Emotion

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Virtual Morality: Emotion and Action in a Simulated Three-Dimensional "Trolley Problem"

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Experimentally investigating the relationship between moral judgment and action is difficult when the action of interest entails harming others. We adopt a new approach to this problem by placing subjects in an immersive, virtual reality environment that simulates the classic "trolley problem." In this moral dilemma, the majority of research participants behaved as "moral utilitarians," either (a) acting to cause the death of one individual in order to save the lives of five others, or (b) abstaining from action, when that action would have caused five deaths versus one. Confirming the emotional distinction between moral actions and omissions, autonomic arousal was greater when the utilitarian outcome required action, and increased arousal was associated with a decreased likelihood of utilitarian-biased behavior. This pattern of results held across individuals of different gender, age, and race.

Keywords: morality, virtual reality, emotion, autonomic response, linguistic analogy

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We are continually bombarded with public policy questions that recruit both our emotions and our capacity for reasoning, including questions relevant to the tradeoffs in outcomes resulting from policies perceived as harmful to a few individuals for a greater societal good (e.g., stem cell research, progressive taxation, and killing during wartime). Although many of us have strong moral intuitions about such issues, most of us have never been required to act on them. This raises the question: is there a connection between our moral intuitions and our moral actions, and if so, what is the nature of this relationship? Here we describe an experiment that attempts to bridge the psychology of moral judgment and behavior in a domain that involves harm to human life. We use immersive virtual reality as a hybrid approach, as it presents a hypothetical moral dilemma but requires actual behavior as opposed to a mere declarative response.

Consider the following well-known philosophical thought experiment (Thomson, 1985): A runaway trolley is headed toward five people. In order to prevent their deaths, the trolley must be switched onto another track where it will kill one person. Are we morally obligated to pull the switch? If we acted along *utilitarian* considerations regarding the greatest good for the greatest number (Mill, 1863), pulling the switch is obligatory, as the death of one person is less harmful overall than the deaths of five people. Alternatively, acting in accordance with a deontological or rule-based perspective, one might call on a rule of "do no harm" and therefore decide against action (Broad, 1930). Studies using variants of this dilemma, conducted across a broad range of cultural and demographic samples, indicate that the vast majority of people agree that it is permissible to pull the switch, with as many as 90% endorsing this utilitarian outcome (Cushman, Young, & Hauser, 2006; Greene, Sommerville, Nystrom, Darley, & Cohen, 2001; Greene, Nystrom, Engell, Darley, & Cohen, 2004; Hauser, Cushman, Young, Jin, & Mikhail, 2007; Mikhail, 2007; Valdesolo & DeSteno, 2006). But if actually confronted with this dilemma—with the sights, sounds, and consequences of our actions thrown into stark relief—would most of us really be able overcome the emotion of the moment, and act in favor of our abstract utilitarian judgments to kill for the greater good?

The tension between how we judge and how we act in moral dilemmas is not trivial, as the processes involved in motivating behavior are often either irrelevant or significantly suppressed in the case of mere judgment. For example, most of us think it is morally permissible, perhaps even obligatory, to intervene to save a person who is being harmed or to donate funds to save victims of natural disasters. Yet many of us do not intervene when witnessing an assault and keep our money rather than donating it to charity, presumably because of differences in emotional significance, self-control, self-interest, and the actual as opposed to imagined reputational, legal, and physical costs of a given course of action (e.g., Rosenthal, 1964; Shotland & Straw, 1976; Chatzidakis, Hibbert, & Smith, 2006).

Behavioral studies that focus on moral action typically involve nonharmful actions, including the allocation of money in economic

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bargaining games (Camerer & Thaler, 1995; Güth & Tietz, 1990; Henrich et al., 2006; Roth, Prasnikar, Okuno–Fujiwara, & Zamir, 1991;Yamagishi, 1986), the willingness to transgress social norms in "broken window" studies (e.g., Kiezer, Lindenberg, & Steg, 2008) and the factors that affect wallet-returns (e.g., Diener, Westford, Fraser & Beaman, 1973). On the other hand, studies that specifically investigate the morality of harm are largely limited to nonbehavioral methods where moral dilemmas are solved by research participants as thought experiments using abstract, hypothetical cases (e.g., Greene et al., 2001; Greene et al., 2004; Graham, Nosek, & Haidt, 2009; Hauser et al., 2007). The present research seeks to address this gap by observing morally relevant behavior with potentially harmful consequences for virtual agents in an artificial, yet realistic three-dimensional (3-D) world.

Recent theoretical and empirical research suggest that emotions, and intuitive, unconscious processes more generally, may play critical roles in generating our moral judgments (e.g., Haidt, 2001), and that such affective states that lead to judgments may be studied, in real time, as research participants contemplate moral dilemmas (e.g., Greene et al., 2001). However, these kinds of studies are typically limited to the processes governing moral judgment and reasoning, which may have little to do with actual behavior. To be sure, there are a growing number of studies that explore the neurophysiology of the emotional states that affect behavior that could be described as "moral" actions (e.g., Sanfey, Rilling, Aronson, Nystrom, & Cohen, 2003), but we are not aware of studies that have explored such factors on explicit moral behavior, occurring in real time, with outcomes that can be described as physically harmful to another individual. The present research thus seeks to fill the gap in the empirical investigation of (a) the role of emotional arousal as it affects moral behavior, and (b) whether observed behavior is consistent with previous findings on moral judgments on hypothetical harmful actions. In doing so, we seek to bridge an understanding of the factors that connect moral judgments to moral actions. To do this, we have embarked on a research program with methods that include behavioral observations and the measurement of the autonomic arousal of research participants as they confront moral dilemmas in a highly realistic, 3-D virtual environment. We describe the findings of our first such study here. We see the primary contribution of this work as both showcasing a new method to explore the interface between hypothetical judgment and real world behavior, and as a contribution to understanding the psychology of judgment as opposed to action, particularly in domains of moral harm.

Experiments in "Virtual Reality"

Ethical concerns preclude the execution of experiments that subject research participants to contexts in which extreme harm to others could be realized. However, recent advances in immersive virtual environment technology allow for such studies to be conducted in artificial, yet realistic, 3-D digital worlds. Such "virtual reality" (VR) experiments reveal a high degree of congruence with behavior observed in typical laboratory settings, but with more experimental control (Blascovich et al., 2002; Gillath, McCall, Shaver, & Blascovich, 2008; McCall, Blascovich, Ariana, & Persky, 2009). For example, Slater and colleagues (2006) found that participants in a VR simulation of Milgram's classic obedience experiments performed almost exactly the way one would expect them to on the basis of the results of the original studies, delivering dangerous shocks to a virtual person following instructions from a virtual experimenter, and with autonomic responses that measured emotional arousal covarying with both the severity of the shock delivered and with proximity to the virtual subject. Likewise, Dotsch and Wigboldus (2008) found that implicit attitudes and autonomic arousal predicted participants' physical distance from an ethnic minority target in a virtual world, consistent with previous work linking nonconscious attitudes and anxiety to behavioral discrimination.

Such examples not only speak to the validity of the method, but also showcase how VR might serve as a conduit for drawing inferences about the relationships among attitudes, judgments, neurophysiology, and action sequences as they occur in behavioral experiments that are impossible to test ethically or practically in a "real" or *grounded* laboratory (Allen et al., 2009; Parsons & Rizzo, 2008; Talbot, Legge, Bulitko, & Spetch, 2009; Tippett et al., 2009). It is important that the properties of the sensory inputs shared by both kinds of environments can be made identical (or at least a close approximation), and that such inputs can have demonstrable, and often quite similar effects, on behavioral outcomes as they unfold in real time (Blascovich et al., 2002).

To be sure, it is worth clarifying that we do not claim that the actions conducted within VR are identical to those committed in the grounded world outside of the research lab, given that actions in the latter clearly have greater legal, reputational, physical, and long-term emotional consequences for the actors. However, we posit that this is an important feature of the method, and not a liability, as it provides an important intermediate step in investigating how the processes of judging and acting may be similar or different when otherwise intractable confounds are present or absent. This feature allows researchers to largely rule out the extent to which calculations of the consequences and repercussions of one's actions affect the outcomes and processes of moral behavior, as opposed to the more direct effects that sensory inputs alone may have in the immediate context. Our goal, therefore, is to use VR as a small step in forging a link between moral judgment and moral behavior involving otherwise intractable behavioral content (i.e., killing for the greater good), as it occurs in real time. In our study described below, we focus on the "trolley" problem given its rich philosophical and psychological history, and its importance for framing the mechanisms underlying our capacity to decide when harm is morally permissible.

The Present Research

Unlike previous studies that assessed moral intuitions in life-or-death situations as hypothetical cases (Greene et al., 2001; Hauser et al., 2007; Petrinovich & O'Neill, 1996), we exposed research participants to a 3-D version of the trolley problem in a virtual environment, giving them the opportunity to pull a lever (or not) in order to determine whether some number of people would die or be saved. The environment was complete with avatar-agents represented as human holograms—capable of movement and sound in real time, and whose fate was dependent on participants' behavior. In our simulation, we used a hologram of an unmanned, runaway boxcar, rather than the original trolley, so as to avoid the complication or assumption that trolleys carry people.

Within this environment, the boxcar was on a collision course with either one or five agents. The experiment was a between-subjects design such that participants could choose the utilitarian outcome in one of two ways, (a) pulling a switch to divert a boxcar headed toward five agents to one agent on a side track, or (b) abstaining from pulling a switch to leave the boxcar headed toward one agent while five were on a side track.

These two conditions therefore represent the distinction between moral actions versus omissions. There is a long-standing tension between philosophical perspectives on morality characterized as *utilitarian* versus *deontological*. Whereas judging harmful actions as worse than inaction that results in harm is irrational for a utilitarian interested primarily in the consequences of behavior (e.g., Mill, 1863), deontological ethics describe the distinction between doing and allowing as both logically and morally defensible, with decreased emphasis on consequences (e.g., Broad, 1930). Consistent with the deontological perspective, there is a large body of empirical research suggesting that people typically judge actions that result in harm as morally worse than omissions of actions that result in equivalent harm—or what is referred to as the *omission bias* (e.g., Baron & Ritov, 2004; Cushman et al., 2006; Hauser, Tonnaer, & Cima, 2009). Given these findings, it may be reasonably assumed that people will feel decreased feelings of culpability for harm caused to a third party by their own omission of action rather than harm caused by overt action. Consequently, when harm befalls a third party via inaction, people should be less likely to experience mental conflict and emotional arousal regarding the outcome, as compared with that found for situations where they had caused the harm by their own actions. As such, we predict that, among research participants in our VR experiment presented with a situation in which their decision results in one death and five saved, higher autonomic arousal will be observed when the utilitarian outcome requires action (action condition) than when it does not (omission condition). To be sure, in both conditions some level of arousal is expected from the anticipation of witnessing the death of another person, but in the action condition, this baseline arousal is expected to be augmented by the conflicting messages from the emotional versus "rational" parts of one's self.

Furthermore, previous research has indicated that the engagement of the emotional systems of the mind are associated with nondeliberative moral judgments, whereas utilitarian moral judgments are more likely to occur under controlled, reasoned, and less-emotional states (e.g., Greene, Sommerville, Nystrom, Darley, & Cohen, 2001). If such perspectives on moral judgment extend to informing expectation regarding morally relevant behavior, then one might expect emotional arousal to covary with whether one chooses a deontological outcome over a utilitarian one. Specifically, we expect that heightened arousal may be associated with an inability to kill for the greater good, as such heightened responses brought about by strong situations may be behaviorally debilitating when it comes to deliberate, utilitarian killing.

Finally, we were also interested in testing whether behavioral actions in our virtual environment were congruent with expectations from previous self-report research on moral judgment. In a large-scale survey of the trolley problem, approximately 90% of subjects judged that it was morally permissible to flip the switch, turning the boxcar onto a side path, killing one person but saving the five people on the main track (Hauser et al., 2007). If the psychological mechanisms that underpin such judgments were deployed in the context of action, then we would expect roughly the same percentage of participants in an immersive VR environment to act in the same utilitarian manner. Additionally, given that these studies typically do not find individual differences based on race or gender, we do not expect moderation by demographic variables.

Method

Participants

We tested 365 participants in an experiment described as "Attitudes and Action in a 3-D World." Observations from 25 participants were excluded because of technical problems, and 15 were removed because the participant did not finish the procedure due to discomfort or distress. An additional 32 observations were removed for participants whose autonomic responses failed to meet standard minimal response criteria for valid electrodermal activity. Data were analyzed for 161 women and 132 men between the ages of 18 and 29 ($M = 19.61$, $SD = 1.65$). Race composition was 88% White, 7% Black, and 5% non-White or those who decline to respond. Demographic variables were assessed in a posttest questionnaire.

Autonomic arousal. Autonomic arousal during the procedure was assessed via electrodermal activity recorded during each trial. Recording electrodes were attached to the second and fourth distal phalanges of participants' nondominant hand, and transmitted skin conductance responses to a Biopac MP150 Data Acquisition System. Minimum response criteria were 1 μS for tonic skin conductance level (SCL) and .02 μS for phasic skin conductance responses (SCR). SCL and SCR count was standardized within participants, and then combined to produce composite scores of autonomic arousal for each participant, where SCL and SCR counts were weighted equally ($M = .11$, $SD = .67$).

Procedure

In the grounded laboratory environment, participants stood in a dimly lit, sound-resistant room, where they wore a head-mounted display device (nVisor SX by NVIS) that transmitted video and audio directly to the eyes and ears. The virtual environment unfolded with the participant standing on a platform overhanging a railway track (see Appendix 2 for sample video). Behind the participant, a main track stretched to the horizon, while in front, the main track split into two tracks, one that continued straight though a ravine, and a side track that veered off through another ravine. Directly in front of the participant was a rail switch, manipulated via a force-feedback joystick.

The procedure began with several trials in order to habituate participants with the environment and task, followed by an experimental trial (the results of which are described below), and then three exploratory, postexperimental trials. Trials were approximately 50s in duration.

Dilemma content. Participants were presented with the following information:

> Boxcars travel to their destination by force of gravity. Boxcars change tracks if the lever is switched between left and right, but will arrive at

their destination on either track. Travelers on foot often use these tracks as a shortcut. However, they are unable to see or hear the approaching boxcars until it is too late, as the steep ravines prevent escape.

Participants were randomly assigned to one of two conditions. In the *action condition,* pulling the switch generated the utilitarian outcome: the boxcar turned away from five human-like agents, allowing them to survive but causing one person on the side track to die. In the *omission condition,* not pulling the switch resulted in the boxcar continuing down the main track, killing the one person on this track, but allowing the five on the side track to survive. The dilemma began with agents traveling away from the switch platform onto the tracks leading through the ravines in the distance, with one and five agents walking on either track. After 20s, a moving boxcar became audible, and was visible in the distance over the left shoulder of the participant. The boxcar became louder as it approached, and reached the switch platform after 20s. It then traveled underneath the platform, heading down either the main track if the participant did not pull the switch, or veering off onto the sidetrack if the participant pulled the switch. Screams of distress from either one or five agents became audible depending on the direction of the boxcar and the placement of the agents. Screaming was cut short at the moment of impact, and the visual environment faded to black.

Results

Among participants in the action condition ($N = 147$), 133 pulled the switch to kill one to save five, 11 did not pull the switch, and 3 pulled the switch but then returned it to its initial position. That is, 90.5% of participants acted to achieve a utilitarian outcome.

Among participants in the omission condition ($N = 146$), 94 did not pull the switch, 35 pulled the switch but returned it to its initial position, while 17 pulled the switch and allowed the five to die. Among the latter category of participants, 8 pulled the switch because they failed to notice the five participants on the other track, and exclaimed to the researcher as such—a few even apologizing to the dead agents as a result. Thus, 88.5% of participants endorsed the utilitarian outcome.

To examine whether commission of an act to achieve a utilitarian outcome was more emotionally arousing than omission of an action to achieve the same end, we inspected the mean arousal levels between participants assigned to the action versus omission conditions among participants who chose the utilitarian outcome. A t test confirmed that arousal among participants in the action condition ($M = .21$, $SD = .70$) was significantly greater than in the omission condition ($M = .002$, $SD = .63$), $t(260) = 2.36$, $p = .02$.

A logistic regression ($N = 293$) using data from research participants who opted for utilitarian and nonutilitarian outcomes was conducted with utilitarian action as the dependent variable (1 = utilitarian, 0 = nonutilitarian). Experimental condition was the independent variable (action = 1, omission = −1). The analysis revealed no significant difference in the likelihood of utilitarian outcomes between conditions, $\chi^2 < 1$. Specifically, the distribution of individuals who endorsed the utilitarian outcome was not affected by whether participants committed a harmful action or harmful omission. In total, 89% of participants across conditions chose the utilitarian outcome.

We then assessed whether emotional arousal was associated with an increase in the likelihood of choosing a utilitarian outcome by adding a second step to the logistic regression model described above, where participants' autonomic arousal, and its interaction term with condition were entered as an independent variables. Following Aiken and West (1991), arousal was zero centered at the grand mean. The analysis revealed a significant negative relationship between autonomic arousal and the odds of choosing a utilitarian outcome, $Logit = -.63$, $SE = .28$, $\chi^2 = 5.01$, $p = .03$. Specifically, the higher the level of arousal, the lower the likelihood that participants would endorse the utilitarian outcome. This was particularly true for participants in the action condition, $Logit = -.81$, $SE = .36$, $p = .03$, and less so for those in the omission condition, $Logit = -.45$, $SE = .43$, $p = .29$, though the slope difference was not significant, $\chi^2 < 1$ (see Figure 1).

We next examined whether demographic variables moderated moral action. To do so, we added a third step to the logistic regression model described above, and added the independent variables of gender, age, and race (dummy-coded White/Non-White). Each independent variable was entered stepwise into the model (forward entry), and was removed if its 95% confidence interval overlapped with zero. The regression analysis revealed no statistically significant effects on moral action for any demographic variable.

Discussion

In a study of emotional arousal and social behavior in a 3-D virtual simulation of the trolley problem, we found that (a) the distribution of individual actions leading to a utilitarian outcome converged with that found for judgments given by participants in large scale surveys, (b) emotional arousal is associated with a reduced likelihood of acting to achieve a utilitarian outcome, and (c) emotional arousal is greater when behaviorally resolving a dilemma that requires commission of an action as opposed to omission of an action. Furthermore, we found no statistically significant effects of race, age or gender on participants' behavior.

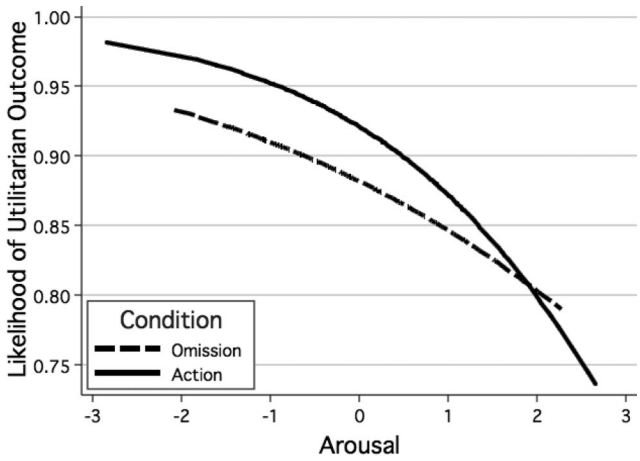

Figure 1. Likelihood estimation of choosing a utilitarian outcome as a function of emotional arousal. Slopes represent smoothed predicted values (logit) by condition. *Note:* x-axis is standardized (z-score).

Because our findings primarily describe emotional arousal and behavior, and not declarative judgment or reasoning, the connection to current perspectives within the contemporary literature on moral philosophy and psychology are not obvious. Nevertheless, we interpret our findings regarding emotional arousal as largely consonant with Greene et al.'s dual process model (2001), in which psychological conflict occurs when one must choose between the signals from two separate psychological systems pitting harm aversion against utilitarian gains. We interpret our findings regarding the similarities in behavior in a virtual environment and judgment in large surveys, and the constancy of the results across demographic variables, as consistent with expectations from certain conceptualizations of the linguistic analogy (Hauser, 2006) regarding the claims of a universal moral grammar. To be sure, these connections are tenuous given the current state of theory, and of our understanding of how moral judgment and behavior are connected, and readers should be cautious about inferring too much about the affirmation of any given contemporary theory. Nevertheless these findings are important, as they affirm the empirical link between emotion and moral action, and provide preliminary evidence that similar neurophysiological processes may mediate moral judgment and action. Furthermore, these findings can be seen as setting an empirical groundwork for investigating the contexts in which judgment and action may dissociate.

Perhaps behavioral experiments conducted in virtual environments represent only rough proxies of behavior in grounded reality. Surely there are factors, irrelevant in virtual worlds, that may influence the association between moral judgment and moral behavior in the "real world," such as knowledge of legal constraints, forecasted emotional states, degree of self-control and reflection, one's physical abilities, and one's appraisal of the competing reputational or retaliatory costs resulting from various courses of action. However, even though factors affecting behavior in virtual and grounded environments are not identical in every way, our experiment may be an accurate representation of the experience of deciding and acting to harm another person for the greater good when the relevant sensory inputs are salient in the absence of real-life consequences. Among others, this is a key advantage of this approach, as it suggests that any potential differences between judgment and real-world action in this trolley dilemma are not likely to be at the level of sensory input processing, but are more likely to occur at the level the calculations of the costs and benefits of the consequences.

As noted above, we found no effect of individual differences in demographics on actions leading to a utilitarian outcome. Although this lack of significant effects is consistent with other reports using survey data (e.g., Hauser et al., 2007), there are limitations to interpreting our null findings as "evidence of absence" of an effect, as measurement constraints make it difficult to distinguish from the "absence of evidence." Caution should be exercised, therefore, in drawing the strong conclusion that individual differences do not matter in situations such as the trolley problem, as we are sure that some individuating feature of the mind must be related to the outcomes given that not all research participants exhibit the same pattern of behavior in this dilemma. Further research is needed that explores the role of other individual difference variables relevant to moral behavior before reasonable inferences can be made regarding the role of personality and social attitudes in moral judgment and action. It is also important to note that this particular version of the trolley problem tends to elicit only minimal variance in both moral judgment and action. Future explorations in this area should utilize variations of the dilemma that tend to produce more behavioral variance. In addition to this, it is also essential to extend the work presented here to other cases to explore the generality of our findings, and the contexts in which it breaks down, including cases where utilitarian harms require contact that is "up close and personal," where the victims themselves may be used as direct "means to an end," and where the level of outcome utility is varied in terms of harm caused and benefits obtained.

It is worth emphasizing the importance of studying behaviors with realistic sensory inputs that occur in real time—even if in a virtual world—and not merely explicit judgments, in attempting to draw a deeper understanding of the nature of our moral minds. Posing hypothetical scenarios can only provide one piece of the puzzle, as carrying judgments into actions clearly necessitates the workings of decision-making processes that mere judgments do not activate. We think that as this research program matures, it will yield important answers as to what it is about "real world" moral dilemmas that may cause moral dissociations, and the relative importance of the proximate mental processing of sensory inputs (e.g., seeing and hearing individuals in distress) versus the processing of real-life consequences likely to result from any course of action. Additionally, because such explorations involving the potential for harmful outcomes are not possible in a standard research setting, virtual approaches such as ours that bridge the gap between judgment and behavior are crucial if we are to know whether the mechanisms underlying one also apply to the other. Though our method does not offer a definitive solution to the long-standing trade-off between behavioral realism and scientific control, presenting participants with visual and auditory representations of what they can typically only imagine will undoubtedly allow further insights into the moral mind not readily inferred from questionnaires or experiments involving low-level manipulations of harm.

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(*Appendices follow*)

Appendix 1

Appendix 1 provides descriptive statistics for autonomic response and action outcomes by trial. Appendix 2 provides samples of virtual environment stimuli.

Table 1
Descriptive Statistics for Autonomic Arousal by Phase, Trial, and Condition

		Condition					
		Action			Omission		
Phase	Trial	*M*	*SD*	*N*	*M*	*SD*	*N*
Habituation	1	0.16	0.64	159	0.08	0.61	131
	2	−0.11	0.55	142	−0.06	0.54	145
	3	−0.13	0.61	150	−0.17	0.54	141
	4	−0.16	0.64	127	−0.10	0.54	163
Experimental	1	0.21	0.69	147	0.00	0.63	146
	1	0.55	0.69	153	0.46	0.65	139
Postexperimental	2	0.34	0.63	143	0.29	0.61	146
	3	0.21	0.63	137	0.27	0.74	148

Table 2
Count for Utilitarian Outcomes by Phase, Trial, and Condition

		Condition			
		Action		Omission	
Phase	Trial	Yes	No	Yes	No
Experimental	1	133	14	129	17
	1	140	12	124	14
Postexperimental	2	134	8	139	7
	3	123	14	136	11

Note. The yes/no columns refer to counts of participants choosing a utilitarian outcome (yes) versus not (no).

Appendix 2

The following media files have been uploaded to the supplementary files area. If unable to view, a site with a permanent link contains links to flash versions for each file: *http://www.cdnresearch.net/vm11.html*

Video 1. Video capture example of subject perspective in the virtual environment during a typical habituation trial.

Video 2. Video capture example of subject perspective in the virtual environment during a typical experimental trial.

Audio 1. Audio capture example of agent vocalizations before impact.

Video 3. Dramatization of virtual environment described in the manuscript.

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