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Effects of Testosterone on Moral Dilemma Judgments

Skylar M. Brannon, Sarah Carr, Ellie Shuo Jin, Robert A. Josephs, Bertram Gawronski*

The University of Texas at Austin

Abstract

Societies often wrestle with the question of how to balance the rights of the individual versus the greater good (e.g., is it acceptable to shoot a hijacked passenger plane to prevent the death of a larger number of people?). Whereas the moral principle of deontology emphasizes the irrevocable universality of moral norms, the moral principle of utilitarianism emphasizes the consequences of a given action for the greater good. The current research will test the effect of the steroid hormone testosterone on moral dilemma judgments using a double-blind administration of testosterone or placebo. To gain deeper insights into how testosterone influences moral dilemma judgments, the research will use a mathematical model that disentangles three determinants of moral judgments: (a) sensitivity to consequences in a utilitarian sense, (b) sensitivity to moral norms in a deontological sense, and (c) general preference for inaction versus action irrespective of consequences and norms. The findings will provide deeper insights into the role of neuroendocrine factors in moral judgment and their contribution to moral debates about controversial issues.

Keywords: deontology; moral judgment; utilitarianism, omission bias; testosterone

On September 11, 2001, members of the terrorist group al-Qaeda hijacked two airplanes and crashed them into the twin towers of the World Trade Center in New York, killing close to 3000 people and injuring more than 6000 others. This horrifying event ignited heated debates about whether it would be acceptable to shoot down hijacked passenger planes to prevent terrorists from crashing them into densely populated areas.[1] Whereas some argued that it would be morally acceptable to actively kill innocent passengers on a hijacked plane to prevent greater harm, others argued that such actions would be immoral regardless of how many lives would be saved.

The conflicting views in this debate can be linked to two moral principles that play a central role in research on moral judgment.[2-4] First, the principle of *deontology*, often associated with the moral philosophy of Immanuel Kant,[5] emphasizes the irrevocable universality of rights and duties. From a deontological view, the moral status of a given action depends on its consistency with moral norms. That is, a given action is acceptable if it is consistent with a set of moral norms, but it is unacceptable if it is inconsistent with this set of moral norms (e.g., shooting a hijacked passenger plane is unacceptable from a deontological view, because it violates the norm that one should not kill innocent people). Second, the principle of *utilitarianism*, often associated with the moral philosophy of John Stuart Mill,[6] emphasizes actions that bring about the greatest good. From a utilitarian view, the moral status of a given action depends on its consequences for overall well-being. To the extent that a given action increases overall well-being, it is deemed morally acceptable. Conversely, if the same action decreases overall well-being, it is deemed morally unacceptable (e.g., shooting a hijacked passenger plane is acceptable from a utilitarian view to the extent that it prevents the potential death of a larger number of people).

To understand the psychological roots of conflicting views in moral debates, a substantial body of research has investigated personal and situational factors that influence people's preference for utilitarian versus deontological judgments in moral dilemmas where the two principles have conflicting implications.[7-11] In an attempt to provide deeper insights into the determinants of moral preferences, several studies aimed to identify their neural underpinnings using neuroimaging[2,3] and patients with focal brain lesions.[12] Expanding on the latter work, there has been an increasing interest in the contribution of neuroendocrine factors to moral dilemma judgments.[13-18] This interest is rooted in the idea that neuroendocrine factors can influence moral judgments in a fundamental way by regulating brain activity in areas that have been associated with moral judgments.[15,16] Moreover, moral judgments have been claimed to be at least partly rooted in evolved psychological mechanisms related to reproduction and cooperation among conspecifics.[19,20] To the extent that neuroendocrine processes play a central role in regulating these mechanisms,[21] a multi-level approach that integrates social, psychological, neural, and endocrine factors promises a deeper theoretical understanding of moral judgments compared to research that focuses exclusively on behavioral responses and associated brain regions.[22] Such an integrative approach is essential for understanding conflicting views in moral debates (e.g., about whether it is acceptable to shoot down a hijacked passenger plane) by identifying their origin and the conditions under which they may be responsive or resistant to persuasive arguments.[23] To the extent that moral conflicts are at least partly rooted in deep-seated biological factors, these conflicts may be difficult to resolve by means of arguments, which explains why moral conflicts tend to be notoriously difficult to reconcile.

Expanding on the need for a multi-level approach to understanding moral judgments,[22] the current research will investigate the effect of the steroid hormone testosterone on moral

dilemma judgments by experimentally manipulating testosterone levels through double-blind administration of either testosterone or placebo. Compared to other hormones with downstream effects on decision-making, testosterone is a prime candidate for understanding neuroendocrine effects on moral judgments, in that elevated levels of testosterone have been linked with various outcomes that are relevant for moral judgments. Based on earlier research suggesting that higher levels of testosterone are associated with a stronger preference for utilitarian over deontological judgments,[15-17] the main goal of the current work is to provide deeper insights into *how* testosterone influences moral dilemma judgments. Toward this end, we will use a mathematical model that disentangles three functionally distinct determinants of moral dilemma judgments: (a) sensitivity to consequences in a utilitarian sense, (b) sensitivity to moral norms in a deontological sense, and (c) general preference for inaction versus action regardless of consequences and norms.[24] Using the 9/11 dilemma as an illustrative example, we are interested in whether testosterone increases the perceived acceptability of shooting down a hijacked passenger plane to prevent greater harm, and if so, whether this increase is driven by an increased sensitivity to consequences (i.e., number of lives saved), a reduced sensitivity to moral norms (i.e., norm that one should not kill), or an increased preference for action responses regardless of consequences and moral norms.

Moral Dilemma Judgments

Previous research on moral dilemma judgments has been shaped by a paradigm known as the trolley problem.[2-4] The paradigm is based on the idea that utilitarian and deontological judgments can be measured with scenarios that pit one principle against the other. In the trolley problem, participants are presented with a scenario in which a runaway trolley would kill a group of five workers unless participants engage in actions to redirect or stop the trolley. In the original

switch dilemma, participants could pull a lever to redirect the trolley to another track, where it would kill only one person instead of five.[25] Other variants of the trolley problem include the footbridge dilemma, in which the five workers could be saved by pushing a man from a bridge to stop the trolley.[26] From a utilitarian view, pulling the lever or pushing the man would be morally acceptable, because both actions maximize overall well-being (i.e., it is morally acceptable to kill one person, if it helps to save the lives of five). In contrast, both actions are morally unacceptable from a deontological view, because they are in conflict with the moral norm that one should not kill other people (i.e., it is morally unacceptable to kill another person, regardless of the consequences). Thus, participants who judge pulling the lever or pushing the man as acceptable are typically claimed to have made a utilitarian judgment, whereas participants who judge these actions as unacceptable are claimed to have made a deontological judgment.

Despite its widespread use in psychology and neuroscience, the trolley problem has been criticized on several methodological grounds. One important criticism is that the traditional paradigm treats utilitarian and deontological inclinations as bipolar opposites (i.e., stronger inclinations of one kind are associated with weaker inclinations of the other kind) although their underlying processes are claimed to be functionally independent.[27] Further, deontological judgments (e.g., not pulling the lever, not pushing the man) are conflated with inaction, whereas utilitarian judgments (e.g., pulling the lever, pushing the man) are conflated with action.[28] These confounds make it impossible to determine (a) which aspects (i.e., sensitivity to consequences, sensitivity to moral norms, or general action tendencies) drive moral dilemma judgments and (b) which aspects are influenced by a particular factor (e.g., does emotional engagement influence moral dilemma judgments by influencing sensitivity to consequences, sensitivity to moral norms, or general action tendencies?).

To resolve these ambiguities, researchers have proposed an expanded approach in which judgments are compared across four types of moral dilemmas involving different consequences and norms: (a) dilemmas in which a proscriptive norm prohibits action, and the benefits of action for overall well-being are greater than the costs; (b) dilemmas in which a proscriptive norm prohibits action, and the benefits of action for overall well-being are smaller than the costs; (c) dilemmas in which a prescriptive norm prescribes action, and the benefits of action for overall well-being are greater than the costs; (d) dilemmas in which a prescriptive norm prescribes action, and the benefits of action for overall well-being are smaller than the costs (for an example, see Table 1).[29] A major advantage of this approach is that it permits the identification of three independent determinants of moral dilemma judgments: (a) sensitivity to consequences, (b) sensitivity to moral norms, and (c) general preference for inaction versus action irrespective of consequences and norms.[24] Sensitivity to consequences and sensitivity to moral norms represent the key aspects of utilitarianism and deontology, respectively. Further, general preference for inaction has been shown to play an important role in moral judgments, in that harm caused by action is typically perceived as worse than equivalent harm caused by inaction (i.e., *omission bias*).[30,31]

Using multinomial modeling to quantify the three determinants of moral dilemma judgments,[32,33] the CNI model of moral decision-making estimates the extent to which participants' judgments in a larger set of moral dilemmas reflect a response pattern that is sensitive to consequences (first row in Figure 1), a response pattern that is sensitive to moral norms (second row in Figure 1), and a response pattern of general inaction versus action irrespective of consequences and norms (third and fourth row in Figure 1).[24] Sensitivity to consequences is captured by the CNI model's *C* parameter with higher scores reflecting a greater

sensitivity to consequences; sensitivity to moral norms is captured by the model's *N* parameter with higher scores reflecting a greater sensitivity to moral norms; and general preference for inaction versus action is captured by the model's *I* parameter with higher scores reflecting a greater preference for inaction and lower scores reflecting a greater preference for action irrespective of consequences and moral norms. The significance of the three parameters for understanding outcomes in real-world contexts has been demonstrated by research showing that participants with subclinical levels of psychopathy showed lower scores on all three model parameters compared to non-psychopaths.[24] Specifically, participants with high levels of psychopathy, compared to participants with low levels of psychopathy, showed (a) a weaker sensitivity to consequences in a utilitarian sense, (b) a weaker sensitivity to moral norms in a deontological sense, and (c) a weaker general preference for inaction regardless of consequences and moral norms. Given that psychopaths are known to make judgments that can be deemed problematic in a moral sense,[34] these findings support the usefulness of the CNI model in providing deeper insights into the underpinnings of moral judgments in real-world contexts. The current work will use the CNI model to gain a more nuanced understanding of how testosterone influences moral dilemma judgments.

Psychological Effects of Testosterone

The steroid hormone testosterone plays a cardinal role in the development of primary and secondary sexual characteristics. In addition to its primary biological role, testosterone has been claimed to function as an important neuroendocrine determinant of moral judgments, given that elevated levels of testosterone (i.e., relatively high endogenous levels and elevation produced by administration of exogenous testosterone) have been linked to a variety of morally relevant outcomes.[35] For example, testosterone has been shown to be associated with low empathy,[36]

reduced activity in the ventromedial prefrontal cortex (vmPFC),[37] and enhanced psychopathic tendencies.[38] These same outcomes have also been found to be associated with moral judgments, in that preference for utilitarian over deontological judgments is greater for participants with low levels of empathic concern,[27,39] for participants with lesions in the vmPFC,[12] and for participants with sub-clinical levels of psychopathy.[9,40,41] In line with these parallel findings, it has been suggested that testosterone may increase people's preference for utilitarian over deontological judgments by reducing empathic concern via suppressed activity in the vmPFC.[15,42] Consistent with this hypothesis, research showed that men and women with high levels of endogenous testosterone are more likely to judge harmful actions in the trolley paradigm as acceptable than participants with low levels of endogenous testosterone.[15]

Although these findings are consistent with the idea that testosterone plays a causal role in moral dilemma judgments, it is possible that the observed correlations are driven by a shared association to other psychological variables (e.g., psychopathy), with testosterone itself having no causal influence on moral judgments. In line with this concern, research that experimentally manipulated testosterone levels obtained mixed evidence regarding causal effects of testosterone on moral dilemma judgments. Whereas some studies found unqualified effects of exogenous testosterone,[16] others found significant effects only in the presence of other facilitating factors,[17] or no significant effects at all.[13] Because the sample sizes in all of these studies were rather small with *N*s between 20 and 30, it is difficult to draw strong conclusions from the currently available evidence. On the one hand, it is possible that non-significant effects reflect low statistical power in identifying an actually existing effect.[43] On the other hand, statistically significant effects may reflect the higher likelihood of false positives in underpowered studies.[44]

To overcome these limitations, the current research will experimentally manipulate testosterone levels with a double-blind administration of testosterone versus placebo in a large sample of 200 participants. Expanding on earlier evidence suggesting that higher levels of testosterone are associated with a stronger preference for utilitarian over deontological judgments in the traditional dilemma paradigm,[15,16] our first question is whether this finding replicates with an experimental manipulation of testosterone versus placebo in a sample that is considerably larger compared to the samples in previous experiments. Conceptually, this research question translates into the following hypothesis:

Hypothesis 1: *Participants in the testosterone group, compared to participants in the placebo group, will show a greater preference for utilitarian over deontological responses in the traditional approach to studying moral dilemma judgments. That is, participants in the testosterone group, compared to participants in the placebo group, will show a significantly stronger preference for "action" judgments on moral dilemmas in which a proscriptive norm prohibits action and the benefits of action outweigh its costs to well-being.*

In addition to providing a high-powered replication of earlier research on this hypothesis, the more central goal of the current work is to overcome the ambiguities of the traditional approach by testing whether testosterone influences moral judgments via differences in (a) sensitivity to consequences in a utilitarian sense, (b) sensitivity to moral norms in a deontological sense, or (c) general preference for inaction versus action irrespective of consequences and moral norms (or a combination of the three). The distinction between the three determinants is particularly important for the current investigation, because testosterone may influence moral dilemma judgments via any one (or any combination) of them.

First, elevated levels of testosterone have been associated with increased reward sensitivity[45-47] and heightened concern with outcomes,[48] which may influence moral judgments via increased sensitivity to consequences in a utilitarian sense. Applied to the 9/11 dilemma, these findings suggest that testosterone may increase the support for shooting down a hijacked passenger plane by enhancing a person's concern with the number of lives saved. Conceptually, this idea is reflected in the following hypothesis:

Hypothesis 2a: *Participants in the testosterone group will show significantly higher scores on the CNI model's C parameter compared to participants in the placebo group, indicating a stronger sensitivity to consequences among participants in the testosterone group*.

Second, elevated levels of testosterone have been found to be associated with reduced sensitivity to punishment,[47] which may influence moral judgments via reduced sensitivity to moral norms in a deontological sense. Applied to the 9/11 dilemma, these findings suggest that testosterone may increase the support for shooting down a hijacked passenger plane by reducing a person's concern with potential punishments for violating the moral norm that one should not kill. Conceptually, this idea is reflected in the following hypothesis:

Hypothesis 2b: *Participants in the testosterone group will show significantly lower scores on the CNI model's N parameter compared to participants in the placebo group, indicating a weaker sensitivity to moral norms among participants in the testosterone group*.

Third, elevated levels of testosterone have been found to be associated with stronger approach tendencies in the presence of threatening stimuli[49] as well as higher activity, energy, and persistence,[50] which may influence moral judgments via enhanced willingness to act regardless of consequences and moral norms. Applied to the 9/11 dilemma, these findings suggest that testosterone may increase the support for shooting down a hijacked passenger plane

by enhancing a person's preference for action responses regardless of the number of lives saved and regardless of the moral norm that one should not kill. Conceptually, this idea is reflected in the following hypothesis:

Hypothesis 2c: *Participants in the testosterone group will show significantly lower scores on the CNI model's I parameter compared to participants in the placebo group, indicating a weaker general preference for inaction among participants in the testosterone group*.

The current research will test the three complementary hypotheses by investigating the effects of testosterone administration (versus placebo) on sensitivity to consequences (*C*), sensitivity to moral norms (*N*), and general preference for inaction versus action (*I*) using the CNI model of moral decision-making. By disentangling these three determinants with a large sample of participants, the current work will (a) provide a stronger test of *whether* testosterone influences moral dilemma judgments and (b) illuminate *how* testosterone influences moral dilemma judgments. In doing so, the current research contributes to an integrative understanding of moral judgments at multiple levels of analyses, which has important implications for the origin and potential resolution of moral debates.

Method

Ethics

The study has been approved by the Institutional Review Board of the University of Texas at Austin under protocol # 2014-12-0010. As required by U.S. Law, a description of this study is available at https://www.clinicaltrials.gov/ct2/show/NCT02799277.

Participants and Design

We aim for a final sample of 200 participants after prescreening for physical conditions that prohibit participation in the study and physical symptoms that require termination of the study for a given participant after testosterone administration (see below). Aside from these two preconditions for completion of the study, no other criteria will be used to exclude participants from the final sample. Because multinomial modeling, the statistical procedure underlying the CNI model, is based on aggregate data from groups of participants,[32] it is relatively robust to missing data to the extent that the total sample is sufficiently large. Thus, with the current sample of 200 participants, it is not necessary to exclude participants with incomplete data on the moral dilemma task. With 100 participants in each of the two experimental conditions, the study has a power of 95% in detecting a medium-size difference of Cohen's $d = 0.51$ between two independent mean values in the statistical test for Hypothesis 1 (two-tailed). To estimate the power for the model-based tests in Hypotheses 2a-2c, we used the average number of *action* versus *inaction* responses on the four types of dilemmas in earlier research[24] to obtain population parameters for *C*, *N*, and *I*. Using the estimated population parameters, we then simulated hypothetical differences for each parameter to obtain a power of 95% in detecting a significant difference (two-tailed) with a sample of 100 participants per condition and six observations per participant for each of the four dilemma types.[51] The simulation revealed a power of 95% in detecting a small effect of Cohen's $w = 0.0524$ for each of the three parameters.

Participants will be recruited from the subject pool of the Department of Psychology at the University of Texas at Austin in exchange for 1.5 hours of research credit for an introductory psychology course. The data collection will start at the beginning of the 2017 fall term and continue until the study has a final sample of 200 participants. Participants will be randomly

assigned to either a testosterone or a placebo condition in a double-blind procedure. Toward this end, the last author (B.G.) will mark 100 testosterone and 100 placebo sprays with consecutive numbers ranging from 1 to 200 using a random sequence generated at https://www.randomizer.org. An electronic list identifying each of the 200 sprays as containing testosterone or placebo will be kept by the last author (B.G.). A copy of the file will be kept by the fourth author (R.A.J.). No other person will know the matching between spray number and condition or have access to the list before the data collection is completed. After completion of the data collection, the list will be used to identify whether a given participant was randomly assigned to either the testosterone or the placebo condition.

Procedure

After providing informed consent, participants will complete a medical screening interview to identify potential conditions that would compromise the safety or efficacy of the testosterone administration. After passing the medical screening, participants will provide a saliva sample for the measurement of baseline levels of endogenous testosterone. After the saliva collection, participants will view an instructional video explaining how to properly administer drugs via a nasal spray. Then, participants will self-administer spray puffs of either testosterone or placebo, followed by a 30-minute relaxation period for absorption of the hormone. After the 30-minute relaxation period, participants will read and respond to a validated set of 24 moral dilemmas[24] and complete a post-experimental questionnaire. After completion of the post-experimental questionnaire, participants will be debriefed and dismissed. To monitor potentially adverse side-effects of the hormone administration, ear temperature, heart rate, and blood pressure will be measured by the experimenter before the self-administration of the nasal spray, and again 20 minutes after administration.

Medical screening interview. Participants will be asked to answer several questions to identify potential physical conditions that would preclude testosterone administration. To this end, the experimenter will read the questions of a standardized interview form to the participant and record the participant's response on the form (see Appendix). The interview form will be viewed only by the experimenter as they pose the questions to the subjects. Because testosterone can have adverse side-effects to the unborn fetus, female participants will additionally be asked to self-administer a hormonal urinary pregnancy test in a bathroom located in the same hallway of the laboratory suite. To avoid potential discomfort arising from the necessity of a pregnancy test for female participants, all experimenters in this study will be female. Pregnancy tests (Wondfo Pregnancy Strips, Willowbrook, IL) will be provided by the experimenter individually for each participant. Participants will be excluded from the study if they have a condition that precludes administration of testosterone (those marked with an asterisk in the Appendix). In such cases, participants will be dismissed from completing the following components of the study and granted full credit.

Saliva sample. After completion of the medical screening interview, participants will be asked to provide a saliva sample for the measurement of baseline levels of endogenous testosterone. The saliva samples will be collected for exploratory data analyses that go beyond the main hypotheses of this study (see below). To reduce potential contamination of the saliva samples (e.g., with food particles), participants will be given water and instructed to rinse their mouth thoroughly and to swallow the water completely once they have done so. Then, participants will passively drool at least 2ml of saliva into a sterile vile that is marked with their participant number. The saliva samples will be stored in a freezer at -80°C and kept there until they are analyzed. After data collection is completed, the saliva samples will be immuno-assayed

in duplicate by the first and third authors (S.M.B. and E.S.J.) using DRG Salivary Testosterone ELISA kits.[52] All samples will be thawed to room temperature and centrifuged at 3,000 rpm for 10 minutes, in line with the guidelines provided for the assay kits. Next, 100µl of testosterone standards and controls provided by DRG and 100µl of saliva from each participant will be dispensed into micro-wells (in duplicate). Then, 200µl of enzyme conjugate will be added to each well, and the specimens will be left to incubate for 60 minutes. After incubation, 400µl of wash solution and 200µl of substrate solution will be added to each well, and specimens will incubate for 30 minutes. Finally, 100µl of stop solution will be added to each well. After completing these steps, free testosterone in each sample will be bound to the well. To assess mean concentrations of testosterone for each sample, a photometer will be used to pass light with a wavelength of 450nm through each well and the absorption of the light for each well will be recorded. Then, absorption rates of each sample will be compared to a standard curve created from the absorption rates for the testosterone standards (which have a known amount of testosterone) to infer the mean concentration of testosterone in the sample. Any samples reading as a greater concentration than the highest standard will be re-analyzed. If the sample still yields a concentration greater than that of the highest standard, that participant will be excluded from analyses involving endogenous testosterone levels because their mean concentration will not be able to be inferred. For quality control, any sample duplicate with an individual coefficient of variation (CV) greater than 15 will be re-assayed to ensure intra- and inter-assay variability to be below 15.

Self-administration of nasal spray. The protocol for the intranasal administration of testosterone is based on a pharmacokinetic study by the third and fourth author that investigated the time course of changes in blood level testosterone concentrations via intranasal testosterone

administration.[53] Using the same protocol, dosage, and formulation, blood samples obtained via venipuncture showed peak levels for both free (bioavailable) and SHBG-bound testosterone 30 minutes post-administration in both men and women, which coincides with the proposed start time of the moral dilemma task in the current study (see below). A major advantage of the intranasal route over traditional modes of testosterone administration (e.g., androgel) is the faster absorption of testosterone administered via nasal spray. Whereas traditional modes tend to show peak levels in serum testosterone concentrations several hours post-administration, the intranasal protocol utilized in the current study shows peak levels in serum testosterone concentrations 30 minutes post-administration.[53]

Following the validated protocol, participants will self-administer a sterile, aqueous solution containing either 14mg testosterone or placebo via nasal spray immediately after the saliva collection. The solutions will be prepared by a local pharmacist at NuCara Pharmacy in Austin, TX, who will transfer either 14mg of testosterone or placebo into 200 sterile containers, which will then be sealed. For administration, sterile, disposable nasal applicators will be applied to the containers. Both the experimenters and the participants will be blind to whether the spray assigned to a given participant contains testosterone or placebo (see above). Participants will view an instructional video on how to correctly self-administer the nasal spray. The video instructs participants to insert the applicator into one nostril and to pump until they feel a full, strong spray. Once they feel a full spray, they are instructed to sniff and then switch nostrils. The video instructs them to continue alternating spray pumps until the container is empty. The video also instructs participants not to blow their nose or tilt their head downward during administration, which could inhibit absorption. After the video, the experimenter will ask if the participant has any questions about the administration. If the participant has no questions, they

will be instructed to begin the self-administration. After the self-administration of the nasal spray, participants will be asked to relax for a 30-minute period to allow for absorption of the hormone (see Supplementary Information for a discussion of technical issues in the implementation of a positive control). A documentary video about marine life in the Pacific Ocean (*Pacific Ocean Paradise* by National Geographic) will be played for participants during the relaxation period.

Physiological measurements. To monitor potentially adverse side-effects of the testosterone administration, ear temperature, heart rate, and blood pressure will be measured by the experimenter before the administration of the nasal spray, and again 20 minutes after administration. Participants' ear temperature will be measured by the experimenter in the right ear using a digital thermometer. A disposable speculum cover will be placed on the thermometer prior to use and disposed after use. Following ear temperature measurement, participants' heart rate and blood pressure will be measured using an automatically inflating blood pressure cuff. Participants will be instructed to sit with their legs uncrossed, to not talk, and to breath regularly. If participants are wearing a long sleeved shirt, they will be asked to roll up their sleeve. If participants are wearing a jacket or sweatshirt over their shirt, they will be asked to remove it. The cuff will be placed on their right arm above the elbow, which will be slightly bent and resting on the arm of their chair. If ear temperature changes more than 2 degrees Fahrenheit, heart rate changes more than 20bmp, or if blood pressure changes more than 20%, the experiment will be terminated and subjects will be escorted across the street to the University Emergency Room for examination by a medical professional. The experimenter collecting the physiological measurements will be blind to the experimental conditions of testosterone versus placebo.

Moral dilemma task. After the 30-minute relaxation period, participants will be asked to read and respond to a validated set of 24 moral dilemmas.[24] The dilemma set will include 4 parallel versions of 6 basic scenarios that vary in terms of whether (a) the dilemma involves a proscriptive norm that prohibits action or a prescriptive norm that prescribes action and (b) the benefits of the described action for overall well-being are either greater or smaller than its costs for overall well-being (see Table 1). To address concerns that the scenarios in trolley dilemmas are unrealistic and implausible,[54] all of the dilemmas have been designed to capture real-world cases that ignited moral debates about the most appropriate courses of action (e.g., the debate about whether it would be acceptable to shoot down a hijacked passenger plane to prevent terrorists from crashing it into densely populated areas; the case of Dr. Kent Brantly's Ebola's infection in Liberia and the debate about his return to the United States for treatment).[1,55] Although the dilemmas may be deemed hypothetical in the sense that most participants will never be in a situation where they have to make a decision similar to the ones described in the scenarios, all of them capture real events that ignited controversies about morally acceptable courses of action. Thus, participants' responses to the dilemmas are highly relevant for understanding the roots of conflicting views in real-world moral debates.

In the current study, the 24 dilemmas will be presented in a fixed random order on a desktop computer, with each dilemma being presented individually on a separate screen. Participants will be asked to indicate for each dilemma whether or not they would perform the described action, using forced-choice options labeled *yes* and *no*.[24] Participants will receive the following instructions before they are presented with the dilemmas:

> *On the following screens you will see a series of short stories. Please read them carefully. Even though some stories may seem similar, each story is different in important*

ways. After each story you will be asked to make a judgment about whether you would perform the described action. Using the mouse, click the button that best corresponds to your personal opinion. There is no right or wrong answer—just choose what seems best to you. Please note that some stories refer to things that may seem unpleasant to think about. This is because we are interested in people's thoughts about difficult, real-life issues. If at any time you are uncomfortable, please notify the experimenter immediately. When you are ready to start, please click "Continue".

Post-experimental questionnaire. After completion of the moral dilemma task, participants will be asked to report their gender, age, and ethnicity. In addition, they will be asked to guess whether they have been randomly assigned to the testosterone or the placebo group.

Data Analysis Plan

Data Aggregation

Following the procedures in earlier research with the CNI model, responses in the moral dilemma task will be aggregated by calculating the sum of *action* responses for each of the four types of moral dilemmas.[24] With a total of 6 scenarios for each dilemma type, aggregate scores could range from 0 to 6.

Traditional Analysis

In line with the traditional approach, we will first investigate participants' responses on moral dilemmas involving a proscriptive norm that prohibits action in cases where the benefits of action outweigh its costs to well-being. In the traditional approach, a preference for action over inaction on this type of dilemma would be interpreted as a preference for utilitarian over deontological responses (analogously to responses in the trolley problem). The main analysis for

Hypothesis 1 will include a *t*-test for independent means (two-tailed), testing whether action judgments in the testosterone group significantly differ from those in the placebo group in this type of dilemma. According to Hypothesis 1, participants in the testosterone group, compared to participants in the placebo group, should show a significantly stronger preference for action judgments on moral dilemmas in which a proscriptive norm prohibits action and the benefits of action outweigh its costs to well-being.

CNI Model

CNI model analyses will be conducted using the multinomial modeling software multiTree[51] and the multiTree template file for CNI model analyses provided by the authors of the model at http://www.bertramgawronski.com/documents/CNI-Model_Materials.zip.[24] The template file includes a fixed estimation algorithm with random start values, two replications, and a maximum of 90,000 iterations. The adequacy of the CNI model in describing the data will be evaluated by means of goodness-of-fit statistics (i.e., G^2 statistics), such that poor model fit would be reflected in a statistically significant deviation between empirically observed probabilities of moral dilemma responses and the probabilities of responses predicted by the CNI model. Differences in parameter estimates will be tested by enforcing equal estimates for a given parameter across groups. If setting a given parameter equal across groups leads to a significant reduction in model fit, it can be inferred that the parameter estimates for the two groups are significantly different. If setting a given parameter equal across groups does not lead to a significant reduction in model fit, the parameters for the two groups are not significantly different from each other. To provide a basis for the main analyses, we will first fit the CNI model for the two experimental conditions (testosterone vs. placebo) with no restrictions on the three model parameters (*C*, *N*, *I*). This model specification will be used as a baseline for

subsequent tests of whether the three model parameters significantly differ across the two experimental conditions.

Hypothesis 2a will be tested by setting the *C* parameter equal across the two experimental conditions, and comparing the fit of the restricted model to the unrestricted baseline model. A statistically significant loss in model fit would indicate that the *C* parameter is significantly different across the two experimental conditions. According to Hypothesis 2a, participants in the testosterone group should show significantly higher scores on the *C* parameter compared to participants in the placebo group, indicating a stronger sensitivity to consequences among participants in the testosterone group.

Hypothesis 2b will be tested by setting the *N* parameter equal across the two experimental conditions, and comparing the fit of the restricted model to the unrestricted baseline model. A statistically significant loss in model fit would indicate that the *N* parameter is significantly different across the two experimental conditions. According to Hypothesis 2b, participants in the testosterone group should show significantly lower scores on the *N* parameter compared to participants in the placebo group, indicating a weaker sensitivity to moral norms among participants in the testosterone group.

Hypothesis 2c will be tested by setting the *I* parameter equal across the two experimental conditions, and comparing the fit of the restricted model to the unrestricted baseline model. A statistically significant loss in model fit would indicate that the *I* parameter is significantly different across the two experimental conditions. According to Hypothesis 2c, participants in the testosterone group should show significantly lower scores on the *I* parameter compared to participants in the placebo group, indicating a weaker general preference for inaction among participants in the testosterone group.

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Author Contributions

S.M.B., R.A.J., and B.G. designed the study; S.M.B. and S.C. will collect the data; S.M.B. and E.S.J. will immuno-assay the saliva samples, S.M.B. and B.G. will analyze the data; S.M.B. and B.G. have written the proposal and will write the final paper; S.C., E.S.J., and R.A.J. commented on the proposal and will comment on the final paper.

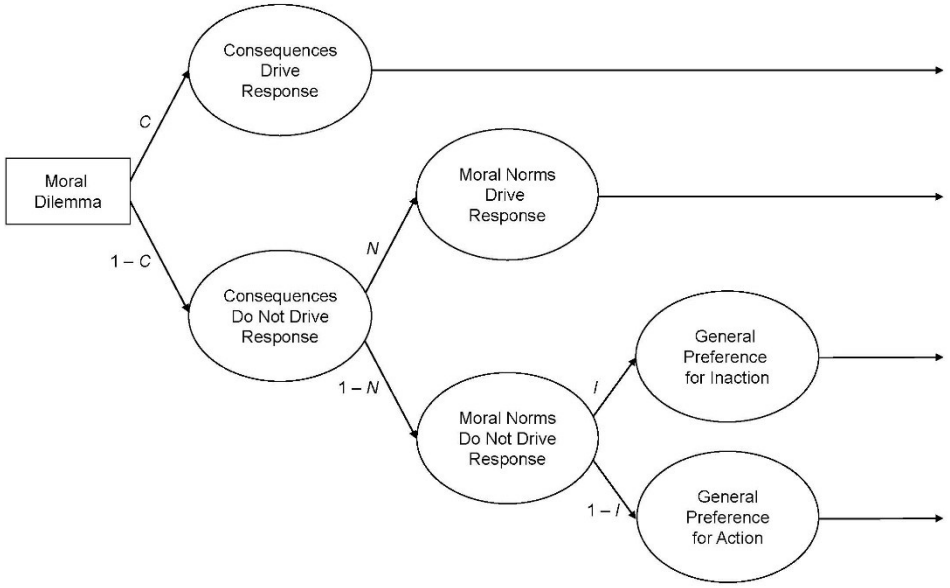
Correspondence

Correspondence and material requests should be addressed to Bertram Gawronski, Department of Psychology, University of Texas at Austin, 108 E Dean Keeton A8000, Austin, TX, 78712, USA, Email: gawronski@utexas.edu.

Table 1. Example of a moral dilemma involving either a proscriptive or a prescriptive norm where the benefits of action are either greater or smaller than the costs of action. Adapted from Gawronski, Armstrong, Conway, Friesdorf, and Hütter (2017). Reprinted with permission.

	Benefits of Action Greater than Costs	**Benefits of Action Smaller than Costs**
Proscriptive Norm Prohibits Action	You are the director of a hospital in a developing country. A foreign student who is volunteering in the country got infected with a rare virus.	You are the director of a hospital in a developing country. A foreign student who is volunteering in the country got infected with a rare virus.
	The virus is highly contagious and deadly to seniors and children. The only medication that can effectively stop the virus from spreading has severe side-effects. Although the virus will not kill her, the student suffers from a chronic immune deficiency that will make her die from these side-effects.	The virus is highly contagious and can cause severe stomach cramps. The only medication that can effectively stop the virus from spreading has severe side-effects. Although the virus will not kill her, the student suffers from a chronic immune deficiency that will make her die from these side-effects.
	Would you give the student the medication in this case?	Would you give the student the medication in this case?
Prescriptive Norm Prescribes Action	You are the director of a hospital in a developing country. A foreign student who is volunteering in the country got infected with a rare virus.	You are the director of a hospital in a developing country. A foreign student who is volunteering in the country got infected with a rare virus.
	The virus is highly contagious and can cause severe stomach cramps. The student suffers from a chronic immune deficiency that will make her die from the virus if she is not returned to her home country for special treatment. However, taking her out of quarantine involves a considerable risk that the virus will spread.	The virus is highly contagious and deadly to seniors and children. The student suffers from a chronic immune deficiency that will make her die from the virus if she is not returned to her home country for special treatment. However, taking her out of quarantine involves a considerable risk that the virus will spread.
	Would you take the student out of quarantine to return her to her home country for treatment in this case?	Would you take the student out of quarantine to return her to her home country for treatment in this case?

Figure 1. CNI model of moral decision-making predicting action versus inaction responses in moral dilemmas with proscriptive and prescriptive norms and consequences involving benefits of action that are either greater or smaller than costs of action. Figure adapted from Gawronski, Armstrong, Conway, Friesdorf, and Hütter (2017). Reprinted with permission.



Proscriptive Norm Prohibits Action		Prescriptive Norm Prescribes Action	
Benefits of Action Greater than Costs	Benefits of Action Smaller than Costs	Benefits of Action Greater than Costs	Benefits of Action Smaller than Costs
action	inaction	action	inaction
inaction	inaction	action	action
inaction	inaction	inaction	inaction
action	action	action	action