.001**	-1.175	-0.626
Time window 9	-1.053	0.140	-7.521	**< 0.001**	-1.328	-0.779
Time window 10	-0.858	0.140	-6.121	**< 0.001**	-1.133	-0.584
Affective component (BVAQ)	-0.045	0.064	-0.694	0.494	-0.172	0.082
Cognitive component (BVAQ)	0.041	0.051	0.808	0.426	-0.058	0.140
TAS-20	-0.021	0.037	-0.557	0.582	-0.093	0.052
PT (IRI)	0.010	0.078	-0.778	0.858	-0.101	0.121
FS (IRI)	-0.082	0.072	0.557	0.306	-0.239	0.072
PD (IRI)	0.040	0.057	0.180	0.582	-0.101	0.181
EC (IRI)	-0.061	0.079	-1.044	0.443	-0.215	0.093
Moral choice (*Utilitarian*)	-0.152	0.073	-2.078	**0.038**	-0.294	-0.009
Personal force (*Impersonal*)	0.117	0.065	1.804	0.071	-0.010	0.245
Intentionality (*Instrumental*)	-0.554	0.069	-7.943	**0.000**	-0.691	-0.417
Benefit recipient (*Self*)	-0.413	0.064	-6.452	**0.000**	-0.538	-0.287

Note: β = estimate; SE = standard error; 95% CI = confidence interval; BVAQ = Bermond–Vorst Alexithymia Questionnaire; TAS-20 = 20-items Toronto Alexithymia Scale; IRI = Interpersonal Reactivity Index; PT = Perspective taking; FS = Fantasy; EC = Empathic concern; PD = Personal distress. Significant p values are in bold. Reference condition for categorical factors is reported in italic inside bracket.

Appendix C

Supplemental results of Chapter 4

***Table 1C**. Summary of linear mixed effects model on odour and arousal ratings of Study 1a.*

Valence Ratings	***β***	***SE***	***t value***	***p value***	***95%CI***	
Fixed effects					***Lower***	***Upper***
Intercept	4.63	0.23	19.85	**<0.001**	4.180	5.095
Clean Air	0.10	0.13	0.77	0.43	-0.157	0.364
Supra-threshold odour	-0.19	0.13	-1.45	0.15	-0.453	0.068
Arousal Ratings	***β***	***SE***	***t value***	***p value***	***95%CI***	
Fixed effects					***Lower***	***Upper***
Intercept	7.08	0.35	18.87	**<0.001**	6.385	7.783
Clean Air	0.16	0.12	1.31	0.191	-0.080	0.400
Supra-threshold odour	-0.04	0.12	-0.32	0.745	-0.280	0.200

Note: β = estimate; SE = standard error; 95% CI = confidence interval; Clean Air = no odour condition; Supra Threshold Odour = supra threshold neutral odour condition. Significant p values are reported in bold. Table shows model with Sub-threshold odour condition set as reference.

***Table 2C.** Summary of the best linear mixed effects models on ratings for Study 1b.*

Intensity Ratings	***β***	***SE***	***t value***	***p value***	***95%CI***	
Fixed effects					***Lower***	***Upper***
Intercept	3.97	0.39	10.18	**<0.001**	3.203	4.731
Clean Air	-1.27	0.53	-2.37	**0.020**	-2.314	-0.219
Supra-threshold odour	3.00	0.53	5.61	**<0.001**	1.952	4.057
Valence Ratings	***β***	***SE***	***t value***	***p value***	***95%CI***	
Fixed effects					***Lower***	***Upper***
Intercept	4.03	0.45	8.95	**<0.001**	3.153	4.922
Clean Air	0.29	0.44	0.66	0.508	-0.564	1.145
Supra-threshold odour	-0.44	0.43	-1.01	0.314	-1.284	0.409

Note: β = estimate; SE = standard error; 95% CI = confidence interval; Clean Air = no odour condition; Supra Threshold Odour = supra threshold neutral odour condition. Significant p values are reported in bold. Table shows model with Sub-threshold odour condition set as reference.

Table 3C. *Summary of the best linear mixed effects model on SCR for Study 1b.*

SCR	***β***	***SE***	***t value***	***p value***	***95%CI***	
Fixed effects					***Lower***	***Upper***
Intercept	-0.07	0.09	-0.86	0.389	-0.243	0.094
No-odour Odour	0.00	0.03	0.03	0.974	-0.058	0.060
Supra- threshold Odour	0.07	0.03	2.21	**0.027**	0.007	0.125
Moral choice (*Utilitarian*)	0.08	0.03	2.76	**0.006**	0.022	0.129
Personal force (*Impersonal*)	-0.02	0.01	-1.41	0.158	-0.053	0.009
Intentionality (*Instrumental*)	-0.04	0.01	-2.75	**0.006**	-0.075	-0.013
Benefit recipient (*Self*)	0.02	0.01	1.51	0.132	0.007	0.054
Evitability (*Inevitable*)	0.01	0.01	0.66	0.507	-0.020	0.041
AQ	0.01	0.01	2.26	**0.043**	0.001	0.018
Moral choice* No-odour	-0.10	0.03	-2.61	**0.009**	-0.177	-0.025
Moral choice* Supra- threshold Odour	-0.09	0.03	-2.22	**0.026**	-0.159	-0.010

Note: β = estimate; SE = standard error; 95% CI = confidence interval; Sub- threshold Odour = sub threshold neutral odour condition; Supra- threshold Odour = supra threshold neutral odour condition; AQ = Autism Quotient. Table shows model with Sub-threshold odour condition set as reference. Contrast condition from the reference for categorical factors is reported in italic inside bracket.

Table 4C. *Summary of the best linear mixed effects model on IHR for study 1b*

IHR	***β***	***SE***	***t value***	***p value***	***95%CI***	
Fixed effects					***Lower***	***Upper***
Intercept	0.17	0.43	0.38	0.703	-0.466	1.262
No-odour Odour	0.65	0.23	2.85	**0.004**	0.203	1.010
Supra- threshold Odour	0.03	0.23	0.11	0.914	-0.429	0.479
Personal force (*Impersonal*)	0.00	0.19	0.02	0.981	-0.367	0.376
Intentionality (*Instrumental*)	-0.11	0.19	-0.58	0.559	-0.494	0.267
Benefit recipient (*Self*)	-0.35	0.19	-1.82	0.069	-0.720	0.026
Evitability (*Inevitable*)	0.08	0.19	0.43	0.669	-0.295	0.460
Moral choice (*Utilitarian*)	-0.23	0.20	-1.14	0.253	-0.629	0.166
Time window 2	0.77	0.32	2.40	**0.016**	0.142	1.394
Time window 3	0.83	0.32	2.58	**0.010**	0.201	1.453
Time window 4	0.86	0.32	2.68	**0.007**	0.233	1.484
Time window 5	0.41	0.32	1.28	0.199	-0.215	1.036
Time window 6	0.13	0.32	0.40	0.685	-0.496	0.755
STAI difference	-0.09	0.04	-2.27	**0.041**	-0.161	-0.012

Note: β = estimate; SE = standard error; 95% CI = confidence interval; Sub- threshold Odour = sub threshold neutral odour condition; Supra- threshold Odour = supra threshold neutral odour condition; STAI = State subscale of the State–Trait Anxiety Inventory. Significant p values are reported in bold. Table shows model with Sub-threshold odour condition set as reference. Contrast condition from the reference for categorical factors is reported in italic inside bracket.

Table 5C. *Summary of the best linear mixed effects models on ratings for Study 2*

Intensity Rating	***β***	***SE***	***t value***	***p value***	***95%CI***	
Fixed effects					***Lower***	***Upper***
Intercept	2.77	0.40	6.91	**<0.001**	1.982	3.552
Neutral	1.03	0.44	2.32	**0.023**	0.161	1.905
Pleasant	1.38	0.55	2.48	**0.015**	0.292	2.469
Unpleasant	0.56	0.58	0.96	0.337	-0.581	1.712
Valence Rating	***β***	***SE***	***t value***	***p value***	***95%CI***	
Fixed effects					***Lower***	***Upper***
Intercept	4.60	0.32	14.46	**<0.001**	3.976	5.223
Neutral Odour	-0.07	0.38	-0.18	0.860	-0.805	0.672
Pleasant Odour	0.59	0.47	1.26	0.212	-0.325	1.506
Unpleasant Odour	-1.03	0.49	-2.09	**0.039**	-1.996	-0.068

Note: β = estimate; SE = standard error; 95% CI = confidence interval. Significant p values are reported in bold. Table shows model with no-odour odour condition set as reference.

Table 6C. *Summary of the best linear mixed effects model on SCR for Study 2.*

SCR	***β***	***SE***	***t value***	***p value***	***95%CI***	
Fixed effects					***Lower***	***Upper***
Intercept	0.12	0.02	4.42	**<0.001**	0.064	0.165
No-odour Odour	-0.01	0.02	-0.47	0.640	-0.057	0.035
Unpleasant Odour	0.07	0.03	2.22	**0.027**	0.008	0.136
Pleasant Odour	0.04	0.02	2.22	0.129	-0.012	0.097
Moral choice (*Utilitarian*)	0.02	0.02	0.75	0.455	-0.028	0.064
Personal force (*Impersonal*)	-0.03	0.01	-1.93	0.054	-0.054	0.000
Intentionality (*Instrumental*)	-0.05	0.01	-3.71	**<0.001**	-0.079	-0.024
Benefit recipient (*Self*)	0.01	0.01	1.04	0.297	-0.013	0.041
Evitability (*Inevitable*)	0.01	0.03	-0.78	0.391	-0.015	0.039
Moral choice* No-odour	-0.03	0.03	-0.78	0.433	-0.092	0.039
Moral choice* Unpleasant Odour	-0.08	0.04	-1.91	0.056	-0.166	0.002
Moral choice* Pleasant Odour	-0.06	0.04	-1.52	0.127	-0.138	0.017

Note: β = estimate; SE = standard error; CI = confidence interval. Significant p values are reported in bold. Table shows model with neutral odour condition set as reference. Contrast condition from the reference for categorical factors is reported in italic inside bracket.

Table 7C. *Summary of the best linear mixed effects model on IHR for study 2*

IHR	***β***	***SE***	***t value***	***p value***	***95%CI***	
Fixed effects					***Lower***	***Upper***
Intercept	1.04	0.38	2.71	**0.007**	-0.358	1.133
No-odour Odour	0.57	0.21	2.71	**0.007**	0.157	0.978
Unpleasant Odour	0.28	0.27	1.05	0.293	-0.242	0.803
Pleasant Odour	0.49	0.28	1.75	0.081	-0.059	1.042
Time window 2	1.22	0.29	4.18	**<0.001**	0.648	1.789
Time window 3	1.19	0.29	4.11	**<0.001**	0.625	1.767
Time window 4	0.72	0.29	2.48	**0.013**	0.153	1.294
Time window 5	0.78	0.29	2.67	**0.008**	0.207	1.349
Time window 6	0.78	0.29	2.68	**0.007**	0.211	1.353
Moral choice (*Utilitarian*)	-0.65	0.18	-3.60	**<0.001**	0.298	0.011
Personal force (*Impersonal*)	-0.11	0.17	-0.63	0.528	-0.447	0.229
Intentionality (*Instrumental*)	-0.04	0.17	-0.22	0.829	-0.384	0.307
Benefit recipient (*Self*)	-0.01	0.17	-0.08	0.931	-0.354	0.324
Evitability (*Inevitable*)	-0.41	0.17	-2.32	**0.020**	-0.752	-0.063

Note: β = estimate; SE = standard error; 95% CI = confidence interval. Significant p values are reported in bold. Table shows model with neutral odour condition set as reference. Contrast condition from the reference for categorical factors is reported in italic inside bracket.

Appendix D

English version of the Moral dilemma set

1)
You and five other people are trapped in a burning building. There is only one emergency exit through which all of you could escape, but it is blocked by burning debris. Another injured person is about to crawl through a hole at the bottom of the exit door. You and the five people behind you do not have time to do the same.

If you use the injured person to break down the debris you will be able to escape. You will certainly kill him, but you will save yourself and the five people behind you.

Do you use the injured person to break down the blockage so you and the five other people can escape?

2)
You and five other people are trapped in a burning building. There is only one emergency exit through which all of you could escape, but it is blocked by burning debris. Another injured person is about to crawl through a hole at the bottom of the exit door. You and the five people behind you do not have time to do the same.

If you activate the emergency system it will release foam which will put out the fire. However, the foam will suffocate the injured person. This will kill him, but you and the five people behind you will be saved.

Do you put out the fire by activating the emergency system, which will smother the injured person, so you and the five other people can escape?

3)
Enemy soldiers have taken over your village and will kill all civilians above the age of two. You and ten neighbors are hiding in two rooms of the cellar of a large house. You can hear the voices of soldiers who have come to search the house for valuables. Your baby begins to cry loudly. The crying will attract the attention of the soldiers, who will spare your baby's life, but will kill you and the other refugees in both rooms.

If you put your hand over its mouth the crying will be absorbed, but your baby will not be able to breathe. You will kill him, but you will save yourself and the other ten neighbors.

Do you put your hand over your baby's mouth, which will leave it without air, to absorb the crying so the soldiers won't find you and the ten neighbors?

4)

Enemy soldiers have taken over your village and will kill all civilians above the age of two. You and ten neighbors are hiding in two rooms of the cellar of a large house. You can hear the voices of soldiers who have come to search the house for valuables. Your baby begins to cry loudly. The crying will attract the attention of the soldiers, who will spare your baby's life, but will kill you and the other refugees in both rooms.

If you activate a noisy boiler it will cushion the crying, but it will become uncomfortably hot. The heat will be mortal for your baby, but it will save you and the ten neighbors.

Do you cushion the crying by activating the noisy boiler which will asphyxiate the baby, so they won't find you and the ten neighbors?

5)
You are a crewmember on a submarine traveling under a large iceberg. An explosion has damaged the ship, injured several crewmembers and collapsed the only access between the upper and lower decks of the ship. You and ten survivors are in the upper section, which does not have enough oxygen for all of you to survive until you reach the surface. One single crewmember is lying unconscious in the lower section, where there is enough oxygen.

If you push the emergency access hatch between the sections of the ship it will allow oxygen in the upper section. However, the hatch will fall down on the crewmember in the lower section. You will kill him, but you will save yourself and the ten survivors.

Do you push the hatch, which will fall on the crewmember below, to let in the air so you and the ten survivors will get enough oxygen?

6)
You are a crewmember on a submarine traveling under a large iceberg. An explosion has damaged the ship, injured several crewmembers and collapsed the only access between the upper and lower parts of the ship. You and ten survivors are in the upper section, which does not have enough oxygen for all of you to survive until you reach the surface. One single crewmember is lying unconscious in the lower section, where there is enough oxygen.

If you push an emergency button, a hatch between the sections of the ship will be released and will allow the oxygen in the upper section. However, the hatch will fall on the crewmember in the lower section and kill him, but it will save you and the ten survivors.

Do you push the button, which will make the hatch fall down on the crewmember, so you and the ten survivors get enough oxygen?

7)
You and ten divers are part of an U.N. team who is deactivating anti-ship mines from World War II. One team member has hurt himself and the blood in the water has attracted several sharks. You have an underwater rifle but only one harpoon. The bleeding diver is swimming towards the last protective cage and will reach it before you and the others. The sharks, following the blood, are coming too close for you and the other divers to escape.

If you shoot at the injured diver you will kill him and the sharks will stop to eat him, but you will save yourself and the ten divers.

Do you shoot at the injured diver letting the sharks eat him, so you and the other ten divers can reach the protective cage?

8)
You and ten divers are part of an U.N. team who is deactivating anti-ship mines from World War II. One team member has hurt himself and the blood in the water has attracted several sharks. You have an underwater rifle but only one harpoon. The bleeding diver is swimming towards the last protective cage and will reach it before you and the others. The sharks, following the blood, are coming too close for you and the other divers to escape.

If you detonate one of the mines by means of a remote control, it will kill the injured diver and the sharks will stop to eat him. Then, you and the ten divers will be saved.

Do you let the sharks eat the injured diver by detonating the mine next to him with a remote control, so you and the other ten divers can reach the protective cage?

9)
You work in an orphanage that hosts ten orphans in a war swept country. Rebels have taken over the government. They kill who does not support their regime and they conduct an 'ethnic cleansing' genocide campaign to eliminate a particular ethnic group. You and the ten children of the orphanage did not support the rebellion and you also have one child of this ethnic group in your orphanage. There is no way for you and the children to escape.

If you smother the child of the pursued ethnic group to death with a pillow while he is sleeping, the soldiers will believe that you support their regime. You will kill the child, but you will save yourself and the remaining ten children.

Do you smother the child making the soldiers believe you are supporting their regime, so they will spare your and the other ten children's life?

10)
You work with a nurse in an orphanage that hosts ten orphans in a war swept country. Rebels have taken over the government. They kill who does not support their regime and they conduct an 'ethnic cleansing' genocide campaign to eliminate a particular ethnic group. You and the ten children of the orphanage did not support the rebellion and you also have one child of this ethnic group in your orphanage. There is no way for all of you to escape.

If you order a nurse to give the child of the pursued ethnic group a lethal overdose of sleeping pills, the soldiers will believe that you support their regime. This will kill the child, but it will save you, the nurse and the remaining ten children.

Do you make the soldiers believe you are supporting their regime ordering the nurse to give that one child an overdose, so they will spare your and the other ten children's life?

11)
You are a Peace Corps health-worker volunteering in a rural African village. A man has been infected with the cholera bacterium that is extremely contagious, incurable, and almost always deadly. This man is still alive which means he must be immune to the bacterium. He wrongly believes that your health center can cure his disease completely. You know that if he enters the village he will pass the virus to 100 innocent people who, unlike him, will die.

If you shoot him with the gun of the health center you will prevent him from spreading the virus to you and the rest of the village. You will kill him, but you will save yourself and the 100 inhabitants of the village.

Do you shoot the man preventing him from entering the village, so he won't spread the virus to you and the 100 inhabitants?

12)
You are a Peace Corps health-worker volunteering in a rural African village. A man has been infected with the cholera bacterium that is extremely contagious, incurable, and almost always deadly. This man is still alive which means he must be immune to the bacterium. He wrongly believes that your health center can cure his disease completely. You know that if he enters the village he will pass the virus to 100 innocent people who, unlike him, will die.

If you warn the village council they will shoot him to prevent him from spreading the virus to you and the rest of the village. This will kill him, but it will save you and the 100 inhabitants of the village.

Do you prevent the man from entering the village by warning the village council so they shoot him, so he won't spread the virus to you and the 100 inhabitants?

13)
You are a doctor alone in a rescue helicopter during a devastating flood. You have rescued eight critically injured people and you are keeping them alive. Suddenly, the pilot notifies you of a problem in the engine and gives the order that the helicopter needs to release weight or it will crash and you will all die. You cannot abandon the helicopter because the wounded need your help and the heavy medical equipment is bolted down.

If you throw off one of the injured people, you will release enough weight to keep the helicopter in the air. You will kill him, but you will save yourself and the eight people on board.

Do you throw one of the injured people off the helicopter releasing weight, so you and the eight persons on board will be able to stay in the air?

14)
You are a doctor alone in a rescue helicopter during a devastating flood. You have rescued eight critically injured people and you are keeping them alive. Suddenly, the pilot notifies you of a problem in the engine and gives the order that the helicopter needs to release weight or it will crash and you will all die. You cannot abandon the helicopter because the wounded need your help and the heavy medical equipment is bolted down.

If you order the pilot to release the cable by which the last rescued person is ascending, you will release enough weight to keep the helicopter in the air. This will kill him, but it will save you and the eight people on board.

Do you release weight by ordering the pilot to release the cable by which the last person is ascending, in order to keep you and the eight people on board in the air?

15)
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.

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.

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?

16)
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.

If you push a button, the portal will close activating the emergency system which will put out the fire. This will suck the mechanic into space and kill him, but it will save you and the remaining ten astronauts.

Do you put out the fire pushing the button which seals the inner portal, sucking the mechanic into space, so the fire won't reach you and the ten astronauts?

17)
You are an inspector of a nuclear power plant. The plant foreman and you are visiting the facility when one of the supply conduits overheats. The emergency coolant system fails to activate, and a chain reaction which will result in a nuclear meltdown is about to start. This will release lethal radiation into the nearby town, killing thousands of people.

If you push the foreman onto the conduits it will dissolve enough heat to prevent the nuclear chain reaction. You will kill him, but you will save yourself and the thousands of town inhabitants.

Do you push the foreman down on the conduits to cool down it, so the nuclear chain reaction will be stopped in time for you and the thousands of people?

18)
You are an inspector of a nuclear power plant. The plant foreman and you are visiting the facility when one of the supply conduits overheats. The emergency coolant system fails to activate, and a chain reaction which will result in a nuclear meltdown is about to start. This will release lethal radiation into the nearby town, killing thousands of people.

If you insert liquid nitrogen manually into the supply chamber it will absorb enough heat to prevent the nuclear chain reaction. This will kill one employee, who is trapped in the supply chamber, but it will save you and the thousands of town inhabitants.

Do you insert liquid nitrogen into the supply chamber where the employee is trapped, so the nuclear chain reaction will be stopped in time for you and the thousands of people?

19)
You are the explosives expert of a company that has been hired to demolish a skyscraper. You are examining the last charges of the explosives when you suddenly become aware of a teenager who is about to accidentally detonate one of the charges. The explosion will result in the building's uncontrolled collapse over you, the teenager, and the crowd of spectators. The teenager stands several floors below you and cannot hear you.

If you drop a heavy cinderblock on his head, you will kill him, but you will prevent the explosion and save yourself and the crowd.

Do you drop the cinderblock on teenager's head stopping him, so the building won't collapse over you and the crowd of spectators?

20)
You are the explosives expert of a company that has been hired to demolish a skyscraper. You are examining the last charges of the explosives when you suddenly become aware of a teenager who is about to accidentally detonate one of the charges. The explosion will result in the building's uncontrolled collapse over you, the teenager, and the crowd of spectators. The teenager stands several floors below you and cannot hear you.

If you reactivate the building's electricity, the boy will get an electric shock because he is touching an open circuit. This will kill him, but it will save you and the crowd by preventing the explosion.

Do you stop the teenager by reactivating the building's electricity, so the building won't collapse over you and the crowd of spectators?

21)
You are a construction worker. You and your crew are standing on some scaffolding, working on a skyscraper. Suddenly, the scaffolding collapses partially. You and several others are hanging on to a dangling crossbar, but it cannot hold the weight of all of you. A worker next to you slips off the crossbar and grabs your one free arm. However, you realize that the entire structure is about to give way.

If you kick your coworker until he falls, you will remove just enough weight so the rest of you can make it to safety before the scaffolding collapses entirely. You will kill your colleague but you will save yourself and the others.

Do you hit this colleague until he lets go of your arm and falls removing weight , so you and the others can continue to hold on to the structure?

22)
You are a construction worker. You and your crew are standing on some scaffolding, working on a skyscraper. Suddenly, the scaffolding collapses partially. You and several others are hanging on to a dangling crossbar, but it cannot hold the weight of all of you. The worker next

to you slips off the crossbar and catches himself on another portion of the scaffolding. The entire structure is about to give way.

If you pull out a latch that will detach the section of scaffolding with your co-worker on it, this will remove enough weight on the scaffolding. This will kill him but save you and the other five coworkers.

Do you remove weight by pulling out the latch so your co-worker falls off the crossbar, so you and the others can continue to hold on to the structure?

23)
You are the bus driver of a kindergarten trip to the zoo. On the way, faulty tires cause the bus to plunge off a bridge and into a roaring river. You and three of the children are still in the sinking bus. The rest has already been swept away by the river. You grab the two children next to you and begin to swim towards the exit. The third child latches onto your leg. You are not strong enough to fight against the current and swim with all three children.

If you shake off the third child you will be able to fight against the current, but the child dropped behind will drown. You will kill him, but you will save yourself and the other two children.

Do you shake off the child, which will make him to drown, to fight against the current so you and the other two children can reach the surface?

24)
You are the bus driver of a kindergarten trip to the zoo. On the way, faulty tires cause the bus to plunge off a bridge and into a roaring river. You and three of the children are still in the sinking bus. The rest has already been swept away by the river. You grab the two children next to you and begin to swim towards the exit, but bulky seats are blocking it.

If you pull the seats away you will free the exit, but you will block the corridor and the third child will be trapped, causing him to drown. This will kill him, but it will save you and the other two children.

Do you free the exit putting the seats in the corridor, which will trap the third child, so you and the other two children can reach the surface?

25)
You are a doctor. You have five patients who will all die if they don't get an immediate organ transplant. Another patient is just being rushed to the hospital after a serious car accident. This person is critically injured, but you can probably save him by means of a long and complicated operation.

If you secretly cut his carotid artery during surgery it will cause his death and you will have the organs for the other five patients. You will kill him, but you will save the other five patients.

Do you cut the carotid artery of the accident victim obtaining the organs so you can undertake the transplantations for the other five patients?

26)
You are a doctor. You have five patients who will all die if they don't get an immediate organ transplant. Another patient is just being rushed to the hospital after a serious car accident. This person is critically injured. During the long and complicated surgery you notice that a nurse is about to inject the wrong medication, which will be lethal in this case.

If you let the nurse inject the wrong medication the accident victim will die and you will have the organs to save the other five patients.

Do you obtain the organs letting the nurse inject the wrong medication, so you can undertake the transplantations for the other five patients?

27)
You are part of a shipyard dock team that attaches crane cables to containers to unload the cargo ships. You and the others are now climbing on top of it to make sure it is unloaded properly. Suddenly you realize that the crane cable is about to fail. You see that the reason for this is a fight between two crewmembers. The container is swinging dangerously over five other crewmembers on the deck.

If you separate the two fighting crewmembers, you will avoid having the container fall down. However, one of the crewmembers is not wearing his safety harness and will fall off the container. You will kill him, but you will save the five crewmembers on the deck.

Do you stop the swinging of the container by pushing your colleagues, which will cause the death of a crewmember, so the container won't collapse onto the five crewmembers on the deck?

28)
You are part of a shipyard dock team that attaches crane cables to containers to unload the cargo ships. You and the others have just attached cables to a container and are now climbing on top of it to make sure it is unloaded properly. Suddenly you realize that the crane cable is about to fail. You see that the reason for this is a fight between two crewmembers. The container is swinging dangerously over five other crewmembers on the deck.

If you push the emergency release button the container will be dropped back into the cargo bay where one crewmember is still working. Dropping the container back there will kill him, but it will save the five men on the deck.

Do you drop the container pushing the emergency button, which will cause the container to fall back into the cargo bay on the crewmember, so the container won't collapse onto the five men on the deck?

29)
A viral epidemic has spread across the globe killing thousands of people. You are a medical researcher and have developed two substances in your laboratory. Due to a mistake both are labeled as vaccine. One of them is indeed the vaccine, which could save thousands of lives. The other one is lethal. You don't have much time to identify the vaccine.

If you inject the substances to your two lab assistants, the only available test subjects, you will be able to identify the vaccine. You will kill one of the assistants, but you will save thousands of lives with your vaccine.

Do you inject these two substances into your two lab assistants, which will poison one of them, identifying the vaccine so thousands of people can be vaccinated?

30)
A viral epidemic has spread across the globe killing thousands of people. You are a medical researcher and have developed two substances in your laboratory. Due to a mistake both are labeled as vaccine. One of them is indeed the vaccine, which could save thousands of lives. The other one is lethal. You don't have much time to identify the vaccine.

If you allow a nurse to inject the two substances to two patients, the only available test subjects, you will be able to identify the vaccine. One of the patients will die, but you will be able to save thousands of lives with the vaccine.

Do you identify the vaccine allowing the nurse to inject the two substances to two patients which will poison one of them, so thousands of people can be vaccinated?

31)
A runaway trolley is speeding down the tracks towards five workmen who will be killed if the trolley continues on its present course. You are standing next to the tracks, but you are too far away to warn them. Next to you there is a very large stranger.

If you push the large stranger onto the tracks, the trolley will slide off the tracks and won't continue its course towards the workmen. You will kill the stranger, but you will save the five workmen.

Do you push the stranger onto the tracks cause the trolley to derail, so the trolley does not reach the five workmen?

32)
A runaway trolley is speeding down the tracks towards five workmen who will be killed if the trolley continues on its present course. You are standing next to the tracks, but you are too far away to warn them. Next to you there is a control switch that can redirect the trolley onto a different track, where only one workman is working.

If you flip the control switch it will divert the trolley onto the track with one workman and will not continue its course towards the five workmen. This will kill this workman, but it will save the other five.

Do you divert the trolley by flipping the control switch, which will cause the trolley to run over one workman, so the trolley does not reach the five workmen?

33)
You and a fellow researcher have discovered a powerful new energy source that is cheap, safe, and clean. It has the potential to put an end to pollution and poverty in the world However, your colleague wants to sell the discovery and you know that he is planning to contact the

potential buyers today. You also know for sure that the latter will use the invention as a deadly weapon, but your colleague doesn't believe you.

If you poison your colleague with a common poison available in your lab, you will avoid having the discovery fall into the wrong hands. You will kill your colleague, but you will save thousands of people.

Do you poison your colleague to prevent the sale of the discovery, so the source of energy can't be used as a weapon against thousands of people?

34)
You and a fellow researcher have discovered a powerful new energy source that is cheap, safe, and clean. It has the potential to put an end to pollution and poverty in the world However, your colleague wants to sell the discovery and you know that he is planning to contact the potential buyers by email today. You also know for sure that the latter will use the invention as a deadly weapon, but your colleague doesn't believe you.

If you release a flammable gas in the lab, it will cause an explosion when your colleague turns on his computer and you will avoid having the discovery fall into the wrong hands.. This will kill him, but it will save thousands of people.

Do you cause the computer of your colleague to explode releasing the flammable gas, in order to prevent the discovery being used as a weapon against thousands of people?

35)
You are an expert motorcyclist participating in a Bike Week. As you are driving down the road in front of a group of ten bikers, you notice that a biker up front is losing control over his machine. As you speed up to pull alongside him, you realize that he is going to crash any moment. This would result in a large pile-up and the group of ten bikers behind you will die.

If you force this biker off the road he will crash into the trees, but you will prevent the pile-up. At his current speed you will kill him, but you will save the group of ten riders.

Do you force this biker off the road preventing the large pile-up by, in order to impede that the group of ten bikers crash into him?

36)
You are an expert motorcyclist participating in a Bike Week. As you are driving down the road in front of a group of ten bikers, you notice that a biker up front is losing control over his machine and is falling. You can easily evade him yourself but the bikers behind you will crash into each other and die in the resulting pile-up.

If you let your bike run into the falling biker while jumping into the roadside ditch yourself, you will warn the others in time. This will kill this biker, but it will save the other ten.

Do you alert the others about the imminent accident by running your bike into the falling bikers' machine, so the other ten riders will have enough time to drive around him?

37)

You are the leader of a group of soldiers. You are on your way back from a mission in enemy territory when one of your men steps in a trap that catches his leg, injuring him badly. You cannot free him without killing him, but if you leave him behind, enemy troops will torture him until he reveals the position of an allied base camp with a platoon of 10. The soldier begs you not to leave him, but you can't stay because you don't have any more ammunition.

If you stab the soldier yourself you will impede that he'll be tortured and reveal the information which leads to the death of the allied platoon. You will kill him, but you will save the ten soldiers of the platoon.

Do you stab him yourself to death to impede he will be tortured , so he can't reveal the location of the ten allied troop members?

38)
You are the leader of a group of soldiers. You are on your way back from a mission in enemy territory when one of your men steps in a trap that catches his leg, injuring him badly. You cannot free him without killing him, but if you leave him behind, enemy troops will torture him until he reveals the position of an allied base camp with a platoon of 10. The soldier begs you not to leave him, but you can't stay because you don't have any more ammunition.

If you signalize the position of the soldier with an illumination rocket, the region will be bombed. The soldier won't be tortured and won't reveal the information which will lead to the death of the allied troop. This will kill him, but it will save the ten soldiers of the allied platoon.

Do you impede that the trapped soldier is tortured by ordering the bombing of that region, so he can't reveal the location of the ten allied troop members?

39)
You are on the night watch in a hospital. A chemical product has been spilled from a large crack on the air duct in a room with six patients. This chemical is highly toxic and it will kill all the patients in the room. You don't have much time to evacuate all the patients.

If you move the closest patients' bed in front of the crack, you will stop the spilling and you could evacuate the other patients. You will kill this patient but you will save the other five patients in the room.

Do you move this patient's bed in front of the crack to prevent the spilling, so the other five patients won't be poisoned?

40)
You are on the night watch in a hospital. A chemical product has been spilled from a large crack on the air duct in a room with six patients. This chemical is highly toxic and it will kill all the patients in the room. You don't have much time to evacuate all the patients.

If you activate the ventilation system the poisonous gas will be taken out of the room. However, it will be transferred into a room upstairs with one patient, whom you won't be able to evacuate in time. This will kill this patient, but it will save the other five.

Do you divert the gas out of the room by activating the ventilation system, causing it to be transferred to the room with one patient, so the other five patients won't be poisoned?

41)
You are on a rowboat with a tour guide on a lake in Alaska. Nearby, three children have fallen off their boat and are in danger of freezing to death. You rescue the children, but one of them is very heavy and you realize that if you keep him on board your boat will sink and all will die. Neither you nor the guide can leave the boat because you are rowing and the guide is giving CPR to one of the children.
If you throw the heavy child off the boat you will be able to reach the shore. You will kill this child, but you will save the other two.
Do you throw that one child overboard to get rid of load, so you can reach the shore with the other two children?

42)
You are on a rowboat with a tour guide on a lake in Alaska. Nearby, three children have fallen off their boat and are in danger of freezing to death. After you rescue two of the children, you realize that the weight of the third child would cause your boat to sink and all would die. Neither you nor the guide can leave the boat because you are rowing and the guide is giving CPR to one of the children.
If you row to the shore leaving the third child behind in the water, you will prevent your boat from sinking. This will kill the child left behind, but it will save the other two.
Do you prevent your boot from sinking by leaving the third child behind, which will cause him to die, so you can reach the shore with the other two children?

43)
You are a miner. The only way out of the mine is to ride up with a cable car. The shift is end and everybody is riding up to the surface in the cubicles. While you are in the queue, you see that the cable supporting all the cubicles is about to snap. 10 miners are riding in the cubicles at this time.
If you knock over the last cubicle, the miner inside will fall down. In this way, you will reduce the load enough for the cable to resist breaking. You will kill the miner in the cubicle you knock over, but you will save the other 10.
Do you knock over the cubicle with only one miner to reduce weight, so the other ten miners will reach the exit?

44)
You are a miner. The only way out of the mine is to ride up with a cable car. It is the end of your turn and everybody is riding up to the surface in the cubicles. While you are in the queue, you see that the cable supporting all the cubicles is about to snap. 10 miners are riding the cubicles at this time.
If you push an emergency switch the last cubicle will be detached from the cable. This will reduce enough weight to maintain the cubicles of the other 10 miners. This will kill the miner in the detached cubicle, but it will save the other ten.
Do you reduce weight by pushing the emergency switch which detaches the last cubicle, so the other ten miners can reach the exit?

45)

You are an electrician hired to fix an electrical problem in the home of a very wealthy tycoon who is terminally ill of cancer. Recently, it has been announced that upon his death, his enormous fortune will be donated to the local children's hospital. You know that there are 100 children at this hospital who could be saved with this money, but who cannot wait much longer before they die.

If you suffocate the tycoon while he is sleeping by covering his nose and mouth with your gloved hands, this essential donation for the children will arrive in time. You will kill the tycoon, but you will save the lives of 100 children.

Do you suffocate this man to speed the donation, so it will get to the 100 ill children in time?

46)
You are an electrician hired to fix an electrical problem in the home of a very wealthy tycoon who is terminally ill of cancer. Recently, it has been announced that upon his death, his enormous fortune will be donated to the local children's hospital. You know that there are 100 children at this hospital who could be saved with this money, but who cannot wait much longer before they die.

If you short-circuit the cables instead of fixing the problem, the tycoon's life support equipment will fail and this essential donation for the children will arrive in time. This will kill the tycoon, but it will save the lives of 100 children.

Do you anticipate the donation by causing the tycoon's life support equipment to fail, so the donation gets to the 100 ill children in time?

47)
You are a military officer during a war. Your soldiers have found an enemy spy trapped and injured in a collapsed building. You have been informed that enemy soldiers are planning a surprise attack on a nearby town. They will kill thousands of civilians if you and your soldiers do not stop them. The spy knows which town will be attacked. You have questioned him but he doesn't want to tell you. He won't survive much longer due to his injuries.

If you torture the spy, he will reveal the information about the town. In this way you will kill him, but you will save thousands of civilians.

Do you torture the spy to make him reveal the information, so you can prevent the attack on thousands of civilians?

48)
You are a military officer during a war. Your soldiers have found an enemy spy trapped and injured in a collapsed building. You have been informed that enemy soldiers are planning a surprise attack on a nearby town. They will kill thousands of civilians if you and your soldiers do not stop them. The spy knows which town will be attacked. You have questioned him but he doesn't want to tell you. He won't survive much longer due to his injuries.

If you let the rats enter in his cell, they will chew his legs until he reveal the information about the town. The torture will kill him, but it will save thousands of civilians.

Do you make the spy reveal the information by letting the rats enter in his cell, so you can prevent the attack on the thousands of civilians?

49)
You are in charge of the Maritime Police. You have received a message that the captain and a seaman of a cargo ship are healthy carriers of a lethal and contagious virus. They do not know that they are infected, and are travelling towards a small gulf where fishermen live. The communications system of the cargo ship is not working and, therefore, they cannot be contacted.

If you launch one of your missiles and sink the cargo ship you will avoid it mooring and thus spreading the virus. You will kill the captain and seaman, but you will save the fishermen.

Do you launch on of your missiles and sink the cargo ship, so the fishermen won't be infected?

50)
You are in charge of the Maritime Police. You have received a message that the captain and a seaman of a cargo ship are healthy carriers of a lethal and contagious virus. They do not know that they are infected, and are travelling towards a small gulf where fishermen live. The communications system of the cargo ship is not working and, therefore, they cannot be contacted.

If you signal the cargo ship to the Aviation they will sink it so you will avoid it mooring and thus spreading the virus. This will kill the captain and seaman, but it will save the fishermen.

Do you signal the cargo ship to the Aviation making it be sunk, so the fishermen won't be infected?

51)
You are in the office of your bank together with four other people. Suddenly, the director calls you because he has discovered a bomb in in the vault, where there is a client. He knows you are a bomb disposal expert and asks you to defuse it. You realize immediately that there is not enough time defuse the bomb or to evacuate the people in the bank before the bomb explodes.

If you manually close the vault's door, the explosion will be isolated in the vault, but the client won't have enough time to go out. You will kill the client, but you will save yourself and the other four people in the bank.

Do you manually close the vault's door, where there is the client, make the explosion be isolated inside the vault, so it won't reach you and the other four people?

52)
You are in the office of your bank together with four other people. Suddenly, the director calls you because he has discovered a bomb in in the vault, where there is a client. He knows you are a bomb disposal expert and asks you to defuse it. You realize immediately that there is not enough time defuse the bomb or to evacuate the people in the bank before the bomb explodes.

If you push the emergency button the vault's door will close and the explosion will be isolated in the vault. However,

the client won’t have enough time to go out. This will kill the client, but it will save yourself and the other four people in the bank.
Do you make the vault’s door close by pushing the emergency button, so the explosion won’t reach you and the other four people?

Appendix E

Italian version of the Moral dilemma set

1)
Tu e altre cinque persone siete intrappolati in un edificio in fiamme. C'è un'unica uscita di emergenza da cui potete tutti scappare ma è bloccata da detriti incendiati. Un'altra persona ferita sta attraversando un'apertura alla base della porta di uscita. Tu e le altre cinque persone dietro di te non avete tempo di fare la stessa cosa.

Se sblocchi il varco usando la persona ferita, sarete in grado di scappare. In questo modo sicuramente ucciderai il ferito, ma salverai te stesso e le altre cinque persone.

Usi la persona ferita per aprire il varco cosí che tu e le altre cinque persone possiate scappare?

2)
Tu e altre cinque persone siete intrappolati in un edificio in fiamme. C'è un'unica uscita di emergenza da cui potete scappare ma è bloccata da detriti incendiati. Un'altra persona ferita sta attraversando un'apertura alla base della porta di uscita. Tu e le altre cinque persone dietro di te non avete tempo di fare la stessa cosa.

Se attivi il sistema di emergenza questo rilascerà della schiuma, spegnendo l'incendio, ma la schiuma soffocherà la persona ferita. La persona ferita morirà, ma tu e le cinque persone dietro di te vi salverete.

Spegni l'incendio attivando il sistema di emergenza, cosa che farà soffocare la persona ferita, cosí che tu e le altre cinque persone possiate scappare?

3)
Dei soldati nemici hanno occupato il tuo villaggio e uccideranno tutti i civili sopra i due anni di età. Tu e dieci vicini siete nascosti in due stanze nel seminterrato di una grande casa. Puoi sentire le voci dei soldati alla ricerca di oggetti di valore. Il tuo neonato comincia a piangere forte. Il rumore del pianto attirerà l'attenzione dei soldati, che rispamieranno la vita del tuo neonato, ma uccideranno te e gli altri rifugiati in entrambe le stanze.

Se usi la mano per tappare la bocca al neonato, smorzerai il rumore del pianto, ma il tuo neonato non riuscirà a respirare. In questo modo lo ucciderai, ma salverai te stesso e gli altri dieci vicini.

Tappi la bocca al tuo neonato, cosa che lo lascerà senz'aria, per smorzare il rumore del suo pianto cosí che i soldati nemici non scoprano te e gli altri dieci rifugiati?

4)
Dei soldati nemici hanno occupato il tuo villaggio e uccideranno tutti i civili sopra i due anni di età. Tu e dieci vicini siete nascosti in due stanze nel seminterrato di una grande casa. Puoi

sentire le voci dei soldati alla ricerca di oggetti di valore. Il tuo neonato comincia a piangere forte. Il rumore del pianto attirerà l'attenzione dei soldati, che rispamieranno la vita del tuo neonato, ma uccideranno te e gli altri rifugiati in entrambe le stanze.

Se attivi una rumorosa caldaia, questa attutirà il rumore del pianto, ma renderà l'ambiente insopportabilmente caldo. Il calore sarà mortale per il tuo neonato, ma salverà te e i dieci vicini.

Smorzi il rumore del pianto attivando la rumorosa caldaia che asfissierà il tuo neonato, cosí che tu e i dieci vicini non veniate scoperti?

5)
Fai parte dell'equipaggio di un sottomarino che sta viaggiando sotto un grande iceberg. Un'esplosione ha ferito molti membri dell'equipaggio e sta facendo collassare l'unico passaggio tra la sezione superiore e inferiore. Tu e dieci sopravvissuti siete nella sezione superior senza ossigeno a sufficienza perché tutti raggiungiate la superficie. Un solo membro dell'equipaggio si trova privo di sensi nella sezione inferiore, dove c'è abbastanza ossigeno.

Se apri il portello di sicurezza l'ossigeno salirà. Tuttavia il portello cadrà sul membro dell'equipaggio nella sezione inferiore. Cosí facendo lo ucciderai, ma salverai te stesso e i dieci sopravvissuti.

Apri il portello di sicurezza, che cadrà sul membro dell'equipaggio nella sezione inferiore, cosí che tu e i dieci sopravvissuti abbiate ossigeno a sufficienza?

6)
Fai parte dell'equipaggio di un sottomarino che sta viaggiando sotto un grande iceberg. Un'esplosione ha ferito molti membri dell'equipaggio e sta facendo collassare l'unico passaggio tra la sezione superiore e inferiore. Tu e dieci sopravvissuti siete nella sezione superior senza ossigeno a sufficienza perché tutti raggiungiate la superficie. Un solo membro dell'equipaggio si trova privo di sensi nella sezione inferiore, dove c'è abbastanza ossigeno.

Se premi un pulsante, il portello di sicurezza si aprirá e farà salire l'ossigeno. Tuttavia, il portello cadrà sul collega nella sezione inferiore uccidendolo, ma questo salverá te e i dieci sopravvissuti.

Premi il pulsante, che fará cadere il portello sul membro dell'equipaggio, cosí tu e i dieci sopravvissuti abbiate abbastanza ossigeno?

7)
Tu e altri dieci sommozzatori delle Nazioni Unite disattivate mine navali della IIa Guerra Mondiale. Un sommozzatore si è ferito e il sangue nell'acqua ha attirato molti squali. Hai un fucile subacqueo con un solo arpione. Il sommozzatore insanguinato sta nuotando verso l'ultima gabbia di protezione e la raggiungerà prima di te e degli altri. Gli squali, seguendo il sangue, si avvicineranno troppo perchè tu e gli altri sommozzatori possiate scappare.

Se spari al sommozzatore ferito lo ucciderai e gli squali si fermeranno per mangiare lui, ma salverai te stesso e i dieci sommozzatori.

Spari al sommozzatore ferito, lasciando che gli squali si fermino a mangiarlo, cosí che tu e i dieci subacquei possiate raggiungere la gabbia di protezione?

8)
Tu e altri dieci sommozzatori delle Nazioni Unite disattivate mine navali della IIa Guerra Mondiale. Un sommozzatore si è ferito e il sangue nell'acqua ha attirato molti squali. Hai un fucile subacqueo con un solo arpione. Il sommozzatore insanguinato sta nuotando verso l'ultima gabbia di protezione e la raggiungerà prima di te e degli altri. Gli squali, seguendo il sangue, si avvicineranno troppo perchè tu e gli altri sommozzatori possiate scappare.

Se fai detonare una delle mine con un telecomando a distanza, questa ucciderà il sommozzatore ferito e gli squali si fermeranno per mangiare lui. Tu e i dieci sommozzatori vi salverete.

Lasci che gli squali mangino il sommozzatore ferito facendo detonare una delle mine, cosí che tu e gli altri dieci sommozzatori possiate raggiungere la gabbia di protezione?

9)
Lavori in un orfanotrofio che accoglie dieci bambini in un paese in guerra. I soldati ribelli hanno sostituito il governo e stanno uccidendo tutti coloro che non appoggiano il regime. Stanno inoltre facendo una campagna di pulizia etnica contro un particolare gruppo. Tu e i dieci bambini non appoggiate i ribelli e nel tuo orfanotrofio c'è un bambino di questo gruppo etnico. Non avete modo di sfuggire.

Se soffochi il bambino del gruppo etnico perseguitato con un cuscino mentre dorme, i soldati crederanno che tu sostieni il loro regime. In questo modo ucciderai il bambino, ma salverai te stesso e i restanti dieci bambini.

Soffochi il bambino facendo credere ai soldati che appoggi il loro regime, cosí che risparmino la vita a te e agli altri dieci bambini?

10)
Lavori insieme ad un'infermiera in un orfanotrofio che accoglie dieci bambini in un paese in guerra. I soldati ribelli hanno sostituito il governo e stanno uccidendo tutti coloro che non appoggiano il regime. Stanno inoltre facendo una campagna di pulizia etnica contro un particolare gruppo. Tu e i dieci bambini non appoggiate i ribelli e nel tuo orfanotrofio c'è un bambino di questo gruppo etnico. Non avete modo di sfuggire.

Se ordini all'infermiera di dare al bambino del gruppo etnico perseguitato una dose letale di sonnifero, i soldati crederanno che tu sostieni il loro regime. Questo ucciderà il bambino, ma salverá te l'infermiera e gli altri dieci bambini.

Fai credere ai soldati che appoggi il regime ordinando all'infermiera di dare una overdose di sonnifero al bambino, cosí che risparmino la vita a te e agli altri dieci bambini?

11)
Sei un volontario dei Corpi di Pace in un villaggio rurale dell'Africa. Un uomo di un villaggio vicino è stato infettato dal colera, un batterio estremamente contagioso e quasi sempre mortale. Lui è ancora vivo, indicando che deve essere immune. L'uomo ritiene erroneamente

che il tuo centro medico possa curare completamente la sua malattia. Lo vedi avvicinarsi al villaggio e sai che se entra contagerà 100 persone innocenti, che a differenza sua, moriranno.

Se gli spari con la pistola del centro medico, gli impedirai di diffondere il batterio a te e al resto del villaggio. In questo modo lo ucciderai ma salverai te e i 100 abitanti del villaggio.

Spari all'uomo impedendogli di entrare nel villaggio, cosí che non contagi te e i 100 abitanti?

12)
Sei un volontario dei Corpi di Pace in un villaggio rurale dell'Africa. Un uomo di un villaggio vicino è stato infettato dal colera, un batterio estremaente contagioso e quasi sempre mortale. Lui è ancora vivo, indicando che deve essere immune. L'uomo ritiene erroneamente che il tuo centro medico possa curare completamente la sua malattia. Lo vedi avvicinarsi al villaggio e sai che se entra contagerà 100 persone innocenti, che a differenza sua, moriranno.

Se avverti il consiglio del villaggio questi gli spareranno e gli impediranno di contagiare te e e il resto del villaggio. Questo lo ucciderà, ma salverà te e i 100 abitanti del villaggio.

Impedisci all'uomo di entrare nel villaggio avvertendo il consiglio del villaggio che gli sparerà, così che non contagi te e i 100 abitanti?

13)
Sei l'unico medico in un elicottero di soccorso durante una devastante alluvione. Hai salvato otto feriti in condizioni critiche e li stai mantenendo in vita. Improvvisamente, il pilota ti avvisa che c'è un guasto al motore e ordina che l'elicottero debba perdere peso altrimenti precipiterà e morirete tutti. Non puoi abbandonare l'elicottero perchè le persone ferite hanno bisogno del tuo aiuto e le pesanti attrezzature mediche sono fissate alla parete.

Se lanci uno dei feriti, ridurrai il peso a sufficienza da mantenere l'elicottero in aria. In questo modo ucciderai quell'uomo, ma salverai te stesso e le altre persone a bordo.

Lanci uno dei feriti fuori dall'elicottero per ridurne il peso, cosí che tu e le altre otto persone a bordo non precipitiate?

14)
Sei l'unico medico in un elicottero di soccorso durante una devastante alluvione. Hai salvato otto feriti in condizioni critiche e li stai mantenendo in vita. Improvvisamente, il pilota ti avvisa che c'è un guasto al motore e ordina che l'elicottero debba perdere peso altrimenti altrimenti precipiterà e morirete tutti. Non puoi abbandonare l'elicottero perchè le persone ferite hanno bisogno del tuo aiuto e le pesanti attrezzature mediche sono fissate alla parete.

Se ordini al pilota di rilasciare il cavo con cui l'ultima persona salvata sta salendo, ridurrai il peso a sufficienza da mantenere l'elicottero in aria. Questo ucciderà quella persona, ma salverà te e le altre otto persone a bordo.

Riduci il peso del carico ordinando al pilota di rilasciare il cavo con cui l'ultima persona sta salendo, cosí che tu e le altre otto persone a bordo non precipitiate?

15)

Sei un ingegnere della Stazione Spaziale Internazionale. Un incendio scoppia nella stiva. Il sistema antincendio puó automaticamente aprire la porta esterna della stiva per far fuoriuscire l'ossigeno e spegnere l'incendio. Il sistema si attiva solo se la porta interna è sigillata, ma un un meccanico è rimasto nella stiva. Non ha tempo di togliersi l'ingombrante tuta spaziale e quando attraverserà la porta interna rimarrà bloccato, e l'incendio divamperà uccidendo tutti.

Se chiudi manualmente la porta interna, il sistema antincendio si attiverà. In questo modo ucciderai il meccanico, che verrà risucchiato nello spazio, ma salverai te e gli altri dieci astronauti.

Chiudi manualmente la porta interna, facendo risucchiare il meccanico nello spazio, cosí che il fuoco non raggiunga te e i dieci astronauti?

16)

Sei un ingegnere della Stazione Spaziale Internazionale. Un incendio scoppia nella stiva. Il sistema antincendio puó automaticamente aprire la porta esterna della stiva per far fuoriuscire l'ossigeno e spegnere l'incendio. Il sistema si attiva solo se la porta interna è sigillata, ma un un meccanico è rimasto nella stiva. Non ha tempo di togliersi l'ingombrante tuta spaziale e quando attraverserà la porta interna rimarrà bloccato, e l'incendio divamperà uccidendo tutti.

Se premi un pulsante di emergenza, il portellone si chiuderà, attivando il sistema antincendio. Cosí facendo il meccanico morirà risucchiato nello spazio, ma tu e gli altri dieci astronauti vi salverete.

Spegni l'incendio premendo il pulsante che sigilla la porta interna, facendo risucchiare il meccanico nello spazio, così che il fuoco non raggiunga te e i dieci astronauti?

17)

Sei l'ispettore di una centrale nucleare. Tu e il direttore state visitando l'impianto quando uno dei condotti di alimentazione si surriscalda. Il sistema di raffreddamento di emergenza non riesce ad attivarsi e sta per iniziare una reazione a catena con conseguente fusione nucleare che rilascerà radiazioni letali nella città vicina, uccidendo migliaia di persone.

Se spingi il direttore nel condotto, il suo corpo diffonderà abbastanza calore da prevenire la reazione a catena. In questo modo lo ucciderai ma salverai te e le migliaia di abitanti della città.

Spingi il direttore nel condotto di alimentazione raffreddandolo a sufficienza, cosí che la reazione a catena si interrompa in tempo per salvare te e le migliaia di abitanti?

18)

Sei l'ispettore di una centrale nucleare. Tu e il direttore state visitando l'impianto quando uno dei condotti di alimentazione si surriscalda. Il sistema di raffreddamento di emergenza non riesce ad attivarsi e sta per iniziare una reazione a catena con conseguente fusione nucleare che rilascerà radiazioni letali nella città vicina, uccidendo migliaia di persone.

Se inserisci manualmente dell'azoto liquido nella camera di alimentazione questo ridurrá la temperatura cosí da prevenire la reazione a catena. Questo ucciderà uno dei dipendenti che si trova intrappolato nel condotto, ma salverà te e le migliaia di abitanti della città.

Inserisci l'azoto liquido nel condotto, dove uno dei dipendenti è intrappolato, cosí che la reazione a catena venga fermata in tempo per salvare te e le migliaia di abitanti?

19)
Sei un esperto di esplosivi per una compagnia incaricata di demolire un grattacielo. Stai esaminando l'ultima carica esplosiva quando vedi un ragazzo che sta per far esplodere accidentalmente una delle cariche. L'esplosione provocherà il crollo incontrollato dell'edificio sopra di te, il ragazzo e sulla folla di spettatori. Il ragazzo si trova diversi piani sotto di te e non può sentirti.

Se lasci cadere un blocco di cemento sopra la testa del ragazzo lo ucciderai, ma sventerai l'esplosione e salverai la vita a te e alla folla.

Fai cadere un blocco di cemento sulla testa del ragazzo fermandolo, cosí che l'edificio non collassi su di te e sulla folla di spettatori?

20)
Sei un esperto di esplosivi per una compagnia incaricata di demolire un grattacielo. Stai esaminando l'ultima carica esplosiva quando vedi un ragazzo che sta per far esplodere accidentalmente una delle cariche. L'esplosione provocherà il crollo incontrollato dell'edificio sopra di te, il ragazzo e su una folla di spettatori. Il ragazzo si trova diversi piani sotto di te e non può sentirti.

Se riattivi la corrente nell'edificio, il ragazzo riceverà uno shock elettrico perchè sta toccando un filo scoperto. Questo lo ucciderà, ma salverà te e la folla impedendo l'esplosione.

Fermi il ragazzo riattivando la corrente dell'edificio, cosí che l'edificio non collassi su di te e sulla folla di spettatori?

21)
Sei un muratore e stai lavorando con la tua squadra sui ponteggi di un grattacielo. Improvvisamente, il ponteggio crolla parzialmente. Tu e molti altri siete appesi ad una traversa che pende e che non può reggere il peso di tutti. Uno dei lavoratori vicino a te perde la presa sulla traversa e afferra il tuo braccio libero. Tuttavia, ti rendi conto che la struttura sta per cadere.

Se colpisci il tuo collega fino a quando cade, riduci il peso sulla traversa permettendo a tutti di mettersi in salvo. In questo modo ucciderai il tuo collega ma salverai te e gli altri.

Colpisci il tuo collega fino a che non lascia il tuo braccio e cade riducendo il peso sulla traversa, cosí che tu e gli altri possiate restare appesi alla struttura?

22)
Sei un muratore e stai lavorando con la tua squadra sui ponteggi di un grattacielo. Improvvisamente, il ponteggio crolla parzialmente. Tu e molti altri siete appesi ad una traversa che pende e che non può reggere il peso di tutti. Uno dei lavoratori vicino a te perde

la presa sulla traversa e afferra un altro pezzo del ponteggio. Tuttavia, ti rendi conto che la struttura sta per cadere.

Se rimuovi il perno che tiene agganciato il pezzo del ponteggio a cui il tuo collega è appeso, questo ridurrà il peso sulla struttura. Questo lo ucciderà, ma salverà te e gli altri.

Riduci il peso sulla traversa rimuovendo il perno e facendo cadere il tuo collega, cosí che tu e gli altri possiate restare appesi alla struttura?

23)
Sei l'autista di un bus che accompagna bambini dell'asilo allo zoo. Lungo la strada i pneumatici difettosi fanno precipitare il bus in un fiume in piena. Tu e tre bambini siete nel bus che sta affondando, mentre gli altri sono già stati portati via dalla corrente. Afferri i due bambini vicino a te e inizi a nuotare verso l'uscita; il terzo bambino si aggrappa alla tua gamba. Non sei abbastanza forte per contrastare la corrente e nuotare con tutti e i tre bambini.

Se ti liberi del terzo bambino potrai nuotare contro corrente, ma il bambino lasciato indietro annegherà. In questo modo lo ucciderai, ma salverai te e gli altri due bambini.

Ti liberi del terzo bambino, che affogherà cosí che tu e gli altri due bambini possiate raggiungere la riva contrastando la corrente?

24)
Sei l'autista di un bus che accompagna bambini dell'asilo allo zoo. Lungo la strada i pneumatici difettosi fanno precipitare il bus in un fiume in piena. Tu e tre bambini siete nel bus che sta affondando, mentre gli altri sono giá stati portati via dalla corrente. Afferri i due bambini vicino a te e inizi a nuotare verso l'uscita, ma i sedili ingombranti la bloccano.

Se togli i sedili potrai liberare la via di fuga, ma bloccherai il corridoio e il terzo bambino rimarrà intrappolato, cosa che lo fará annegare. Questo lo ucciderà, ma salverà te e gli altri due bambini.

Liberi la via di fuga togliendo i sedili nel corridoio lasciando intrappolato il terzo bambino, cosí che tu e gli altri due bambini possiate raggiungere la superficie?

25)
Sei un medico e hai cinque pazienti che moriranno se non avranno un tempestivo trapianto di organi. Un altro paziente vittima di un grave incidente stradale è traspostato d'urgenza all'ospedale. Questa persona è gravemente ferita, ma probabilmente puoi salvarla con un lungo e complicato intervento chirurgico.

Se di nascosto tagli la sua corotide durante l'intervento, lo ucciderai, ma avrai gli organi per salvare gli altri cinque pazienti. .

Tagli la carotide della vittima dell'incidente ottenendo gli organi che ti servono, cosí da poter effettuare il trapianto sugli altri cinque pazienti?

26)
Sei un medico e hai cinque pazienti che moriranno se non avranno un tempestivo trapianto di organi. Un altro paziente vittima di un grave incidente stradale è trasportato d'urgenza

all'ospedale. Durante un lungo e complicato intervento chirurgico ti accorgi che l'infermiera sta per iniettargli un medicinale sbagliato che in questo caso sarebbe letale.

Se lasci che l'infermiera inietti il medicinale sbagliato, il paziente vittima dell'incidente morirà e tu avrai gli organi necessari per salvare gli altri cinque pazienti.

Ottieni gli organi che ti servono lasciando che l'infermiera inietti al paziente il medicinale sbagliato cosí che tu possa effettuare il trapianto di organi sugli altri cinque pazienti?

27)

Lavori al porto di un cantiere navale e ti occupi di collegare i cavi delle gru ai container per scaricarli dalle navi mercantili. Tu e i tuoi colleghi vi state arrampicando per verificare che lo scarico avvenga correttamente. Ti accorgi che il cavo della gru si sta per spezzare. Vedi che il problema nasce da un litigio tra due membri dell'equipaggio. Il container sta pericolosamente ondeggiando sopra altri cinque operai dell'equipaggio che si trovano sul ponte.

Se separi i due membri dell'equipaggio che stanno litigando eviterai che il container cada sugli altri. Tuttavia, uno dei due non indossa l'imbragatura di sicurezza. Spingendolo lo ucciderai, ma salverai i cinque membri sul ponte.

Separi i due membri dell'equipaggio, cosa che causerà la caduta di quello senza imbragatura, fermando l'ondeggiare del container cosí che questo non cada sopra i cinque sul ponte?

28)

Lavori al porto di un cantiere navale e ti occupi di collegare i cavi delle gru ai container per scaricarli dalle navi mercantili. Tu e I tuoi colleghi vi state arrampicando per verificare che lo scarico avvenga correttamente. Ti accorgi che il cavo della gru si sta per spezzare. Vedi che il problema nasce da un litigio tra due membri dell'equipaggio. Il container sta pericolosamente ondeggiando sopra altri cinque operai dell'equipaggio che si trovano sul ponte

Se premi un pulsante il container verrà rilasciato sul mercantile, dove un membro dell'equipaggio sta ancora lavorando. Questo lo ucciderà ma salverà la vita dei cinque sul ponte.

Premi il pulsante per rilasciare il container, che cadrá sul membro dell'equipaggio sul mercantile, cosí che il container non cada sopra i cinque sul ponte?

29)

Un'epidemia si è diffusa in tutto il pianeta uccidendo migliaia di persone. Sei un medico ricercatore e hai sviluppato due sostanze in laboratorio. Per errore entrambe sono state etichettate come vaccino. Una è di certo un vaccino, che permetterebbe di salvare milioni di vite. L'altra è una sostanza letale. Non hai molto tempo per individuare qual è il vaccino.

Se inietti le sostanze ai tuoi due assistenti di laboratorio, gli unici due soggetti testabili, sarai in grado di identificare il vaccino. In questo modo ucciderai uno dei tuoi due assistenti ma salverai migliaia di vite.

Inietti le sostanze ai tuoi due assistenti, uccidendo uno dei due per indentificare il vaccino in modo che migliaia di persone possano essere immunizzate?

30)
Un'epidemia si è diffusa in tutto il pianeta uccidendo migliaia di persone. Sei un medico ricercatore e hai sviluppato due sostanze in laboratorio. Per errore entrambe sono state etichettate come vaccino. Una è di certo un vaccino, che permetterebbe di salvare milioni di vite. L'altra è una sostanza letale. Non hai molto tempo per individuare qual è il vaccino.

Se permetti all'infermiera di iniettare le sostanze a due pazienti, gli unici due soggetti testabili, sarai in grado di identificare il vaccino. Uno dei pazienti morirà, ma migliaia di vite verranno salvate.

Identifichi il vaccino permettendo all'infermiera di iniettare le due sostanze a due pazienti, uccidendo uno dei due, così che migliaia di persone potranno essere vaccinate?

31)
Un tram fuori controllo sta correndo a forte velocità sui binari verso cinque operai che moriranno se il tram continua la sua corsa. Sei vicino ai binari, ma troppo lontano per avvertirli. Vicino a te c'è uno sconosciuto di stazza imponente.

Se spingi lo sconosciuto sui binari il tram deraglierà e non investirà i cinque operai. In questo modo ucciderai lo sconosciuto, ma salverai i cinque operai.

Spingi lo sconosciuto sui binari facendo deragliare il tram così che il tram non investa i cinque operai?

32)
Un tram fuori controllo sta correndo a forte velocità sui binari verso cinque operai che moriranno se il tram continua la sua corsa. Sei vicino ai binari, ma troppo lontano per avvertirli. Accanto a te c'è una leva che può reindirizzare il tram su un altro binario dove c'è un solo operaio al lavoro.

Se azioni una leva, il tram verrà indirizzato sul binario dove c'è un operaio ma non investirà i cinque operai. Questo ucciderà un operaio, ma salverà gli altri cinque.

Fai cambiare la direzione del tram azionando la leva, che causerà la morte di un operaio, così che il tram non investa i cinque operai?

33)
Tu e un tuo collega ricercatore avete scoperto una nuova fonte di energia che è economica, sicura e pulita. Ha il potenziale di porre fine all'inquinamento e alla povertà nel mondo. Tuttavia il tuo collega vuole vendere la scoperta e sai che sta pianificando di contattare i potenziali clienti oggi stesso. Sai che sicuramente cercheranno di usare questa tecnica come un'arma mortale, ma il tuo collega non vuole crederti.

Se avveleni il tuo collega con una sostanza facilmente accessibile nel tuo laboratorio, impedirai che la vostra scoperta cada nelle mani sbagliate. In questo modo ucciderai il tuo collega, ma salverai migliaia di persone.

Avveleni il tuo collega impedendo la vendita della tua scoperta, così che la vostra tecnica non venga usata come un'arma contro migliaia di persone?

34)
Tu e un tuo collega ricercatore avete scoperto una nuova fonte di energia che è economica, sicura e pulita. Ha il potenziale di porre fine all'inquinamento e alla povertà nel mondo. Tuttavia il tuo collega vuole vendere la scoperta e sai che sta pianificando di contattare i potenziali clienti oggi stesso. Sai che sicuramente cercheranno di usare questa tecnica come un'arma mortale ma il tuo collega non vuole crederti.

Se rilasci del gas infiammabile in laboratorio ci sarà un'esplosione nel momento in cui il tuo collega accenderà il suo computer. Questo lo ucciderà, ma salverà migliaia di persone impedendo che la vostra scoperta arriva in mani sbagliate.

Rilasci del gas, che farà esplodere il computer del tuo college uccidendolo, così che la vostra tecnica non venga usata come un arma contro migliaia di persone?

35)
Sei un motociclista esperto e stai partecipando ad un evento. Mentre stai guidando di fronte ad un gruppo di dieci motociclisti vedi che un motociclista davanti a te che ha perso il controllo della sua moto. Mentre acceleri per avvicinarti al suo fianco ti accorgi che si schianterà da un momento all'altro. Questo provocherà un grande tamponamento a catena e il gruppo di motociclisti dietro di voi morirà.

Se spingi il motociclista fuori strada si schianterà sugli alberi ma eviterai il tamponamento a catena. Alla velocità in cui sta andando lo ucciderai, ma salverai il gruppo dei dieci motociclisti.

Spingi il motociclista fuori strada evitando il tamponamento a catena, così che il gruppo di dieci motociclisti non si schianti?

36)
Sei un motociclista esperto e stai partecipando ad un evento. Mentre stai guidando di fronte ad un gruppo di dieci motociclisti vedi che un motociclista di fronte a te ha perso il controllo della sua moto e sta cadendo. Tu puoi facilmente evitarlo ma i motociclisti dietro di te andranno a schiantarsi uno sull'altro e moriranno.

Se lasci che la tua moto investa il motociclista caduto mentre salti nel fosso, riuscirai ad avvisare gli altri in tempo. Questo ucciderà il motociclista caduto, ma salverà gli altri dieci.

Avvisi gli altri dell'imminente incidente lasciando che la tua moto colpisca il motociclista caduto, così che gli altri dieci avranno abbastanza tempo per scavalcarlo?

37)
Sei il capo di un gruppo di soldati che sta tornando da una missione in territorio nemico. Uno dei tuoi uomini mette il piede in una trappola, ferendosi. Non puoi liberarlo senza ucciderlo, ma se lo abbandoni le truppe nemiche lo tortureranno finchè non rivelerà la posizione di un accampamento alleato con un plotone di dieci soldati. Il soldato ti prega di non lasciarlo solo ma i nemici si stanno avvicinando e non potete restare perchè avete finito le munizioni.
Se pugnali il soldato questo impedirà che venga torturato e che riveli l'informazione che porterà alla morte del plotone alleato. In questo modo lo ucciderai ma salverai i dieci soldati del plotone.

Pugnali a morte il soldato intrappolato evitando che venga torturato, cosí che non riveli la posizione dei dieci membri delle truppe alleate?

38)
Sei il capo di un gruppo di soldati che sta tornando da una missione in territorio nemico. Uno dei tuoi uomini mette il piede in una trappola, ferendosi. Non puoi liberarlo senza ucciderlo, ma se lo abbandoni le truppe nemiche lo tortureranno finchè non rivelerà la posizione di un accampamento alleato con un plotone di dieci soldati. Il soldato ti prega di non lasciarlo solo ma i nemici si stanno avvicinando e non potete restare perchè avete finito le munizioni.

Se indichi la posizione del soldato con un razzo di segnalazione quell'area verrà bombardata. Eviterai così che il soldato venga torturato e che riveli l'informazione che porterà alla morte del plotone alleato. Questo lo ucciderà ma i dieci soldati del plotone alleato si salveranno.

Eviti che il soldato intrappolato venga torturato ordinando il bombardamento di quella regione, cosí che non riveli la posizione del plotone alleato?

39)
Sei di guardia in un ospedale durante il turno di notte. Scopri che c'è una fuoriuscita di sostanze chimiche da una grande crepa nel condotto di areazione in una stanza con sei pazienti. Questa sostanza è altamente tossica e ucciderà tutti i pazienti nella stanza. Non hai molto tempo per evacuare tutti i pazienti.

Se muovi il letto del paziente vicino davanti alla crepa, fermerai la fuoriuscita e potrai far uscire gli altri pazienti. In questo modo ucciderai quel paziente, ma salverai la vita degli altri cinque pazienti della stanza.

Muovi il letto di uno dei pazienti di fronte alla crepa cosí che gli altri cinque pazienti possano essere evacuati?

40)
Sei di guardia in un ospedale durante il turno di notte. Scopri che c'è una fuoriuscita di sostanze chimiche da una grande crepa nel condotto di areazione in una stanza con sei pazienti. Questa sostanza è altamente tossica e ucciderà tutti i pazienti nella stanza. Non hai molto tempo per evacuare tutti i pazienti.

Se attivi il sistema di ventilazione il gas velenoso sarà risucchiato fuori dalla stanza. Tuttavia sarà trasferito in una stanza al piano superiore dove c'è un altro paziente, che non riuscirà ad andarsene in tempo. Questo ucciderà quel paziente, ma salverà la vita degli altri cinque.

Fai deviare il gas fuori dalla camera dei cinque pazienti, causando il trasferimento del gas nella stanza con un paziente, cosí che i cinque pazienti non vengano avvelenati?

41)
Sei in una barca a remi su un lago in Alaska con una guida. Nelle vicinanze tre bambini sono caduti dalla loro barca e ora rischiano di morire di freddo. Hai salvato i tre bambini, ma uno di loro è molto pesante e realizzi che se lo tieni a bordo, la tua barca affonderà e tutti voi morirete. Nè tu nè la guida potete lasciare la barca perchè tu stai remando e la guida sta rianimando uno dei bambini.

Se butti il bambino pesante fuori bordo sarai in grado di raggiungere la riva. Così facendo ucciderai quel bambino, ma salverai gli altri due bambini.
Butti il bambino pesante in acqua per disfarti del suo peso, cosí da poter raggiungere la riva con gli altri due bambini?

42)
Sei in una barca a remi su un lago in Alaska con una guida. Nelle vicinanze tre bambini sono caduti dalla loro barca e ora rischiano di morire di freddo. Hai salvato due dei trebambini, ma l'ultimo è molto pesante e realizzi che se lo porti a bordo, la tua barca affonderà e tutti voi morirete. Nè tu nè la guida potete lasciare la barca perchè tu stai remando e la guida sta rianimando uno dei bambini.
Se remi verso la riva lasciando il terzo bambino in acqua eviterai che la vostra barca affondi. Questo ucciderà il bambino lasciato indietro, ma salverai gli altri due.
Eviti che la barca affondi lasciando in acqua il terzo bambino, cosa che lo farà morire, così che tu possa raggiungere la riva con gli altri due?

43)
Sei un minatore. L'unica via d'uscita dalla miniera è usare una funivia. Il turno è finito e tutti stanno risalendo in superficie con le cabine. Mentre sei in fila, vedi che il cavo che regge le cabine è sul punto di cedere. Al momento, ci sono dieci minatori dentro alle cabine.
Se spingi con forza l'ultima cabina il minatore al suo interno cadrà. In questo modo ridurrai a sufficienza il peso da permettere al cavo di resistere. Ucciderai il minatore nella cabina che hai spinto, ma salverai gli altri dieci.
Spingi l'ultima cabina con un solo minatore per ridurre il peso sul cavo, cosí che gli altri minatori possano raggiungere l'uscita?

44)
Sei un minatore. L'unica via d'uscita dalla miniera è usare una funivia. Il turno è finito e tutti stanno risalendo in superficie con le cabine. Mentre sei in fila, vedi che il cavo che regge le cabine è sul punto di cedere. Al momento, ci sono dieci minatori dentro alle cabine.
Se premi un interruttore di emergenza l'ultima cabina verrà staccata dal cavo. Questo consentirà di ridurre il peso a sufficienza da permettere al cavo di resistere. Questo ucciderà il minatore nella cabina che hai staccato, ma salverà gli altri dieci.
Riduci il peso sul cavo premendo l'interruttore che stacca l'ultima cabina, in modo da permettere agli altri minatori di raggiungere l'uscita?

45)
Sei un elettricista assunto per risolvere un problema elettrico nella casa di un ricco magnate malato terminale di cancro. Di recente l'uomo ha annunciato che dopo la sua morte la sua enorme fortuna sarà devoluta all'ospedale pediatrico locale. Sai che ci sono 100 bambini in questo ospedale che potrebbero essere salvati da questi soldi, ma che non possono aspettare ancora a lungo prima di morire.

Se soffochi il magnate mentre dorme coprendogli il naso e la bocca con le mani guantate, questa donazione essenziale per i bambini arriverà in tempo. In questo modo ucciderai il magnate, ma salverai le vite dei 100 bambini.

Soffochi l'uomo anticipando la donazione, cosí che arrivi in tempo per salvare i 100 bambini malati?

46)
Sei un elettricista assunto per risolvere un problema elettrico nella casa di un ricco magnate malato terminale di cancro. Di recente l'uomo ha annunciato che dopo la sua morte la sua enorme fortuna sarà devoluta all'ospedale pediatrico locale. Sai che ci sono 100 bambini in questo ospedale che potrebbero essere salvati da questi soldi, ma che non possono aspettare ancora a lungo prima di morire.

Se mandi il sistema elettrico in corto circuito, le apparecchiature che tengono in vita il magnate smetteranno di funzionare e l'essenziale donazione per i bambini arriverà in tempo. Questo ucciderà il magnate, ma salverà la vita di 100 bambini.

Anticipi la donazione provocando il guasto delle apparecchiature che tengono in vita il magnate in modo che la donazione arrivi in tempo ai 100 bambini malati?

47)
Sei un ufficiale dell'esercito in guerra. I tuoi soldati hanno trovato una spia nemica intrappolata e ferita in un edificio diroccato. Sei stato informato che i nemici stanno progettando un attacco a sorpresa su una città vicina. Uccideranno migliaia di civili e la spia è a conoscenza di quale sarà la città attaccata. Hai interrogato l'uomo ma non vuole darti questa informazione e sai che non sopravviverà a lungo a causa delle sue ferite.

Se torturi la spia, questa ti rivelerà il nome della città. In questo modo lo ucciderai, ma potrai salvare migliaia di civili.

Torturi la spia per estorcerle il nome della città, cosí da poter prevenire l'attacco su migliaia di civili?

48)
Sei un ufficiale dell'esercito in guerra. I tuoi soldati hanno trovato una spia nemica intrappolata e ferita in un edificio diroccato. Sei stato informato che i nemici stanno progettando un attacco a sorpresa su una città vicina. Uccideranno migliaia di civili e la spia è a conoscenza di quale sarà la città attaccata. Hai interrogato l'uomo ma non vuole darti questa informazione e sai che non sopravviverà a lungo a causa delle sue ferite.

Se lasci entrare dei ratti nella sua cella, questi gli morderanno le gambe finchè non rivelerà il nome della città. Questo lo ucciderà, ma salverà migliaia di civili.

Estorci l'informazione alla spia lasciando che i ratti entrino nella cella, così da poter prevenire l'attacco su migliaia di civili?

49)
Sei al comando della Polizia Marittima. Vieni informato che il capitano e il marinaio di una nave cargo sono portatori sani di un virus letale e contagioso. Non sanno che sono stati infettati e stanno viaggiando verso un golfo dove vivono dei pescatori. Il sistema di comunicazione della nave cargo non funziona e quindi non puoi contattarli.

Se lanci un missile a tua disposizione sulla nave cargo eviterai che questa attracchi e che i due uomini diffondano il virus. In questo modo ucciderai il capitano e il marinaio ma salverai i pescatori.

Lanci un missile sulla nave cargo evitando che la nave attracchi, così da scongiurare che i pescatori vengano infettati?

50)
Sei al comando della Polizia Marittima. Vieni informato che il capitano e il marinaio di una nave cargo sono portatori sani di un virus letale e contagioso. Non sanno che sono stati infettati e stanno viaggiando verso un golfo dove vivono dei pescatori. Il sistema di comunicazione della nave cargo non funziona e quindi non puoi contattarli.

Se segnali la nave all'Aviazione, questa lancerà un missile sulla nave cargo evitando che attracchi e che i due uomini diffondano il virus. Questo ucciderà il capitano e il marinaio ma salverà i pescatori.
Segnali la nave all'Aviazione evitando che la nave attracchi, così da scongiurare che i pescatori vengano infettati?

51)
Ti trovi in un ufficio della tua banca insieme a quattro persone. Improvvisamente, il direttore ti chiama perché ha scoperto una bomba nel caveau della banca, dove in questo momento si trova un cliente. Il direttore sa che sei un artificiere e ti chiede di disinnescare la bomba. Realizzi subito che non c'è abbastanza tempo per disinnescare la bomba o evacuare la banca prima che la bomba esploda.

Se chiudi manualmente la porta blindata del caveau, l'esplosione resterà confinata al suo interno ma il cliente non farà in tempo ad uscire. In questo modo ucciderai il cliente ma salverai te stesso e le altre quattro persone nella banca.

Chiudi manualmente la porta del caveau confinando l'esplosione al suo interno, dove si trova il cliente, così che non colpisca te e le altre quattro persone?

52)
Ti trovi in un ufficio della tua banca insieme a quattro persone. Improvvisamente, il direttore ti chiama perché ha scoperto una bomba nel caveau della banca, dove in questo momento si trova un cliente. Il direttore sa che sei un artificiere e ti chiede di disinnescare la bomba. Realizzi subito che non c'è abbastanza tempo per disinnescare la bomba o evacuare la banca prima che la bomba esploda.

Se premi il pulsante di emergenza la porta blindata del caveau si chiuderà, l'esplosione resterà confinata al suo interno ma il cliente non farà in tempo ad uscire. Questo ucciderà il cliente ma salverà te stesso e le altre quattro persone nella banca.

Fai chiudere la porta del caveau dove si trova il cliente, premendo il pulsante di emergenza così che l'esplosione non colpisca te e le altre quattro persone?