An fMRI Investigation of Emotional Engagement in Moral Judgment
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tecting. The liposomes were created by sonication. To probe the proteome chips, 60 µl of the different liposomes were added onto different chips. The chips were incubated in a humidity chamber for 1 hour at RT. After washing with TBS buffer for three times, C34-conjugated streptavidin (1:5000 dilution) was added to the chip and incubated for 30 min at RT.

Positives were identified using a combination of the GenePix software which computes a local intensity background for each spot and a series of algorithms we developed. Details can be found at http://bioinfo.mbb.yale.edu/proteinchip and at www.sciencemag.org/cgi/content/full/1062191/DC1.


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The long-standing rationalist tradition in moral psychology emphasizes the role of reason in moral judgment. A more recent trend places increased emphasis on emotion. Although both reason and emotion are likely to play important roles in moral judgment, relatively little is known about their neural correlates, the nature of their interaction, and the factors that modulate their respective behavioral influences in the context of moral judgment. In two functional magnetic resonance imaging (fMRI) studies using moral dilemmas as probes, we apply the methods of cognitive neuroscience to the study of moral judgment. We argue that moral dilemmas vary systematically in the extent to which they engage emotional processing and that these variations in emotional engagement influence moral judgment. These results may shed light on some puzzling patterns in moral judgment observed by contemporary philosophers.

The present study was inspired by a family of ethical dilemmas familiar to contemporary moral philosophers (1). One such dilemma is the trolley dilemma: A runaway trolley is headed for five people who will be killed if it proceeds on its present course. The only way to save them is to hit a switch that will turn the trolley onto an alternate track of five people. In this scenario, the only way to save the five people is to push this stranger off the bridge, onto the tracks below. He will die if you do this, but his body will stop the trolley from reaching the five people. Ought you to save the five others by pushing this stranger to his death? Most people say no.

Taken together, these two dilemmas create a puzzle for moral philosophers: What makes it morally acceptable to sacrifice one life to save five in the trolley dilemma but not in the footbridge dilemma? Many answers have been proposed. For example, one might suggest, in a Kantian vein, that the difference between these two cases lies in the fact that in the footbridge dilemma one literally uses a fellow human being as a means to some independent end, whereas in the trolley dilemma the unfortunate person just happens to stand next to a larger stranger on a footbridge that spans the tracks, in between the oncoming trolley and the five people. In this scenario, the only way to save the five people is to push this stranger off the bridge, onto the tracks below. He will die if you do this, but his body will stop the trolley from reaching the five people. Ought you to save the five others by pushing this stranger to his death? Most people say no.

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be in the way. This answer, however, runs into trouble with a variant of the trolley dilemma in which the track leading to the one person loops around to connect with the track leading to the five people (1). Here we will suppose that without a body on the alternate track, the trolley would, if turned that way, make its way to the other track and kill the five people as well. In this variant, as in the footbridge dilemma, you would use someone’s body to stop the trolley from killing the five. Most agree, nevertheless, that it is still appropriate to turn the trolley in this case in spite of the fact that here, too, we have a case of “using.” These are just one proposed solution and one counterexample, but together they illustrate the sort of dialectical difficulties that all proposed solutions to this problem have encountered. If a solution to this problem exists, it is not obvious. That is, there is no set of consistent, readily accessible moral principles that captures people’s intuitions concerning what behavior is or is not appropriate in these and similar cases. This leaves psychologists with a puzzle of their own: How is it that nearly everyone manages to conclude that it is acceptable to sacrifice one life for five in the trolley dilemma but not to conclude that it is acceptable to sacrifice (relatively rare) individuals who nevertheless judge this action to be appropriate to do so against a countervailing emotional response and to exhibit longer reaction times as a result of this emotional interference. More generally, we predicted longer reaction times for trials in which the participant’s response is incongruent with the emotional response (e.g., saying “appropriate” to a dilemma such as the footbridge dilemma). We predicted the absence of such effects for dilemmas such as the trolley dilemma which, according to our theory, are less likely to elicit a strong emotional response.

In each of two studies, Experiments 1 and 2, we used a battery of 60 practical dilemmas (8). These dilemmas were divided into “moral” and “non-moral” categories on the basis of the responses of pilot participants (8). (Typical examples of non-moral dilemmas posed questions about whether to travel by bus or by train given certain time constraints and about which of two coupons to use at a store.) Two independent coders evaluated each moral dilemma using three criteria designed to capture the difference between the intuitively “up close and personal” (and putatively more emotional) sort of violation exhibited by the footbridge dilemma and the more intuitively impersonal (and putatively less emotional) violation exhibited by the trolley dilemma (8, 9). Moral dilemmas meeting these criteria were assigned to the “moral-personal” condition, the others to the “moral-impersonal” condition. Typical moral-personal dilemmas included a version of the footbridge dilemma, a case of stealing one person’s organs in order to distribute them to five others, and a case of throwing people off a sinking lifeboat. Typical moral-impersonal dilemmas included a version of the trolley dilemma, a case of keeping money found in a lost wallet, and a case of voting for a policy expected to cause more deaths than its alternatives. Participants responded to each dilemma by indicating whether they judged the action it proposes to be “appropriate” or “inappropriate.”

In each experiment, nine participants (10) responded to each of 60 dilemmas (11) while undergoing brain scanning using fMRI (12). Figures 1 and 2 describe brain areas identified in Experiment 1 by a thresholded omnibus analysis of variance (ANOVA) performed on the functional images (13). In each case, the

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**Fig. 1.** Effect of condition on activity in brain areas identified in Experiment 1. R, right; L, left; B, bilateral. Results for the middle frontal gyrus were not replicated in Experiment 2. The moral-personal condition was significantly different from the other two conditions in all other areas in both Experiments 1 and 2. In Experiment 1 the medial frontal and posterior cingulate gyri showed significant differences between the moral-impersonal and non-moral conditions. In Experiment 2, only the posterior cingulate gyrus was significantly different in this comparison. Brodmann’s Areas and Talairach (28) coordinates (x, y, z) for each area are as follows (left to right in graph): 9/10 (1, 52, 17); 31 (−4, −54, 35); 46 (45, 36, 24); 74/0 (−48, −65, 26); 74/0 (50, −57, 20).

**Fig. 2.** Brain areas exhibiting differences in activity between conditions shown in three axial slices of a standard brain (28). Slice location is indicated by Talairach (28) z coordinate. Data are for the main effect of condition in Experiment 1. Colored areas reflect the thresholded F scores. Images are reversed left to right to follow radiologic convention.
ANOVA identified all brain areas differing in activity among the moral-personal, moral-impersonal, and non-moral conditions. Planned comparisons on these areas revealed that medi- 
portions of Brodmann’s Areas (BA) 9 and 10 (medial frontal gyrus), BA 31 (posterior cingulate gyrus), and BA 39 (angular gyrus, bilateral) were significantly more active in the moral-personal condition than in the moral-impersonal and the non-moral conditions. Recent functional imaging studies have associated each of these 
areas with emotion (5, 14–16). Areas associat- 
ed with working memory have been found to 
become less active during emotional processing 
as compared to periods of cognitive processing 
(17). BA 46 (middle frontal gyrus, right) and 
BA 7/40 (parietal lobe, bilateral)—both 
associated with working memory (18, 19)—were 
significantly less active in the moral-personal 
condition than in the other two conditions. In 
BA 39 (bilateral), BA 46, and BA 7/40 (bilat- 
eral), there was no significant difference be- 
tween the moral-impersonal and the non-moral 
condition (20, 21).

Experiment 2 served to replicate the 
results of Experiment 1 (22) and to provide 
behavioral data concerning participants’ 
judgments and reaction times. Planned 
comparisons on the seven brain areas iden- 
tified in Experiment 1 yielded results nearly 
identical to those of Experiment 1 with the 
following differences. In Experiment 2 there 
was no difference in BA 9/10 between the 
moral-impersonal and non-moral conditions, 
and no differences were found for 
BA 46 (23).

Reaction time data from Experiment 2 are 
described by Fig. 3. Our theory concerning 
emotional interference predicted longer reac- 
tion times for emotionally incongruent respons- 
es, which occur when a participant responds “appropriate” in the moral-personal condition 
(e.g., judging it “appropriate” to push the man 
off the footbridge in the footbridge dilemma) 
but which do not occur in the moral-impersonal 
and non-moral conditions. As predicted, re- 
sponses of “appropriate” (emotionally incon- 
gruent) were significantly slower than responses 
of “inappropriate” (emotionally congruent) 
within the moral-personal condition, and there 
was no significant difference in reaction time 
time between responses of “appropriate” and “inap- 
propriate” in the other two conditions. In fact, 
the data exhibit a trend in the opposite direction 
for the other two conditions (24), with responses 
of “inappropriate” taking slightly longer than 
responses of “appropriate.”

In each of the brain areas identified in both 
Experiments 1 and 2, the moral-personal condi-
tion had an effect significantly different from 
both the moral-impersonal and the non-moral 
conditions. All three areas showing increased 
relative activation in the moral-personal condi-
tion have been implicated in emotional process-
ing. The behavioral data provide further evi-
dence for the increased emotional engagement 
within the moral-personal condition by revealing a re-
tion time pattern that is unique to that condi-
tion and that was predicted by our hypothesis 
concerning emotional interference. Moreover, 
the presence of this interference effect in the 
behavioral data strongly suggests that the in-
creased emotional responses generated by the 
moral-personal dilemmas have an influence on 
and are not merely incidental to moral judg-
ment (25). These data also suggest that, in terms 
of the psychological processes associated with 
their production, judgments concerning “imper-
sonal” moral dilemmas more closely resemble 
judgments concerning non-moral dilemmas 
than they do judgments concerning “personal” 
do moral dilemmas.

The trolley and footbridge dilemmas emerged as pieces of a puzzle for moral philos-
ophers: Why is it acceptable to sacrifice one person to save five others in the trolley dilemma 
but not in the footbridge dilemma? Here we 
consider these dilemmas as pieces of a psycho-
ological puzzle: How do people manage to 
conclude that it is acceptable to sacrifice one for 
the sake of five in one case but not in the other? 
We maintain that emotional response is likely to be 
the crucial difference between these two cases. 
But this is an answer to the psychological 
puzzle, not the philosophical one. Our conclusion, 
therefore, is descriptive rather than prescriptive. 
We do not claim to have shown any actions or 
judgments to be morally right or wrong. Nor 
have we argued that emotional response is the 
sole determinant of judgments concerning mor-
al dilemmas of the kind discussed in this study. 
On the contrary, the behavioral influence of 
these emotional responses is most strongly sug- 
gested in the performance of those participants 
who judge in spite of their emotions.

What has been demonstrated is that there are 
systematic variations in the engagement of 
emotion in moral judgment. The system-
atic nature of these variations is manifest in 
an observed correlation between (i) certain 
features that differ between the trolley dilemma 
and the footbridge dilemma and (ii) pat-
terns of neural activity in emotion-related 
brain areas as well as patterns in reaction 
time. Methodological constraints led us to 
characterize these “certain features” by 
means of a highly regimented distinction be-
tween actions that are “personal” and “imper-
sonal” (8). This personal-impersonal distinc-
tion has proven useful in generating the 
present results, but it is by no means defini-
tive. We view this distinction as a useful 
“first cut,” an important but preliminary step 
toward identifying the psychologically essen-
tial features of circumstances that engage (or 
fail to engage) our emotions and that ulti-
mately shape our moral judgments—judg-
ments concerning hypothetical examples 
such as the trolley and footbridge dilemmas 
but also concerning the more complicated 
moral dilemmas we face in our public and 
private lives. A distinction such as this may 
allow us to steer a middle course between the 
traditional rationalism and more recent emo-
tivism that have dominated moral psychology 
(26).

The present results raise but do not answer a 
more general question concerning the relation 
between the aforementioned philosophical and 
psychological puzzles: How will a better under-
standing of the mechanisms that give rise to 
our moral judgments alter our attitudes toward 
the moral judgments we make?

References and Notes
2. A. R. Damasio, Descartes’ Error (Putnam, New York, 1994).
7. Testing materials (dilemmas) are available from Scien-
ce Online at www.sciencemag.org/cgi/content/ 
full/293/5537/2105/DC1.
8. The three criteria are as follows: First, coders indicated for each dilemma whether the action in question could 
reasonably be expected to lead to serious bodily harm.” Second, they were asked to indicate whether 
this harm would “be the result of deflecting an existing threat onto a different person.” Our use of this criterion, 
which parallels a distinction made by Thomson (1), is an 
an attempt to operationalize an intuitive notion of 
“agency.” Intuitively, when a harm is produced by 
means of deflecting an existing threat, the agent has 
merely “edited” and not “authorized” the resulting harm, 
and thus its contemplation is less emotionally engaging. 
Lastly, coders were asked to indicate whether the re-
sulting harm would “befall a particular person or a 
member or members of a particular group of people.” 
Here the question, in intuitive terms, is whether the 
victim is “on stage” in the dilemma. The moral dilem-
as of which the coders said that the action in question 
(a) could reasonably be expected to lead to serious 
bodily harm (b) to a particular person or a member 
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or members of a particular group of people (c) where this 
action is “on stage” in the dilemma. The moral dilem-
as of which the coders said that the action in question
personal” condition; the others were assigned to the “moral-impersonal” condition.

10. Participants were five male and four female undergraduates in Experiment 1, four male and five female in Experiment 2. All participants provided written informed consent.

11. Dilemmas were presented in random order in a series of six blocks of ten trials each in Experiment 1, twelve blocks of five trials each in Experiment 2. Participants’ responses to versions of the trolley and footbridge dilemmas were consistent with the intuitions described above (8).

12. Stimuli (dilemmas) were presented on a visual display prototype scanner. Each dilemma was presented as text through a series of three screens, the first two describing a scenario and the last posing a question about the appropriateness of an action one might perform in that scenario (e.g., turning the trolley). Participants were allowed to read at their own pace, pressing a button to advance from the first to the second screen and from the second to the third screen. After reading the third screen participants responded by pressing one of two buttons (“appropriate” or “inappropriate”). Participants were given a maximum of 46 s to read all three screens and press the response button. For the last four images of the ITI, task-related activity was measured using a “floating window” of eight images surrounding (four before, one during, and three after) the point of response. These images were post-response images in order to allow for the 4- to 6-s delay in hemodynamic response to neural activation. This “floating window” technique combined the benefits of an event-related paradigm with the increased flexibility required to image a complex and temporarily extended psychological process that inevitably proceeds at its own pace. In Experiment 1, functional images were acquired in 20 axial slices acquired through the AC-PC (anterior commissure–posterior commissure) line.[spiral pulse sequence; repetition time (TR), 2000 ms; echo time (TE), 45 ms; flip angle, 80°; field of view (FOV), 240 mm; 3.75-mm isotropic voxels] using a 1.5-T GE Signa whole-body scanner. In Experiment 2, functional images were acquired in 22 axial slices parallel to the AC-PC line[ecoplanar pulse sequence; TR, 2000 ms; TE, 25 ms; flip angle, 80°; FOV, 192 mm; 3.0-mm isotropic voxels; 1-mm interstice spacing] using a 3.0-T Siemens Allegra head-dedicated scanner.

13. Before statistical analysis, images for all participants were coregistered using a 12-parameter automatic algorithm. Images were smoothed with an 8-mm full width at half maximum (FWHM) 3D Gaussian filter. In Experiment 1, the images contained in each response window were analyzed with the use of a voxelwise mixed-effects ANOVA with participant as a random effect, and dilemma-type, block, and response-relative image as fixed effects. Statistical maps of voxelwise F-ratios were thresholded for significance (P < 0.0005) and cluster size (≥8 voxels). In Experiments 1 and 2, planned comparisons for significant differences between conditions (P < 0.05, cluster size ≥8 voxels) were made for each condition identified by the thresholded ANOVA in Experiment 1.


20. In BA 7/40 (right) a small minority of voxels (10 of 91) showed a significant difference between the moral-impersonal and non-moral conditions.

21. Due to magnetic susceptibility artifact we were unable to image the orbitofrontal cortex, an area thought to play some important role in moral judgment (3).

22. Experiments 1 and 2 were not identical (8). Experiment 2 employed some modified versions of dilemmas from Experiment 1 as well as some new dilemmas in order to avoid a confound present in the design of the behavioral aspect of Experiment 1 (24).

23. The replicated results for BAs 9/10, 31, and bilateral 7/40 were achieved at a higher significance threshold in Experiment 2 (P < 0.01) than in Experiment 1.

24. A potential confound in the design of the behavioral aspect of the present study deserves attention. One might suppose that participants respond more slowly when giving an “unconventional” response, i.e., a response that differs from that of the majority. One might suppose further that the moral-personal condition makes greater use of dilemmas for which the emotionally incongruent response is also the unconventional response (as in judging that one may push the man off the footbridge in the footbridge dilemma), thus confounding emotional incongruity with unconventionality in participants’ responses. Therefore, an effect that we attribute to emotional engagement may simply be an effect of the conventionality of participants’ responses. To deconfound these factors, in Experiment 2 we included additional moral-personal dilemmas for which the conventional response was emotionally incongruent rather than congruent. For example, one dilemma asked whether it is appropriate to shoot down a plane (as in judging that one may prevent its crying from summoning enemy soldiers who will kill oneself, the baby, and a number of others if summed). Most participants judged this action to be appropriate in spite of their putative emotional tendencies to the contrary. As predicted by our hypothesis, reaction times in such cases were significantly longer [t (8) = 4.333, P < 0.0001] than the reaction time to the conventional and emotionally congruent responses, as were typically made in response to the footbridge dilemma. Thus, after controlling for conventionality, reaction times in the moral-personal condition are longer for trials which, according to our theory, reflect a judgment that is emotionally incongruent rather than congruent.

25. Although our conclusion concerning the behavioral influence of the observed emotional responses does not require that the emotion-related areas identified in Experiments 1 and 2 be different from areas that show increased activity in response to more basic kinds of emotional stimuli, one might wonder to what extent they do differ from such areas. We made a preliminary attempt to answer this question in the form of an addendum study to Experiment 1. Five participants responded to moral-personal and moral-impersonal dilemmas as in Experiments 1 and 2. Participants also performed a task in which they named the colors of visually presented emotional and neutral words, a task similar to the one used by Isenberg et al. (27). The emotional word stimuli were extracted from the text of the moral dilemmas by three independent coders. Neutral words and additional emotional words were drawn from materials used by Isenberg et al. (27). A comparison of the emotional and neutral word conditions (t test, P < 0.05, cluster size ≥8 voxels) revealed no significant activation in the emotion-related areas identified in Experiment 1 and only a marginal activation (9 out of 123 voxels) in one of the working memory areas (left BA 7/40). This comparison did, however, reveal activations in numerous other areas. A comparison of the moral-personal and moral-impersonal conditions from the same five sessions replicated the activations observed in Experiments 1 and 2 in BA 9/10 (55 of 64 voxels at P < 0.05) and left BA 7/40 (40 of 123 voxels at P < 0.05). These results demonstrate, at the very least, that the effects observed in Experiments 1 and 2 in the medial frontal gyrus (BA 9/10) cannot be attributed to the mere reading of emotional words. This area, more than any of the others we have identified, is likely to play a role in the integration of emotion and cognition in complex decision-making (5, 6).


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BAFF-R, a Newly Identified TNF Receptor That Specifically Interacts with BAFF

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B cell homeostasis has been shown to critically depend on BAFF, the B cell activation factor from the tumor necrosis factor (TNF) family. Although BAFF is already known to bind two receptors, BCMA and TACI, we have identified a third receptor for BAFF, which we term BAFF-R.

The TNF family ligand BAFF, also known as TALL-1, THANK, BLYS, and zTNF4 (5–7), enhances B cell survival in vitro (6) and has recently emerged as a key regulator of peripheral B cell populations in vivo. Mice overexpressing BAFF display mature B cell hyperplasia and symptoms of systemic lupus erythematosus (SLE) (7). Likewise, some SLE patients have significantly increased levels of BAFF in their...