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Counterintuitive Moral Judgement following Traumatic Brain Injury

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Abstract

Several neurological patient populations, including Traumatic Brain Injury (TBI), appear to produce an abnormally ‘utilitarian’ pattern of judgements to moral dilemmas; they tend to make judgements that maximise the welfare of the majority, rather than deontological judgements based on the following of moral rules (e.g., do not harm others). However, this patient research has always used extreme dilemmas with highly valued moral rules (e.g., do not kill). Data from healthy participants, however, suggests that when a wider range of dilemmas are employed, involving less valued moral rules (e.g., do not lie), moral judgements demonstrate sensitivity to the psychological intuitiveness of the judgements, rather than their deontological or utilitarian content (Kahane et al., 2011). We sought the moral judgements of 30 TBI participants and 30 controls on moral dilemmas where content (utilitarian/deontological) and intuition (intuitive/counterintuitive) were measured concurrently. Overall TBI participants made utilitarian judgements in equal proportions to controls; disproportionately favouring utilitarian judgements *only when* they were counterintuitive, and deontological judgements *only when* they were counterintuitive. These results speak against the view that TBI causes a specific utilitarian bias, suggesting instead that moral intuition is broadly disrupted following TBI.

Keywords: moral judgement; social cognition; emotion; traumatic brain injury; decision making

Research on the cognitive and neural bases of moral judgments has blossomed in the last 15 years and a clear finding appears to have emerged: utilitarian judgements (i.e., those that maximise aggregate welfare) are associated with increased activation in a core group of frontal brain areas implicated in deliberate controlled processing; deontological judgements (i.e., those judgements that conform to moral laws) are associated with those brain areas associated with automatic processing (Greene et al., 2001, 2004, 2008). Moral judgement has also been investigated in neurological populations with frontal lobe lesions (Ciaramelli et al., 2007; Koenigs et al., 2007) and Traumatic Brain Injury (TBI; Martins et al., 2012); populations who characteristically show emotional blunting, impaired empathy and social cognition, egocentrism (Mitchell et al., 2006; Müller et al., 2003) and demonstrate socially inappropriate behaviour (Beer et al., 2006; Cicerone & Tanenbaum, 1997; Pitman et al., 2014). This profile is observed routinely in TBI, where neuropathology is caused by an impact to, or rapid acceleration/deceleration of, the brain (Lezak et al., 2012). Neural damage is characteristically diffuse in TBI, but the frontal cortex is especially vulnerable to lesion (Lezak et al., 2012). In addition, subcortical and white matter tract damage caused by traumatic axonal injury compromises the integrity of neural networks, causing disruption of functions reliant on the integrity of these networks (Hayes et al., 2016; Lipton et al., 2009). In this study we investigate the moral judgements made by TBI patients to further our understanding of the cognitive and neural bases of moral judgement.

In a two-system cognitive account of moral judgement, Greene et al. (2004) characterize ‘system 1’ as the rapid and automatic processes delivering moral judgement, while higher order processes of deliberative reasoning are engaged by ‘system 2’. The automatic system biases toward ‘deontological’ moral judgements – judgements that conform to moral laws such as *do not lie; do not harm others* (Kant, 1785/1959), whereas controlled processing allows us to override these judgements in favour of more *reasoned* ‘utilitarian’ judgements – ones that maximise aggregate welfare (Greene et al., 2008). Greene et al (2004) provide data to support this assertion. In dilemmas where utilitarian judgements required the maiming or killing of another person (e.g., the infamous “trolley dilemma”, where participants are asked whether they should pull a lever to divert the course of a train condemning one bystander to death but saving five others) participants took longer to endorse utilitarian actions than deontological ones. Additionally, neural activity in dorsolateral prefrontal and anterior cingulate cortices, (areas associated with controlled processing) correlated with utilitarian moral judgement. This was taken as evidence for the involvement of effortful cognition in utilitarian judgements, both in these extreme scenarios and more broadly (Greene et al., 2001, 2004, 2008).

However data from patient studies would appear to pose a problem for Greene's model. Populations with TBI (Martins et al., 2012), circumscribed ventromedial prefrontal cortex (VMPFC) lesions (Ciaramelli et al., 2007; Koenigs et al., 2007), fronto-temporal dementia (Mendez et al., 2005) and psychopathy (Koenigs et al., 2012) all show a utilitarian bias compared to healthy controls in moral dilemmas, which appears at odds with the view that these judgements require careful and controlled moral processing. One explanation for this is that patients have impairments in social cognition (e.g., empathy, perspective taking, Theory of Mind) and consequently have a reduced aversion to harming others (i.e., a reduced aversion to killing the lone protagonist in the service of saving many others – see the example above). Support for this idea is seen in skin conductance response (SCR) studies: a strong skin conductance response (SCR) precedes utilitarian judgements in healthy controls, but no such response is seen when patients with VMPFC lesions make identical judgements (Moretto et al., 2010). Further, in healthy participants, reduced aversion to harming others (Cushman et al., 2012), lower trait empathy (Choe & Min, 2011), and higher psychoticism (characterised by reduced empathy and emotional blunting; Weich et al., 2013) all correlate with increased levels of utilitarian judgement.

Taken together then, the evidence suggests a link between social cognition and utilitarian judgements in both clinical and non-clinical populations, and that this link may arise because the extent of our aversion to harming others may influence how appealing utilitarian solutions to moral dilemmas are. In the present study we therefore included measures of social cognition alongside moral dilemmas.

Another problem for the two systems theory is that only extreme moral dilemmas have been employed to test it, where utilitarian judgements required the violation of highly regarded deontological rules, such as *do not kill.* As such, the observed association between controlled processing and utilitarian judgement could be due to an artefact of the limited range of dilemmas employed. One possibility is that in extreme dilemmas, deontological judgements are more psychologically intuitive, whereas utilitarian judgements are psychologically counterintuitive. This possibility has *prima facie* appeal; judgements which endorse murder in the service of aggregate welfare might not be immediately appealing, whereas judgements which only require a lie or a broken promise may be immediately compelling, or intuitive.

For this reason then, Kahane and colleagues (2011) devised new dilemmas which captured the tension between maximising aggregate welfare and adherence to moral rules, while controlling for psychological intuitiveness. They collected normative data for these dilemmas; recording the non-reflective judgements of a group of independent judges and assigning dilemmas to one of two categories. A dilemma was categorised as *Intuitively Utilitarian (UI)* when most judges intuitively violated the moral rule in order to maximise aggregate welfare. For example:

> "You know a man called Fred. Fred is a prejudiced and grumpy person who often takes a disliking to people for no good reason. You also have a friend who admires Fred and gives great weight to his opinions. However, Fred despises your friend. One day, your friend asks you what Fred thinks of him. Your friend would be devastated to discover that Fred despises him, but will only find out if you tell him. Should you tell your friend that Fred despises him?" [Adapted from the original]

In this case, normative data indicated that people disregarded the deontological rule "do not lie" in favour of the course of action which maximised welfare (preserving your friend's self-esteem) and so it was categorised as a UI dilemma. Thus, a utilitarian judgement in these dilemmas is also an "intuitive" judgement, whilst a deontological judgement is a "counterintuitive" judgement.

Conversely, dilemmas were categorised as *Intuitively Deontological* (DI) when most judges upheld the deontological rule. This category involved deontological rules which were considered more absolute, such as the impermissibility of killing. For example:

> "You are a Doctor. You have five very poorly patients who are all about to die of various failing organs. You have another patient who is healthy. The only way you

> can save the lives of the first five patients is to remove this man's organs, and transplant them into the five poorly patients. The healthy man does not want you to take away his organs. If you do this, the health man will die, and the five will live. Should you perform these transplants?" [Adapted from the original]

The normative sample overwhelmingly rejected utilitarianism here, choosing to uphold the deontological rule despite the net harm (five deaths rather than one). As such, this was categorised as a DI dilemma. In this category then, a utilitarian judgement is a "counterintuitive" judgement, and a deontological judgement is an "intuitive" judgement (the exact inverse of the UI dilemmas, thus allowing preferences for utilitarian and deontological judgements to be measured independently of their intuitiveness).

In an fMRI study using these new stimuli (Kahane et al., 2011), the previously reported neural and behavioural association between controlled processing and utilitarian judgements disappeared. Healthy participants rated counterintuitive judgements as more difficult than intuitive judgements, but did not rate utilitarian judgements as more difficult than deontological ones. Furthermore, the pattern of neural activation was related to the intuitiveness of judgements.

During counterintuitive judgements, activation was recorded in the rostral and dorsal cingulate cortex, primary and secondary somatosensory cortex, insula, ventro-lateral prefrontal cortex, and lateral orbitofrontal cortex, irrespective of the (deontological/utilitarian) content of the judgement. Kahane and colleagues (2011) concluded that previous findings associating utilitarian judgements with controlled processing were an artefact of the limited dilemmas employed, and that healthy people use controlled processing when making any counterintuitive moral judgement, regardless of its content (though see Paxton et al, 2014). They note, however, that it remains unclear precisely *which* controlled processes are involved in moral judgements (e.g., inhibitory control, attentional flexibility or working memory).

During intuitive judgements, activation was recorded in the visual, premotor, and ventromedial prefrontal cortices, and the temporal lobe; areas which have been associated with various aspects of social cognition: empathy (Nummenmaa et al., 2008), affective Theory of Mind (ToM; Shamay-

Tsoory, Tibi-Elhanany & Aharon-Peretz, 2006) and emotional perspective taking (Lamm et al., 2007). Indeed, a trait tendency towards empathy increases preference for deontological judgements in extreme dilemmas (Crockett, Clark, Hauser & Robbins, 2010; Gleichgerrcht & Young, 2013). ToM in particular is understood to rely on a distributed cortical and subcortical network comprising (at least) the medial prefrontal cortex, left and right temporo-parietal junctions, the temporal poles, and the amygdala circuitry (Apperly, 2011; Siegal & Varley, 2002). It is noteworthy that the VMPFC, a necessary area for affective ToM (Shamay-Tsoory, Tibi-Elhanany & Aharon-Peretz, 2006), was implicated in intuitive moral judgement in Kahane and colleagues' fMRI study.

In sum then, the evidence suggests that the intuitiveness of a moral judgement, rather than its content, is the key factor in controlled versus automatic processing, and thus there is reason to doubt reports of utilitarian bias in focal frontal injury, TBI, and other clinical populations including autism, fronto-temporal dementia and psychopathy (Ciaramelli et al., 2007; Gleichgerrcht et al., 2013; Koenigs et al., 2007; Martins et al., 2012; Mendez et al., 2005), as all of these studies employed a limited range of extreme dilemmas which did not control for intuitiveness. It also appears that social cognition, including empathy and ToM likely play a role in moral judgement. Moreover, a wealth of evidence demonstrates that ToM is compromised following TBI (Bibby & McDonald, 2005; Martín-Rodríguez & León-Carrión, 2010; Muller et al., 2010), as are other abilities implicated in moral judgement, such as empathy and emotional expressiveness and regulation (Beer et al., 2006; Cicerone & Tanenbaum, 1997; Mitchell et al., 2006; Müller et al., 2003; Pitman et al., 2014; Stuss, 2011).

The present study

To date, no study has investigated the effect of brain pathology on both content and intuitiveness in moral judgement, and therefore their relative importance in explaining atypical moral judgement patterns is unknown. In order to address this issue, the present study employed a cross-sectional case-control design in which participants with TBI and healthy controls gave their moral judgements on dilemmas devised by Kahane and colleagues (2011). Participants also completed a range of social cognition measures and cognitive assessments.

If TBI causes a *specific* bias towards utilitarianism, then these participants should make more utilitarian judgements compared to controls, regardless of intuitiveness. Such a finding would suggest that the content (utilitarian/deontological) of moral judgement is relevant to the processes of automatic and controlled moral judgement, and would support, and extend previous findings to less extreme dilemmas involving lying and breaking promises.

However, if intuitiveness is the crucial factor, TBI participants should make more utilitarian judgements than controls only in DI dilemmas, *where utilitarianism is counterintuitive*. This would indicate that the neural networks impacted by TBI are not sensitive to the content of a judgement *per se*, but instead its intuitiveness.

In dilemmas where the utilitarian option is *intuitive*, it remains unclear whether TBI participants would show a preference for counterintuitive judgements. One possibility is that TBI causes a preference for counterintuitive judgements only in extreme (DI) dilemmas where serious physical harm is at stake. Alternatively, TBI may result in a general tendency to make counterintuitive judgements, irrespective of dilemma type.

Finally, if reduced aversion to harm underlies counterintuitive judgement following TBI, then the TBI group should be able to make these judgements with relative ease. As such, we expect TBI participants to find counterintuitive responses easier to make compared to controls, within both UI and DI dilemmas. In addition, if disruption of social cognition modulates moral judgement disturbance following TBI, then ToM processes (particularly its emotional components) should be associated with counterintuitive moral judgement.

Method

Participants

Thirty adults (5 female; mean age = 41.3 (SD = 13.67)) with non-penetrating TBI were recruited via NHS community neuropsychology services, Brain Injury Rehabilitation Trust inpatient and community services and the Headway charity across England. Inclusion criteria were: (1) history of TBI, (2) at least 12 months post-injury, (3) fluent in English. Exclusion criteria were: (1) significant visual, perceptual or language impairment, (2) TBI incurred before 18 years, (3) other neurological disorder, (4) current major depressive disorder, PTSD or psychosis, (5) developmental disorder. Self-report was the primary method used to determine eligibility, although the medical records of those recruited from clinical services were screened for eligibility in the first instance by treating clinicians.

TBI severity was categorised according to available information on post-traumatic amnesia (PTA) duration, length of unconsciousness (LOC) and lowest Glasgow Coma Scale (GCS; Jones, 1979) score, in that order of preference. Table 1 displays cut-offs for injury severity categorisation and the number of TBI participants in each category.

Thirty healthy controls (11 female; mean age = 39.8 (SD = 14.56)) were recruited to match the demographic of TBI participants. Exclusion criteria were: (1) neurological disorder, (2) current major depressive disorder, PTSD or psychosis, (3) developmental disorder. All participants gave informed consent and the study was approved by an NHS research ethics committee, in accordance with the Declaration of Helsinki (1991).

The TBI and control groups were comparable in terms of gender [X^2 (2, 60) = 3.068, p = .080] and level of education [U = 404.5, z = -0.706, p = .480]. The groups did not differ significantly in age or the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983) scores, but differed significantly in verbal (VIQ), performance (PIQ) and full scale (FSIQ) intellectual ability as measured by the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) (see Table 2).

Materials and procedure

All participants were tested on a range of moral dilemmas followed by testing on a number of social cognition, IQ and depression and anxiety measures.

Moral Dilemmas: Ten of the eighteen dilemmas from Kahane et al (2011) were adapted for the study. These were selected to encompass the range of deontological rules involved in the originals, comprising five UI and five DI dilemmas. The dilemmas were rearranged into storyboards and cartoon drawings were created to aid comprehension (see supplementary data). In a piloting exercise, two groups (total n = 18) of independent judges gave their *non-reflective* responses to the original or the adapted dilemmas. On average, judges placed each dilemma in its originally assigned category 77% of the time (range = 67% - 100%) (see supplementary data), and as such all ten of the adapted dilemmas retained their original categorisation based on previously employed cut-off of 67% agreement (Kahane et al., 2011).

Dilemmas were presented to participants first, in a fixed randomized order on laminated paper. The experimenter read the dilemmas aloud once, before inviting participants to make a judgement on what they *should* do. Participants were then asked to rate the difficulty of each judgement on a 1 (*not difficult at all*) to 10 (*very difficult*) scale. Answers to each dilemma were recorded and subsequently categorised (intuitive/counterintuitive; utilitarian/deontological).

Social Cognition measures: In a perspective taking task (Tversky & Hard, 2009) participants were shown a photograph and asked to give the spatial location of an object, where the answer differed depending on whether participants took their own or another's visual perspective. This was taken as a measure of spontaneous perspective taking (an automatic process relevant to ToM). Participants were then administered the WASI (Wechsler, 1999). Following a break, participants undertook the Faux Pas (FP) test (Stone, Baron-Cohen & Knight, 1998), which measures the ability to identify a social *faux pas*, and represent both the beliefs, intentions (cognitive ToM) and feelings (affective ToM) of characters involved. Then came the revised version of the Reading the Mind in the Eyes (RME: Baron-Cohen et al., 2001) which measured affective ToM by asking participants to ascribe an emotional experience to actors in 36 images of eyes, choosing one of four adjectives. Finally, participants completed the HADS (Zigmond & Snaith, 1983).

Data Analysis

Within Group Analyses

Moral judgement data was transformed into proportions for each participant. Proportions of intuitive and counterintuitive moral judgement were analysed separately for UI and DI dilemmas using one-sample t-tests, reporting 95% CI's. Preference for utilitarian versus deontological judgements were analysed similarly, pooled across all dilemmas. Mean proportions were tested against a value of 0.5; the value expected if participants showed no preference for either option during moral judgement. Paired-samples t-tests were used to compare difficulty ratings between intuitive and counterintuitive judgements in both UI and DI dilemmas, and between utilitarian and deontological judgements in all dilemmas.

Between Group Analyses

One way mixed ANOVA analysed differences between groups and dilemma type (UI/DI) in proportion of counterintuitive judgements. Dilemmas were then pooled across dilemma type and group differences in counterintuitive judgement were investigated using independent samples t-tests with 95% CI's. Group differences in utilitarian judgement were analysed similarly. As this data was proportional, the sum of intuitive and counterintuitive judgements (and utilitarian and deontological judgements) for each participant was 1.0.

The difficulty cost of selecting the counterintuitive response over the intuitive response, and the utilitarian response over the deontological response, was calculated by subtracting the latter from the former for each case. These were computed because both utilitarian judgements and counterintuitive judgements should theoretically be more difficult than their opposites, according to the positions of Greene and colleagues (2008) and Kahane and colleagues (2011). A one way mixed ANOVA was used to analyse the differences between groups and dilemma type in the difficulty cost of counterintuitive judgements. Again, all dilemmas were then pooled and group differences investigated using independent samples t-tests.

Social Cognition Analyses

Independent samples t-tests were employed to test for group differences on ToM and IQ variables and Pearson's correlation coefficients were calculated for the whole sample between moral judgement and cognitive variables. BCa 95% CI's are reported.

For the TBI group, ToM variables were entered into a hierarchical multiple regression model, with proportion of counterintuitive responses as the dependent variable. Bootstrapped-p-values were computed. Affective ToM variables (Faux Pas empathy and RME) were entered at step one, and the cognitive ToM variable (Faux Pas cognitive index) at step two. Bootstrapping was used in these analyses due to non-normal distribution in the Faux Pas data.

Results

Within Group Analyses

Control group moral judgements

The proportion of intuitive judgements was significantly higher than the 0.5 baseline in both UI [$t(29)$ =8.361, p <.001, 95% CI (.227,.373)] and DI [$t(29)$ = 4.110, p <.001, 95% CI (.101,.300)] dilemmas (see Figure 1A). The control group showed no significant preference for utilitarian (or deontological) judgements when all dilemmas were pooled together and compared against the 0.5 baseline [$t(29) = 1.455$, $p = .156$, 95% CI (-.019,.112)].

Control group difficulty ratings

Controls rated counterintuitive judgements as significantly more difficult than intuitive judgements in both UI [$t(19) = -3.931$, $p = .001$, 95% CI (-3.24,-.988)] and DI [$t(20) = -3.839$, $p = .001$, 95% CI (-3.987,-1.179)] dilemmas (see Figure 1 B). However difficulty ratings did not differ significantly between utilitarian and deontological judgements overall [$t(29) = 0.300$, $p = .766$, 95% CI (.543,.730)].

TBI group moral judgements

The proportion of intuitive judgements was significantly higher than the 0.5 baseline in UI [$t(29) = 3.137$, $p = .004$, 95% CI (.044,.209)], but not DI [$t(29) = 0.377$, $p = .709$, 95% CI (-.089,.129)] dilemmas (see Figure 1C). The TBI group showed no significant preference for utilitarian (or deontological) judgements when all dilemmas were pooled and compared against the 0.5 baseline [$t(29) = 1.306$, $p = .202$, 95% CI (-.028,.128)].

TBI group difficulty ratings

In the TBI group there was no significant difference in the difficulty ratings of intuitive versus counterintuitive judgements in UI [$t(26) = 0.232$, $p = .818$, 95% CI (-.703,.882)] or DI [$t(26) = 0.419$, $p = .679$, 95% CI (-.669,1.010)] dilemmas (see Figure 1D). Additionally, difficulty ratings did not differ significantly between utilitarian and deontological judgements overall [$t(29) = -0.180$, $p = .858$, 95% CI (-.644,.539)].

Between Group Analyses

Moral judgements

There was a main effect of group on the proportions of counterintuitive judgements [$F(1, 58) = 19.484$, $p < .001$], with more counterintuitive judgements in the TBI group, and a main effect of dilemma type [$F(1, 58) = 4.362$, $p = .041$], with more counterintuitive judgements in DI dilemmas. There was no significant group x dilemma type interaction [$F(1, 58) = 0.005$, $p = .947$].

Group comparisons pooled across both dilemma types (see Figure 2A) indicated that overall the TBI group made a significantly higher proportion of counterintuitive judgements than controls [$t(58) = 4.331$, $p < .001$, 95% CI (.093,.253)], but the two groups did not differ significantly in their preference for utilitarian judgements [$t(58) = 0.067$, $p = .947$, 95% CI (-.097,.103)].

Difficulty cost data

There was a main effect of group on the difficulty cost of counterintuitive judgements, with the control group exhibiting higher difficulty costs [$F(1, 33) = 27.065$, $p < .001$]. There was no significant effect of dilemma type [$F(1, 33) = 0.364$, $p = .550$] and no significant group x dilemma type interaction [$F(1, 33) = 0.154$, $p = .697$].

Group comparisons pooled across dilemma type revealed that the control and TBI groups differed significantly in the difficulty cost exhibited when they selected the counterintuitive response [$t(55) = -5.132$, $p < .001$, 95% CI (-2.938,-1.288)], with the control group exhibiting a higher mean difficulty cost than the TBI group (see Figure 2B). TBI and control groups did not differ significantly in the difficulty cost associated with utilitarian judgements [$t(58) = -0.342$, $p = .733$, 95% CI (-.996,.705)].

Social cognition

The TBI group attained significantly lower scores than controls on cognitive [$t(33.61) = -3.465$, $p = .004$, BCa 95% CI (-.112,-.031)] and affective [$t(30.31) = -3.360$, $p = .012$, BCa 95% CI (-.193,-.051)] Faux Pas indices, and the RME [$t(58) = -2.097$, $p = .035$, BCa 95% CI (-.136,-.011)]. There were no significant group differences in the tendency toward spontaneous perspective taking [$X^2(2, 60) = 0.084$, $p = .959$]. As such no further analyses of this measure were conducted.

Moral judgement and Social Cognition

Whole sample

Neither the proportion of utilitarian judgements nor the difficulty cost associated with utilitarian decisions significantly correlated with any ToM or IQ variables. However all IQ and ToM variables showed significant, generally moderate, correlations with the proportion of counterintuitive judgements (see Table 3).

TBI group

The first model in the regression equation, containing affective ToM variables, significantly predicted 20.6% of the variance [$F(2, 27) = 3.492$, $p = .045$]. In this model, only the RME contributed uniquely to prediction of counterintuitive judgements ($\beta = -.520$, $p = .022$). The second model, containing both cognitive and affective ToM variables, accounted for only 3.6% of additional variance in counterintuitive judgements (R^2 change = .036) and did not attain statistical significance [$F(3, 26) = 2.755$, $p = .063$].

Discussion

Previous research has demonstrated that several neurological patient populations, including Traumatic Brain Injury (TBI), produce utilitarian judgements to moral dilemmas (Ciaramelli et al., 2007; Koenigs et al., 2007; Martins et al., 2012; Mendez et al., 2005) although how best to interpret the data was unclear. The present study adapted moral dilemmas from previous research (Kahane et al., 2011), which allowed the intuitiveness of moral judgement to be controlled for, and applied these new dilemmas to participants with TBI for the first time.

Characterising Moral Judgement in TBI

Overall, our TBI participants made similar proportions of utilitarian judgements to controls - but they made substantially more counterintuitive judgements. On closer analysis, our TBI group did in fact show an atypical preference for utilitarian judgements under limited circumstances; disproportionately selecting utilitarian judgements in extreme moral dilemmas where the utilitarian option was counterintuitive (i.e. DI dilemmas similar to those used in previous research). However in more everyday dilemmas where utilitarianism was intuitive (i.e. UI dilemmas), our TBI participants were *less* likely than controls to endorse the utilitarian option, again favouring the counterintuitive (and incidentally, deontological) response. On this evidence then, TBI causes a generalised bias toward the counterintuitive option, not a specific bias towards utilitarianism.

These findings support the hypothesis that the distributed neural systems damaged by TBI are not sensitive to the deontological or utilitarian content of a judgement, but rather to how psychologically intuitive these judgements are. They speak directly against the assertion that TBI gives rise to atypically utilitarian judgements (Martins et al., 2012), and cast doubt more broadly on the generalisability of similar conclusions in other neurological populations (e.g. Ciaramelli et al., 2007; Koenigs et al., 2007; Mendez et al., 2005). Such studies may have been biased by the limited range of dilemmas they employed; our TBI participants made more counterintuitive judgements regardless of utilitarian or deontological content. Previous research has focussed exclusively on extreme dilemmas where a utilitarian response was counterintuitive – as a consequence counterintuitive judgements were able to masquerade as a tendency towards utilitarian judgements.

The generalised pattern of counterintuitive judgements reported here deviates somewhat from recent evidence that higher levels of psychoticism correlates selectively with increased levels of counterintuitive utilitarian judgements, but not counterintuitive deontological judgements (Weich et al., 2013). However, in the present study, 87% of the TBI group had suffered a severe or very severe TBI. Injuries of this type are known to cause extensive cortical and subcortical pathophysiology resulting in chronic and severe disturbances in executive functions, social cognition, judgement and decision making, and a host of supportive cognitive functions (Cicerone & Tanenbaum, 1997; Lezak et al,. 2012; Newcombe et al., 2011; Mathias & Wheaton, 2007; Rao & Lyketsos, 2000). Given this level of impairment, it is perhaps unsurprising that judgement disturbances were apparent across extreme and more everyday moral dilemmas.

Moral Judgement and Social Cognition in TBI

Neither the TBI or control group demonstrated a significant difficulty cost when selecting the utilitarian response over the deontological response, supporting previous findings that utilitarian judgements are not more difficult than deontological judgements (Kahane et al., 2011). Our controls exhibited a substantial difficulty cost when making counterintuitive judgements over intuitive judgements, but the TBI group showed a complete absence of this effect, indicating that they arrived at these counterintuitive judgements with ease relative to controls. This data supports the hypothesis that a strongly reduced aversion to harm underlies counterintuitive judgements following TBI.

This is consistent with neuroimaging and behavioural evidence which implicates social-cognitive processes in moral judgement (Greene et al., 2001; Avramova & Inbar, 2013). It is striking that our TBI group were able to make counterintuitive judgements in the complete absence of a difficulty cost, and this is consistent with evidence that VMPFC patients show a total absence of SCR when making counterintuitive utilitarian judgements involving highly aversive emotional content (Moretto et al., 2010). This absence of a difficulty cost was evident across both DI and UI dilemmas, indicating that aversion to harm is relevant across the spectrum of moral dilemmas. Indeed, although harms were more extreme in DI dilemmas, UI dilemmas still involved significant harms, where negative outcomes included serious social consequences such as the breakdown of a friend's marriage. Nonetheless, the use of objective physiological measures of affect would be beneficial in evaluating this view in future research.

In our whole sample, affective and cognitive ToM correlated moderately with the proportion of counterintuitive judgements, although general intelligence was the strongest correlate. Affective ToM, as measured by the RME, captured significant variance in counterintuitive judgements after TBI, but the Faux Pas test failed to add significant predictive value to the regression model. As such, our regression model indicates that better performance on the affective ToM task predicts more intuitive moral judgements (and thus, fewer counter-intuitive judgements) following TBI. Such a particular role for affective ToM is consistent with the literature suggesting that intuitive judgements (including deontological judgements in extreme dilemmas) are computed by a reflexive 'system 1' involving visual, premotor, and VMPFC activity at the neural level, which is thought to correspond to emotion processing, empathy and affective ToM at the cognitive level (Kahane et al., 2011; Lamm et al., 2007; Nummenmaa et al., 2008; Shamay-Tsoory, Tibi-Elhanany & Aharon-Peretz, 2006).

Indeed, affective and cognitive ToM are supported by partially dissociable prefrontal networks (Shamay-Tsoory & Aharon-Peretz, 2007), with affective ToM relying specifically on the VMPFC, and cognitive ToM recruiting the prefrontal cortex more broadly. On a somewhat speculative note, this suggests that cognitive ToM may be a more computationally complex process, and as such more likely a higher order, conscious and deliberative "system 2" process. As such, its lack of contribution to the prediction of intuitive moral judgements in our study is not surprising. Irrespective of this issue, our findings provide general support for the involvement of socio-cognitive processes and harm aversion in counterintuitive moral judgement following TBI.

Finally, the combined observations that TBI results in a bias toward counterintuitive moral judgement, and that these judgements tend to be arrived at with relatively little effort, may go some way to explaining the clinical and familial observations that TBI survivors are often impulsive in their decision making and make judgements that are hard for others to understand (Bechara & Van Der Linden, 2005). Indeed, when TBI participants responded in a counterintuitive way, our data indicates that they did so *as though the judgement had come to them intuitively*. This is likely to be disconcerting to others and could certainly contribute to post-injury social and communication difficulties.

Conclusion

Our study presents behavioural evidence that intuitive and counterintuitive moral judgements are perturbed in TBI, but utilitarian judgements are not. This evidence is in accordance with recent neuroimaging data (Kahane et al., 2011) and indicates that the neural systems involved in moral judgement are sensitive to the properties of psychologically generated intuitions, but not to the tensions between competing normative philosophical doctrines. Our difficulty rating and social cognition data further suggests that atypical moral judgement in TBI is attributable, at least in part, to an impaired ability to mentalize about the emotional experiences of others, and ultimately an absence of emotional aversion to harming others.

These disturbances in moral judgement held across a wide range of dilemmas, including extreme ‘killing’ scenarios which are unlikely to ever occur to a person, as well as more ‘everyday’ dilemmas regarding marital infidelity, stealing and conflict resolution. It is likely that investigation of these everyday dilemmas will show the most promise in enhancing the clinical impact of this research, which has been identified as an objective for the area (Rosas & Koenigs, 2014).

Table 1. *Classification of severity by Post-Traumatic Amnesia Duration (PTA), Length of loss of consciousness (LOC) and Glasgow Coma Scale (GSC), and number of participants (n)in each group*

Severity classification	PTA	LOC	GCS	n
Mild	< 1 hour	<15 minutes	13 - 15	1
Moderate	1hour - 24 hours	15minutes - 6 hours	9 - 12	3
Severe	24 hours - 7 days	6 hours - 48 hours	3 - 8	8
Very severe	> 7 days	> 48 hours		18

Table 2. *Demographic , clinical and cognitive characteristics of TBI and control groups*

	TBI Group (N = 30) M (SD)	Control Group (N = 30) M (SD)	*t*	*p*
Age	41.3 (13.67)	39.8 (14.56)	0.402	.689
Years post-injury	9.3 (9.83)	N/A		
HADS Depression	4.3 (3.67)	3.5 (4.35)	0.770	.445
HADS Anxiety	6.0 (3.84)	6.2 (5.05)	-0.144	.886
HADS Total	10.2 (7.01)	9.7 (8.97)	0.273	.786
VIQ	100.8 (19.17)	113.2 (12.47)	-2.954	.005**
PIQ	101.5 (17.21)	113.8 (21.11)	-2.487	.016*
FSIQ	101.3 (18.07)	117.5 (11.13)	-4.190	.000***

* $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$

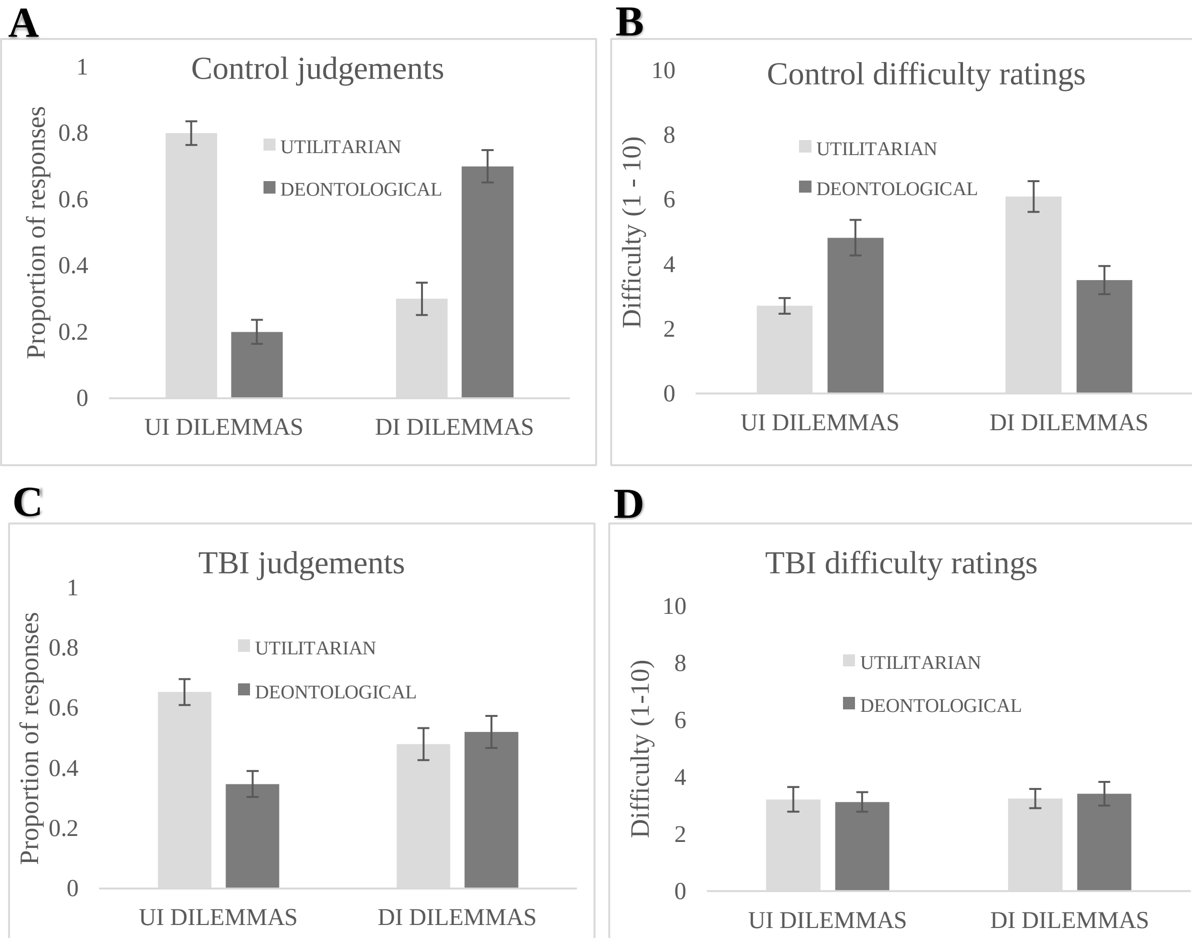


Figure 1. Judgement and difficulty rating data for TBI and controls individually. (**A**) Average proportion of utilitarian and deontological responses in the control group, in dilemmas where the utilitarian option is intuitive (UI) and where the deontological option is intuitive (DI). (**B**) Average difficulty ratings of utilitarian and deontological responses in the control group, in UI and DI dilemmas. (**C**) Average proportion of utilitarian and deontological responses in the TBI group, in UI and DI dilemmas. (**D**) Average difficulty ratings of utilitarian and deontological responses in the TBI group, in UI and DI dilemmas. Error bars are standard error of the mean.

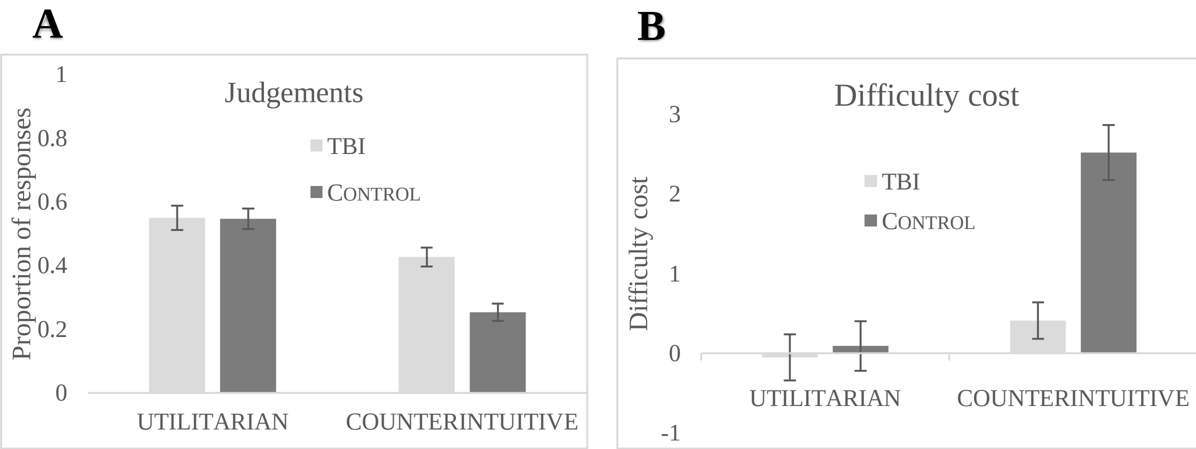


Figure 2. Judgement and difficulty rating data in control and TBI groups. (**A**) Average proportions of utilitarian and counterintuitive judgements in TBI and controls, across all dilemmas. (**B**) Average difficulty cost of counterintuitive judgements (over intuitive judgements) and utilitarian judgements (over deontological judgements) separately for TBI and control groups. Error bars are standard error of the mean.

Table 3. *Pearson product moment correlations between moral judgement variables and cognitive and social cognitive variables in the whole sample (n = 57)*

		Proportion of utilitarian responses	Cost of Utilitarian response	Proportion of Counterintuitive responses	Cost of Counterintuitive response
WASI Verbal IQ	r	.104	.069	-.329*	.269*
	p	.441	.609	.013	.043
	BCa 95% CI	-.134,.367	-.123,.281	-.533,-.042	.056,.451
WASI Performance IQ	r	-.097	.099	-.359**	.154
	p	.474	.463	.006	.251
	BCa 95% CI	-.279,.119	-.109,.358	-.654,-.125	-.128,.483
WASI Full Scale IQ	r	.057	.143	-.482***	.320*
	p	.674	.29	.000	.015
	BCa 95% CI	-.175,.300	-.048,.345	-.636,-.293	.101,.505
Faux Pas Intentions Score	r	.086	.208	-.357**	.198
	p	.526	.121	.006	.139
	BCa 95% CI	-.122,.259	-.077,.444	-.536,-.151	.013,.407
Faux Pas Belief Score	r	.026	.214	-.379**	.26
	p	.845	.11	.004	.051
	BCa 95% CI	-.250,.313	-.117,.486	-.579,-.135	.015,.474
RME	r	-.056	.321*	-.266*	.303*
	p	.676	.015	.046	.022
	BCa 95% CI	-.319,.230	.096,.527	-.465,-.049	.119,.468

* $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$. BCa bootstrap 95% CI's reported

References

Apperly, I. (2010). *Mindreaders: the cognitive basis of" theory of mind"*. Psychology Press: East Sussex.

Avramova, Y. R., & Inbar, Y. (2013). Emotion and moral judgment. *Wiley Interdisciplinary Reviews: Cognitive Science, 4*(2), 169-178.

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The "Reading the Mind in the Eyes" test revised version: A study with normal adults, and adults with Asperger syndrome or high-functioning autism. *Journal of Child Psychology and Psychiatry*, *42*(2), 241-251.

Bechara, A., & Van Der Linden, M. (2005). Decision-making and impulse control after frontal lobe injuries. *Current Opinion in Neurology, 18*(6), 734-739.

Beer, J. S., John, O. P., Scabini, D., & Knight, R. T. (2006). Orbitofrontal cortex and social behavior: integrating self-monitoring and emotion-cognition interactions. *Journal of Cognitive Neuroscience, 18*(6), 871-879.

Bibby, H., & McDonald, S. (2005). Theory of mind after traumatic brain injury. *Neuropsychologia, 43*(1), 99-114.

Choe, S. Y., & Min, K. H. (2011). Who makes utilitarian judgments? The influences of emotions on utilitarian judgments. *Judgment and Decision Making*, *6*(7), 580-592.

Ciaramelli, E., Muccioli, M., Ladavas, E., & di Pellegrino, G. (2007). Selective deficit in personal moral judgment following damage to ventromedial prefrontal cortex. *Social Cognitive and Affective Neuroscience*, *2*(2), 84-92.

Cicerone, K. D., & Tanenbaum, L. N. (1997). Disturbance of social cognition after traumatic orbitofrontal brain injury. *Archives of Clinical Neuropsychology*, *12*(2), 173-188.

Crockett, M. J., Clark, L., Hauser, M. D., & Robbins, T. W. (2010). Serotonin selectively influences moral judgment and behavior through effects on harm aversion. *Proceedings of the National Academy of Sciences*, *107*(40), 17433-17438.

Cushman, F., Gray, K., Gaffey, A., & Mendes, W. B. (2012). Simulating murder: the aversion to harmful action. *Emotion*, *12*(1), 2.

Declaration of Helinski (1991). *British Medical Journal*, 302, 1194.

Gleichgerrcht, E., Torralva, T., Rattazzi, A., Marenco, V., Roca, M., & Manes, F. (2013). Selective impairment of cognitive empathy for moral judgment in adults with high functioning autism. *Social Cognitive and Affective Neuroscience*, *8*(7), 780-788.

Gleichgerrcht, E., & Young, L. (2013). Low levels of empathic concern predict utilitarian moral judgment. *PloS one*, *8*(4), e60418.

Greene, J. D., Morelli, S. A., Lowenberg, K., Nystrom, L. E., & Cohen, J. D. (2008). Cognitive load selectively interferes with utilitarian moral judgment. *Cognition*, *107*(3), 1144-1154.

Greene, J. D., Nystrom, L. E., Engell, A. D., Darley, J. M., & Cohen, J. D. (2004). The neural bases of cognitive conflict and control in moral judgment. *Neuron*, *44*(2), 389-400.

Greene, J. D., Sommerville, R. B., Nystrom, L. E., Darley, J. M., & Cohen, J. D. (2001). An fMRI investigation of emotional engagement in moral judgment. *Science*, *293*(5537), 2105-2108.

Hayes, J. P., Bigler, E. D., & Verfaellie, M. (2016). Traumatic Brain Injury as a Disorder of Brain Connectivity. *Journal of the International Neuropsychological Society*, *22*(2), 120-137

Jones, C. (1979). Glasgow coma scale. *The American Journal of Nursing*, *79*(9), 1551-1557.

Kahane, G., Wiech, K., Shackel, N., Farias, M., Savulescu, J., & Tracey, I. (2011). The neural basis of intuitive and counterintuitive moral judgment. *Social Cognitive and Affective Neuroscience*, *7*(4), 393-402.

Kant, I. (1959). *Foundation of the metaphysics of morals* (l W. Beck, Trans.). Indianapolis, IN: Bobbs-Merrill. (Original work published 1785).

Koenigs, M., Kruepke, M., Zeier, J., & Newman, J. P. (2012). Utilitarian moral judgment in psychopathy. *Social Cognitive and Affective Neuroscience*, *7*(6), 708-714.

Koenigs, M., Young, L., Adolphs, R., Tranel, D., Cushman, F., Hauser, M., & Damasio, A. (2007). Damage to the prefrontal cortex increases utilitarian moral judgements. *Nature*, *446*(7138), 908-911.

Lamm, C., Batson, C. D., & Decety, J. (2007). The neural substrate of human empathy: effects of perspective-taking and cognitive appraisal. *Journal of Cognitive Neuroscience, 19*(1), 42-58.

Lezak, M. D., Howeison, D. B., Bigler, E. D., & Tranel, D. (2012). *Neuropsychological Assessment (fifth Edition)*. Oxford & New York: Oxford University Press.

Lipton, M. L., Gulko, E., Zimmerman, M. E., Friedman, B. W., Kim, M., Gellella, E., ... & Branch, C. A. (2009). Diffusion-Tensor Imaging Implicates Prefrontal Axonal Injury in Executive Function Impairment Following Very Mild Traumatic Brain Injury. *Radiology*, *252*(3), 816-824.

Martins, A. T., Faísca, L. M., Esteves, F., Muresan, A., & Reis, A. (2012). Atypical moral judgment following traumatic brain injury. *Judgment and Decision Making*, *7*(4), 478-487.

Martín-Rodríguez, J. F., & León-Carrión, J. (2010). Theory of mind deficits in patients with acquired brain injury: a quantitative review. *Neuropsychologia*, *48*(5), 1181-1191.

Mathias, J. L., & Wheaton, P. (2007). Changes in attention and information-processing speed following severe traumatic brain injury: a meta-analytic review. *Neuropsychology*, *21*(2), 212.

Mendez, M. F., Anderson, E., & Shapira, J. S. (2005). An investigation of moral judgement in frontotemporal dementia. *Cognitive and Behavioral Neurology*, *18*(4), 193-197.

Mitchell, D. G., Avny, S. B., & Blair, R. J. R. (2006). Divergent patterns of aggressive and neurocognitive characteristics in acquired versus developmental psychopathy. *Neurocase*, *12*(3), 164-178.

Moretto, G., Làdavas, E., Mattioli, F., & Di Pellegrino, G. (2010). A psychophysiological investigation of moral judgment after ventromedial prefrontal damage. *Journal of Cognitive Neuroscience*, *22*(8), 1888-1899.

Müller, J. L., Schuierer, G., Marienhagen, J., Putzhammer, A., & Klein, H. E. (2003). “Acquired psychopathy" and the neurobiology of emotion and violence. *Psychiatrische Praxis*, *30*, S221-5.

Muller, F., Simion, A., Reviriego, E., Galera, C., Mazaux, J. M., Barat, M., & Joseph, P. A. (2010). Exploring theory of mind after severe traumatic brain injury. *Cortex*, *46*(9), 1088-1099.

Newcombe, V. F., Outtrim, J. G., Chatfield, D. A., Manktelow, A., Hutchinson, P. J., Coles, J. P., ... & Menon, D. K. (2011). Parcellating the neuroanatomical basis of impaired decision-making in traumatic brain injury. *Brain*, *134*(3), 759-768.

Nummenmaa, L., Hirvonen, J., Parkkola, R., & Hietanen, J. K. (2008). Is emotional contagion special? An fMRI study on neural systems for affective and cognitive empathy. *Neuroimage*, *43*(3), 571-580.

Paxton, J. M., Bruni, T., & Greene, J. D. (2014). Are “counter-intuitive” deontological judgments really counter-intuitive?: An empirical reply to Kahane et al.(2012). *Social Cognitive and Affective Neuroscience, 9*(9), 1368-1371.

Pitman, I., Haddlesey, C., Ramos, S. D., Oddy, M., & Fortescue, D. (2014). The association between neuropsychological performance and self-reported traumatic brain injury in a sample of adult male prisoners in the UK. *Neuropsychological Rehabilitation*, 25(5), 763-779.

Rao, V., & Lyketsos, C. (2000). Neuropsychiatric Sequelae of Traumatic Brain Injury. *Psychosomatics*, *41*(2), 95-103.

Rosas, A., & Koenigs, M. (2014). Beyond “utilitarianism”: Maximizing the clinical impact of moral judgment research. *Social Neuroscience, 9*(6), 661-667.

Shamay-Tsoory, S. G., & Aharon-Peretz, J. (2007). Dissociable prefrontal networks for cognitive and affective theory of mind: a lesion study. *Neuropsychologia*, *45*(13), 3054-3067.

Shamay-Tsoory, S. G., Tibi-Elhanany, Y., & Aharon-Peretz, J. (2006). The ventromedial prefrontal cortex is involved in understanding affective but not cognitive theory of mind stories. *Social Neuroscience*, *1*(3-4), 149-166.

Siegal, M., & Varley, R. (2002). Neural systems involved in 'theory of mind'. *Nature Reviews Neuroscience, 3*(6), 463-471.Stone, V.E., Baron-Cohen, S. & Knight, R.T. (1998). Frontal lobe contributions to theory of mind. *Journal of Cognitive Neuroscience*, 10, 640-656.

Stone, V.E., Baron-Cohen, S. & Knight, R.T. (1998). Frontal lobe contributions to theory of mind. *Journal of Cognitive Neuroscience, 10,* 640-656.

Stuss, D. T. (2011). Traumatic brain injury: relation to executive dysfunction and the frontal lobes. *Current Opinion in Neurology*, *24*(6), 584-589.

Tversky, B., & Hard, B. M. (2009). Embodied and disembodied cognition: Spatial perspective-taking. *Cognition*, *110*(1), 124-129.

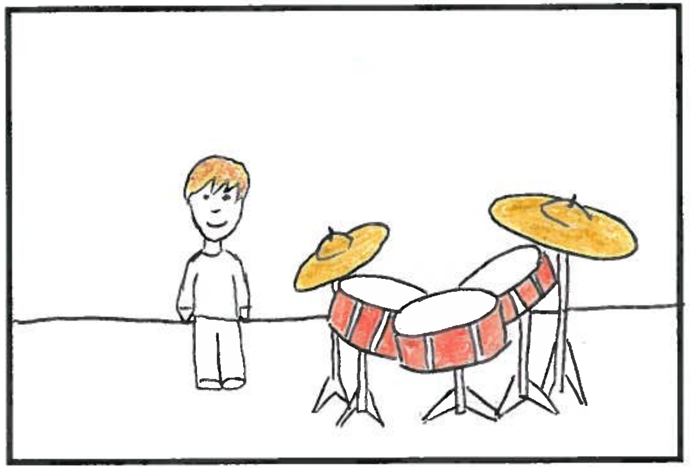
Wechsler, D. (1999). *Wechsler Abbreviated Scale of Intelligence.* Harcourt Assessment, Inc., San Antonia, TX.

Wiech, K., Kahane, G., Shackel, N., Farias, M., Savulescu, J., & Tracey, I. (2013). Cold or calculating? Reduced activity in the subgenual cingulate cortex reflects decreased emotional aversion to harming in counterintuitive utilitarian judgment. *Cognition*, *126*(3), 364-372.

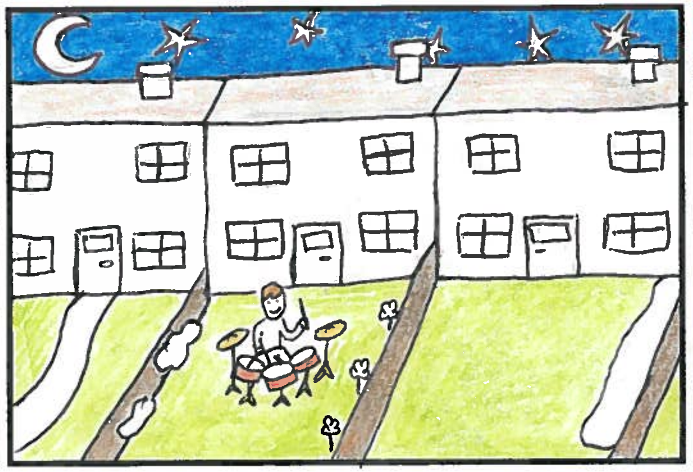
Zigmond, A. S., & Snaith, R. P. (1983). The hospital anxiety and depression scale. *Acta Psychiatrica Scandinavica*, *67*(6), 361-370.

Moral dilemma illustrations

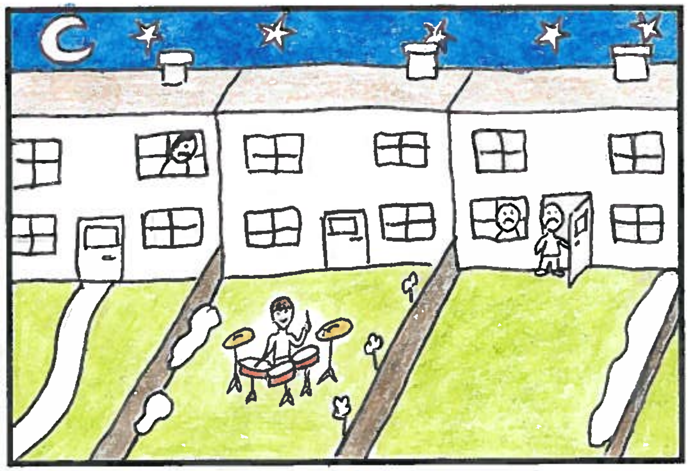
A troublesome property version 1.1 11/01/15



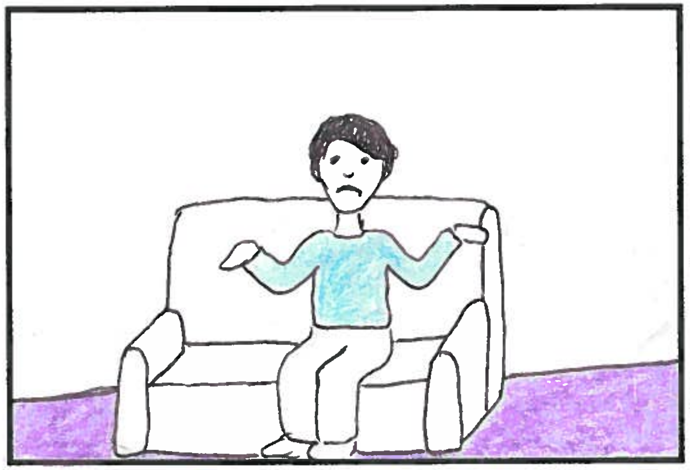
Your next door neighbour's son, Joey, enjoys playing the drums, and owns a cheap drum-kit



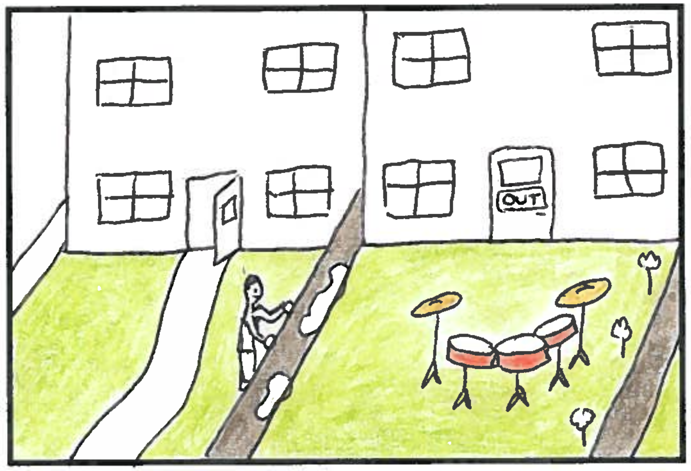
The problem is Joey plays his drum-kit loudly in his garden, even at night



This keeps you, your family, and others in the neighbourhood awake at night



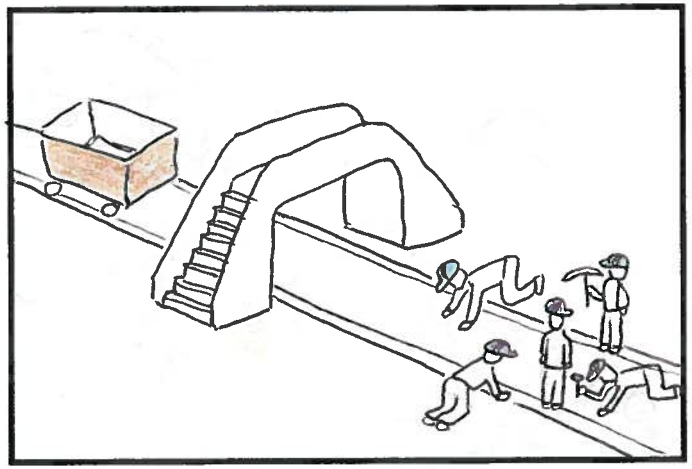
You have tried reasoning with the boy and his family, but this hasn't helped. The police will not help, and life has become a real nightmare



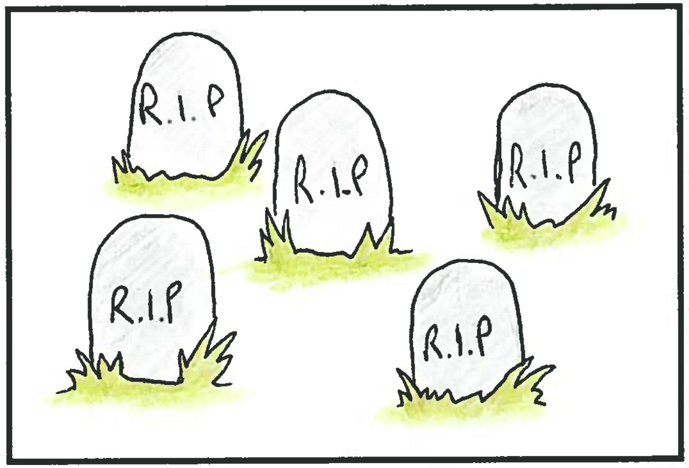
One day, you notice that your neighbours are out of the house. You could go into the garden and take the drum-kit and get rid of it somewhere.

Should you take Joey's drum-kit?

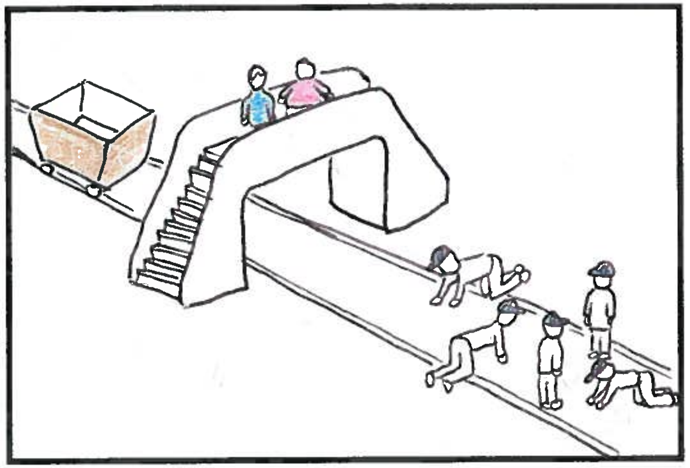
Footbridge version 1.1 11/01/15



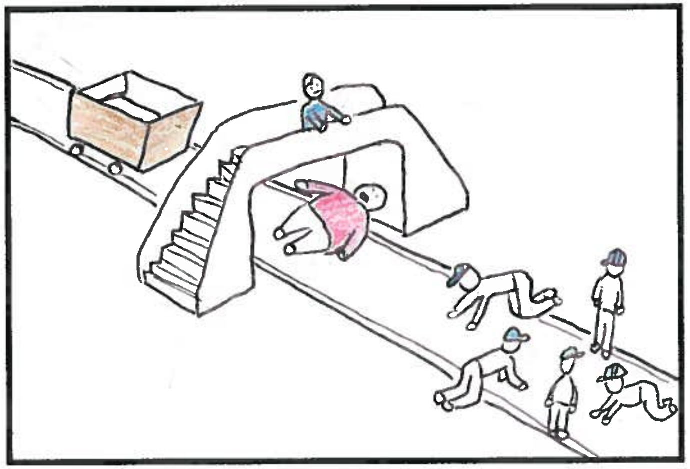
A runaway trolley is heading down the tracks toward five men who are working on the track



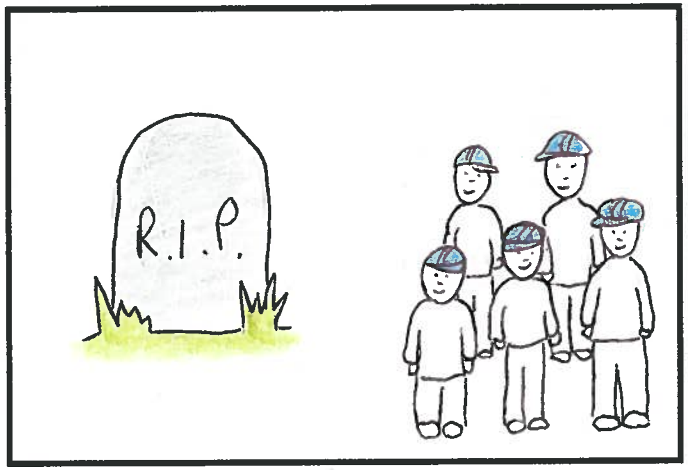
These five men will be killed if the trolley reaches them



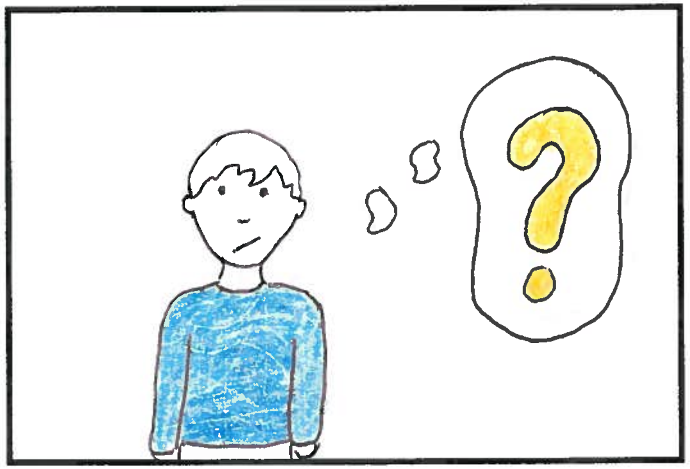
You are on a bridge over the tracks, in between the approaching trolley and the workmen, and next to you is a stranger who is very large



The only way to save the five workmen is to push this stranger off the bridge, so that he stops to trolley with his large body.

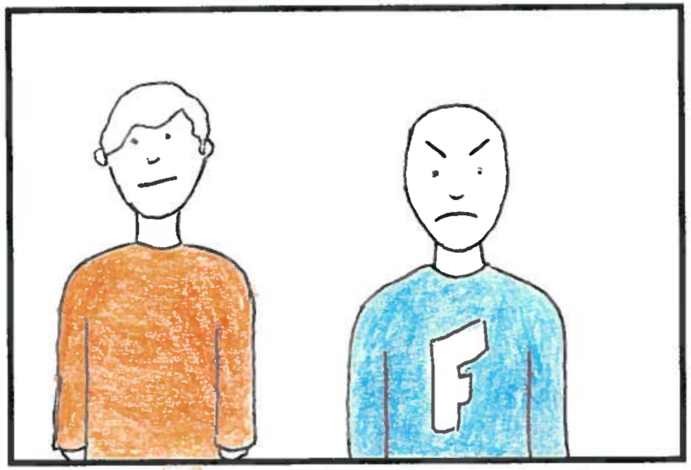


If you do this, the large man will die, but the five workmen will be saved



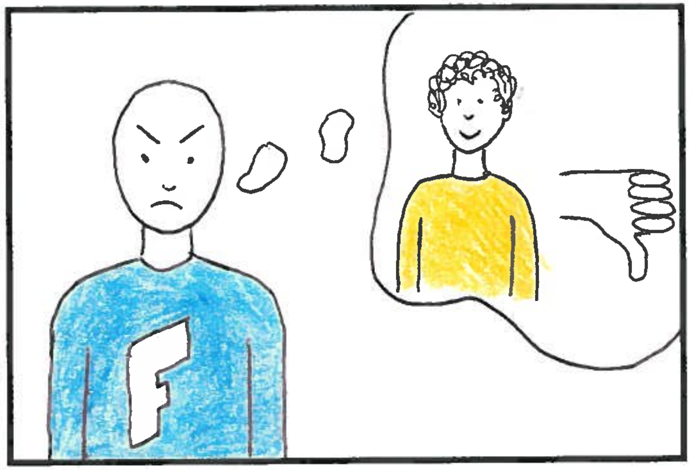
Should you push the man onto the tracks in order to save the five workmen?

lie 1 version 1.1 11/01/15

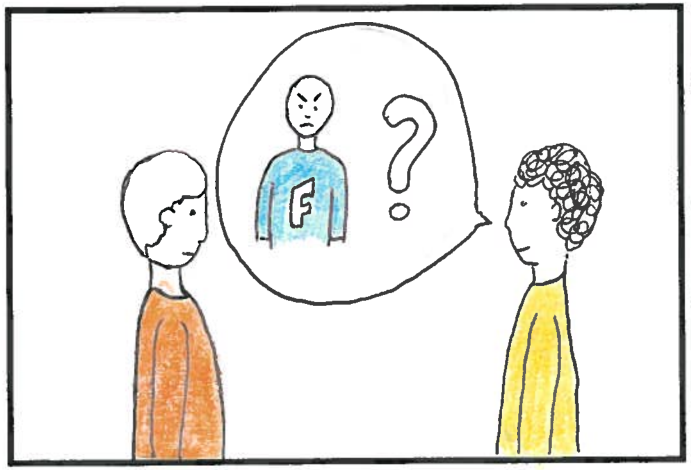


You know a man called Fred. Fred is a prejudiced, grumpy person who often takes a disliking to people for no good reason.

You also have a friend who admires Fred and gives great weight to his opinions

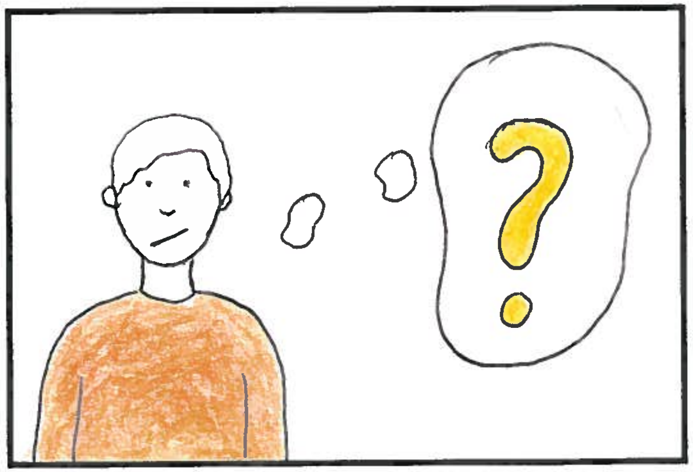


However, Fred despises your friend.



One day, your friend asks you what Fred thinks of him.

Your friend would be devastated to discover that Fred despises him, but will only find out if you tell him.

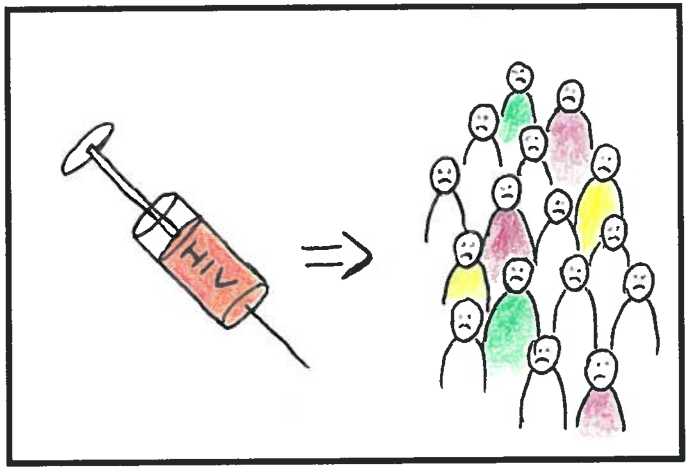


Should you tell your friend that Fred despises him?

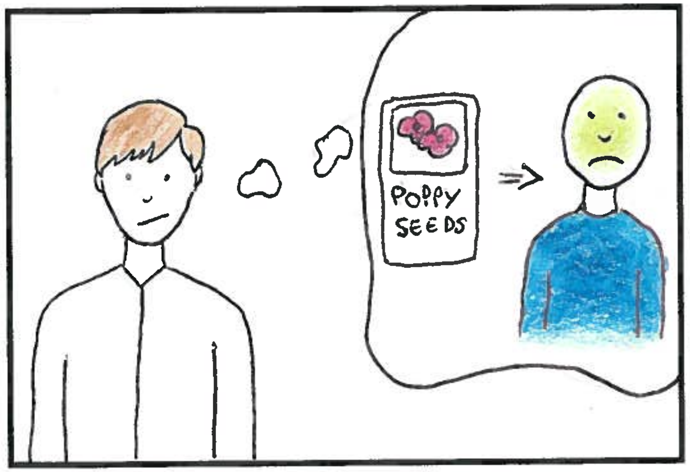
Modified preventing the disease version 1.1 11/01/15

You are a waiter. You overhear one of your customers say that he is about to go to prison...

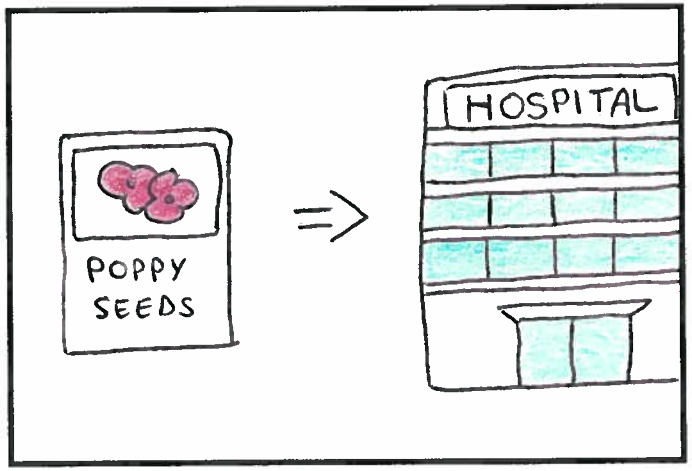
...and that in his last 48 hours of freedom he plans to intends to infect as many people as he can with HIV



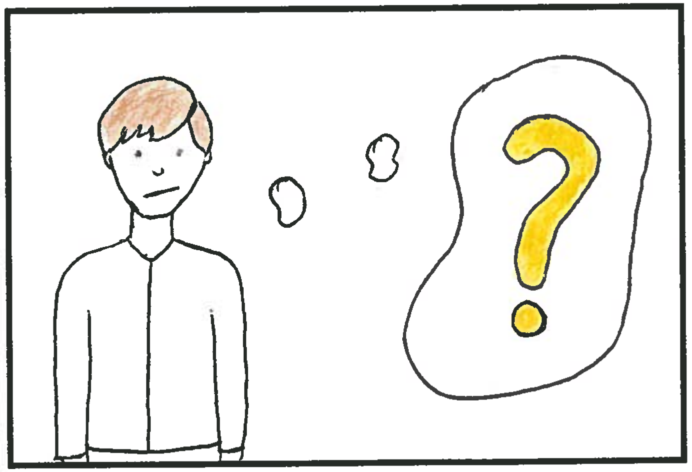
You know this man well enough to know he is telling the truth and has access to many potential victims



You also know that this man has a strong allergy to poppy seeds

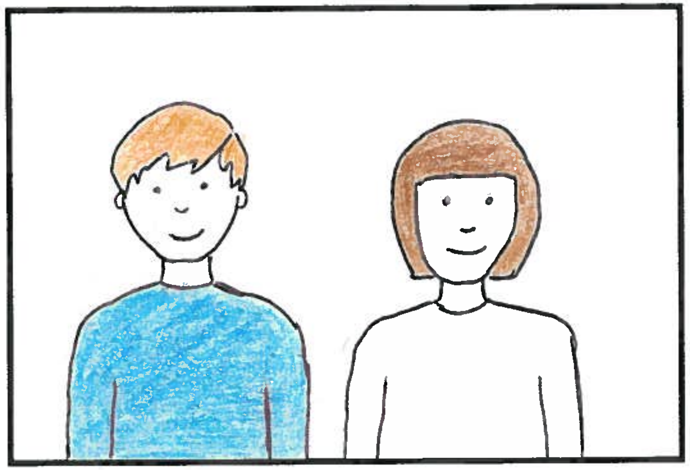


If he eats just one he will go into convulsions and have to be hospitalised for at least 48 hours

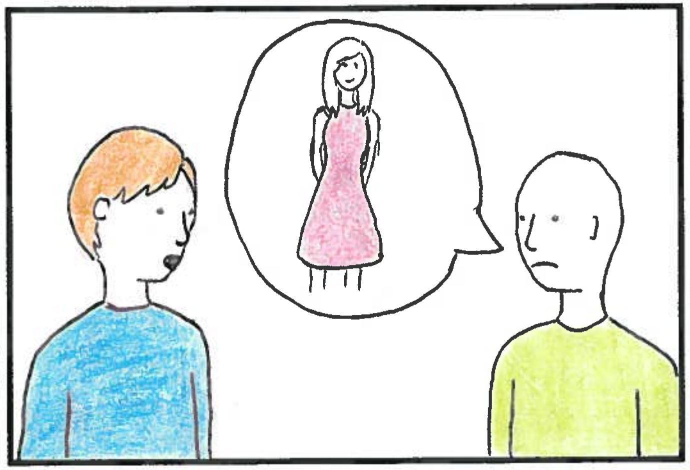


Should you cause this man to have a serious allergy attack in order to prevent him from spreading HIV?

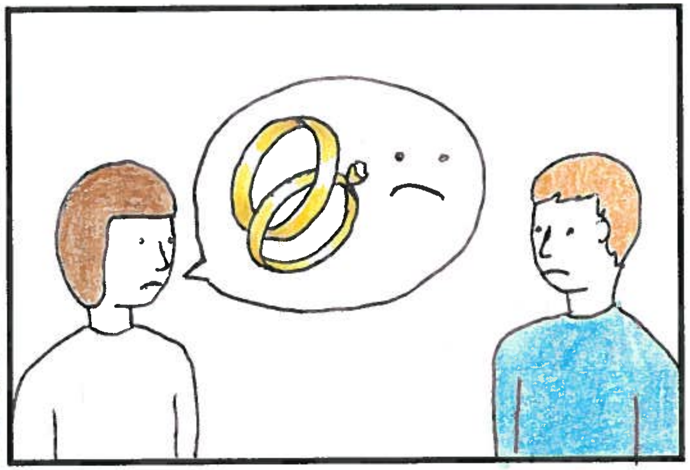
Lie 3 version 1.1 11/01/15



You have a close friend called Jane.

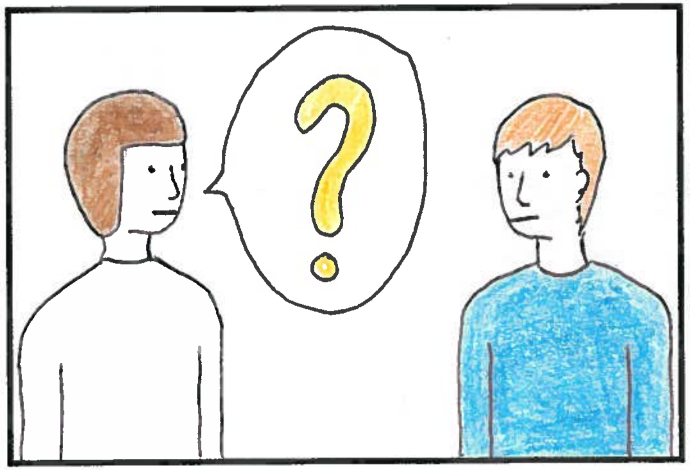


Jane's husband has told you that four years ago he had an affair with another woman, but he would never do it again as his marriage means so much to him

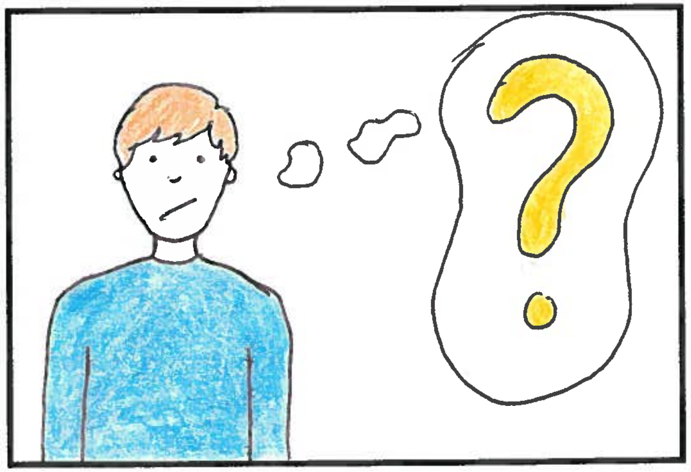


One night, Jane tells you that she has in the past been worried about her marriage

She tells you that her marriage is immensely important to her, and that if her husband was ever unfaithful it would destroy the marriage



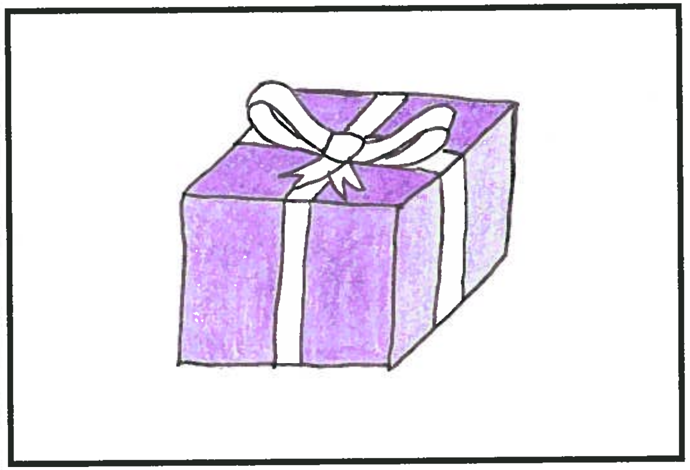
Jane asks you if you have any reason to believe that her husband has not been faithful.



Should you tell Jane that her husband had an affair?

Autonomy 2 Version 1.1 11/01/15

Your friend, Jack, recently had Hepatitis, and has been told by his doctor that he must not drink alcohol again.

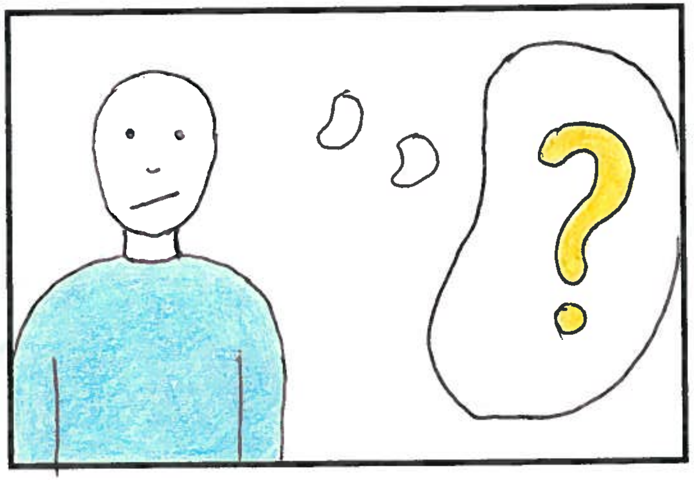


You have promised to buy him whatever he wants for his birthday.

Jack insists you buy him a bottle of single-malt whiskey that you bought him years ago for being the best man at your wedding.

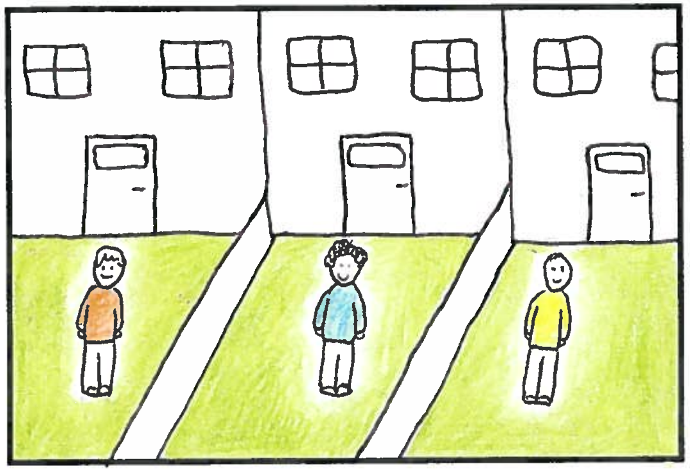
Jack will feel betrayed if you don't respect his wishes

But you know that giving him almost any other present would be better for him.

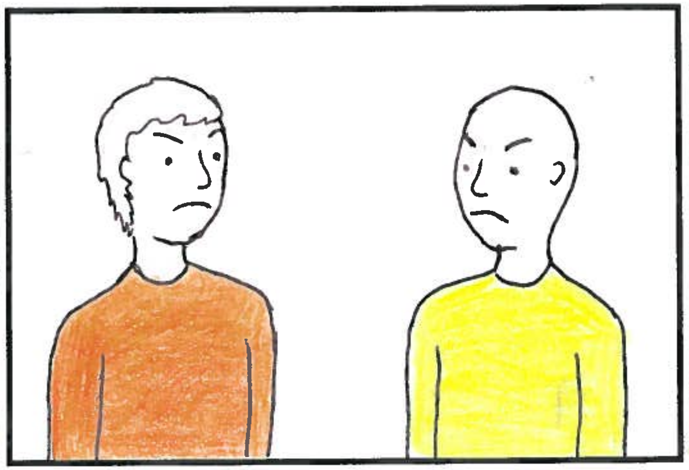


Should you buy Jack the bottle of whiskey?

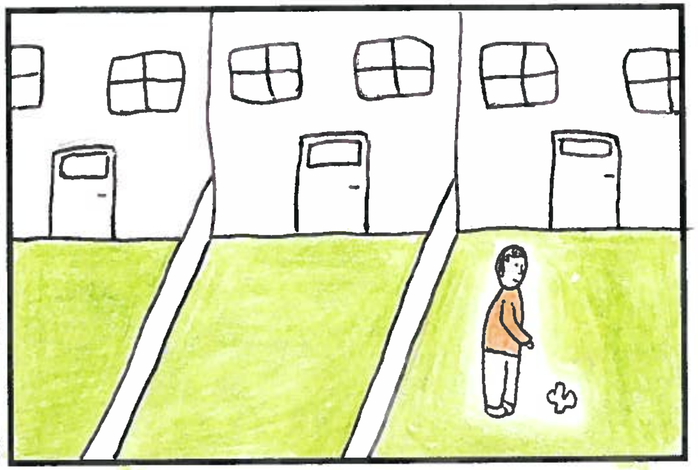
Lie 5 version 1.1 11/01/15



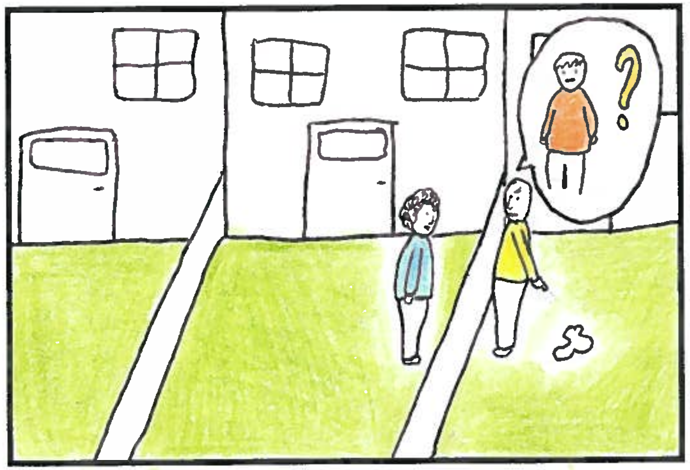
You are on friendly terms with both of your neighbours, Jeff and Bob.



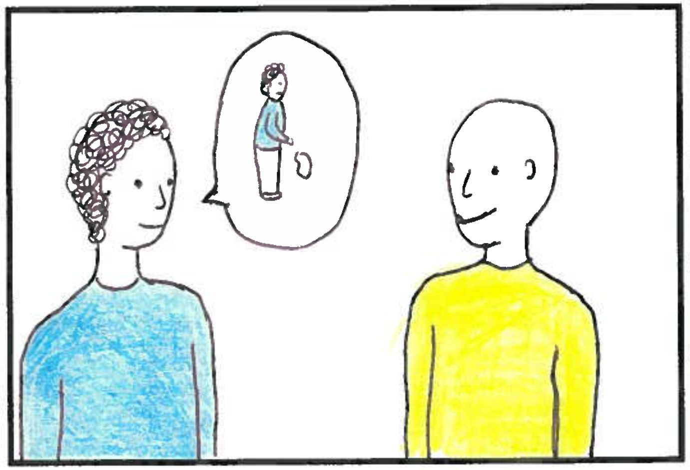
However they are both hot-headed and hate each other. Things have been becoming very tense between them recently.



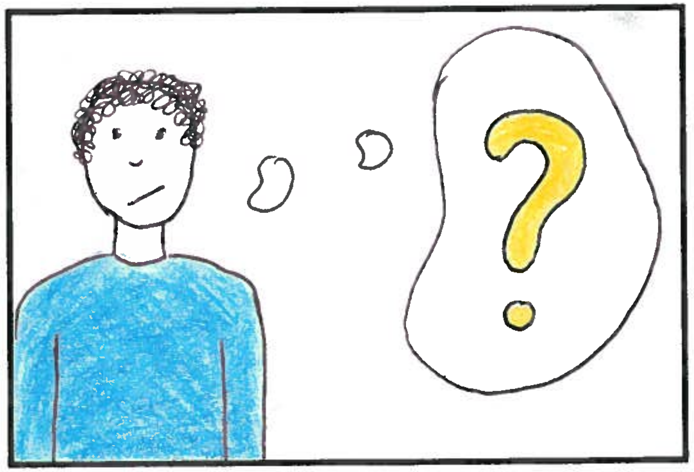
Yesterday, you saw Bob carelessly drop some litter near Jeff's garden.



An angry Jeff has come to your house and asked if it was Bob who dropped the litter. If you tell him the truth, he will go over to Bob's house and there will be a violent fight.

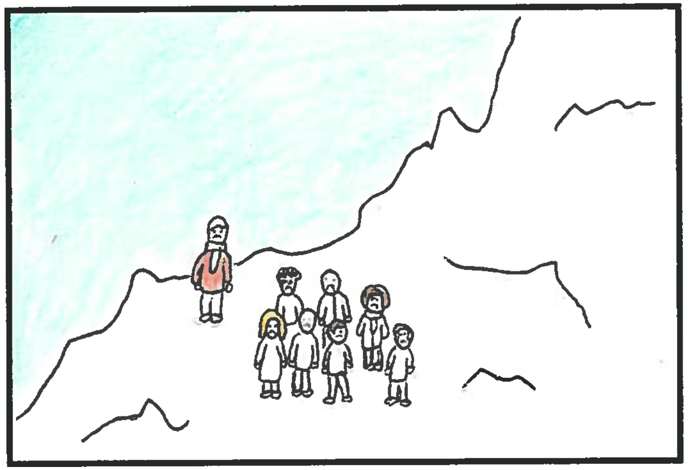


However if you lie and tell Jeff that you accidently dropped the litter, he will soon forget about the whole thing.

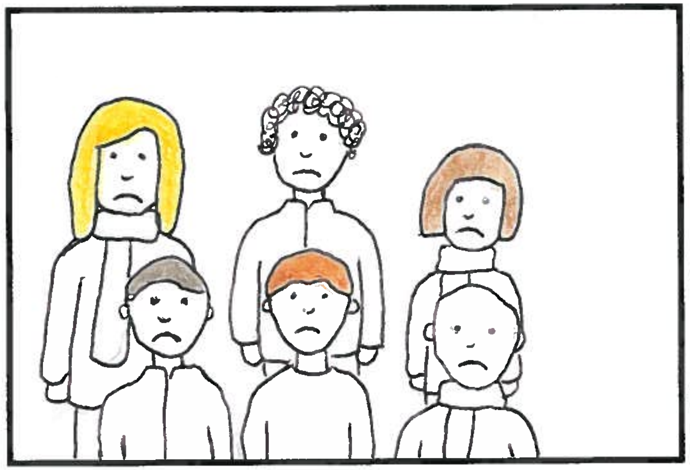


Should you tell him that Bob dropped the litter?

Vitamins version 1.1 11/01/15

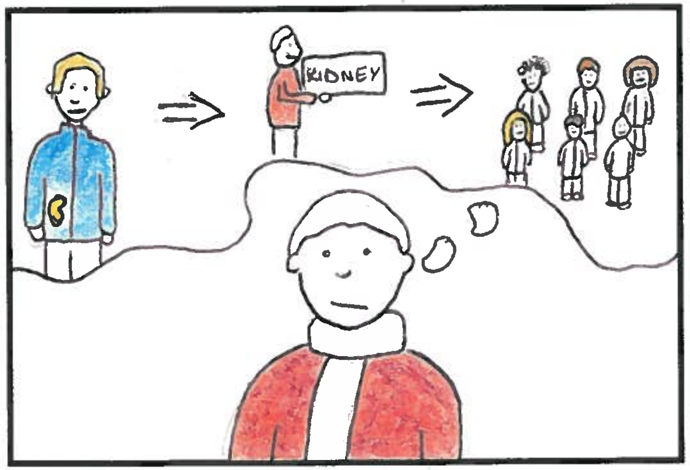


You are the leader of a mountaineering expedition that is stranded in the wilderness, waiting to be rescued

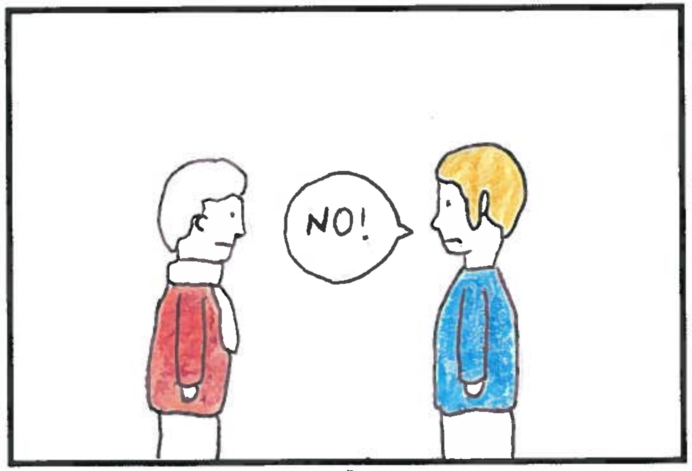


In the party is a family of six with a dangerous vitamin deficiency who will die before you are rescued if they do not get the vitamins they need

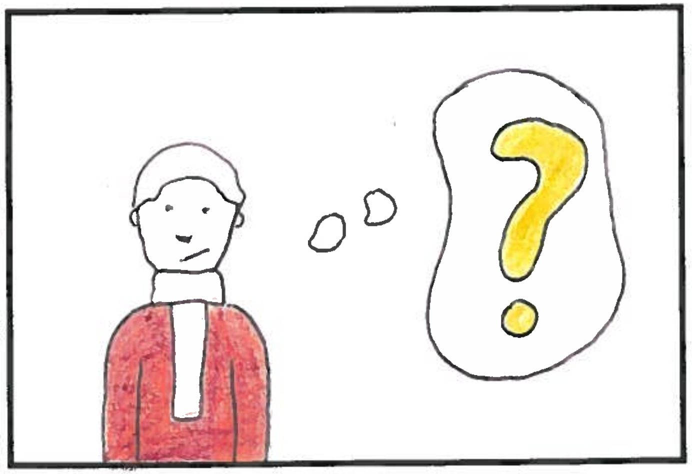
One man's kidney contains a lot of this vitamin



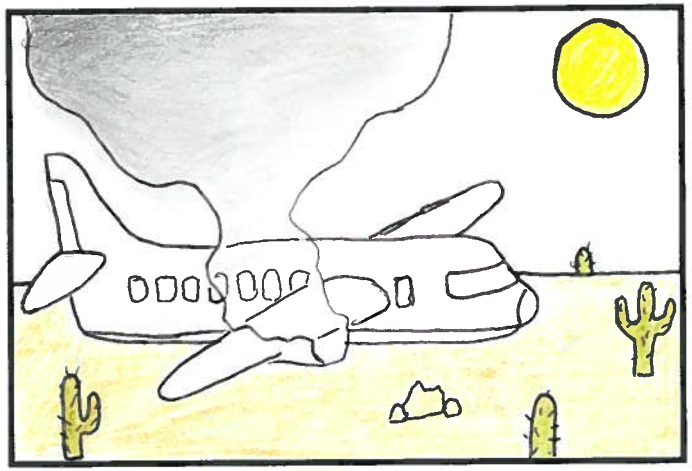
The only way to save the lives of the six people is to remove one of this man's kidneys and extract its vitamins



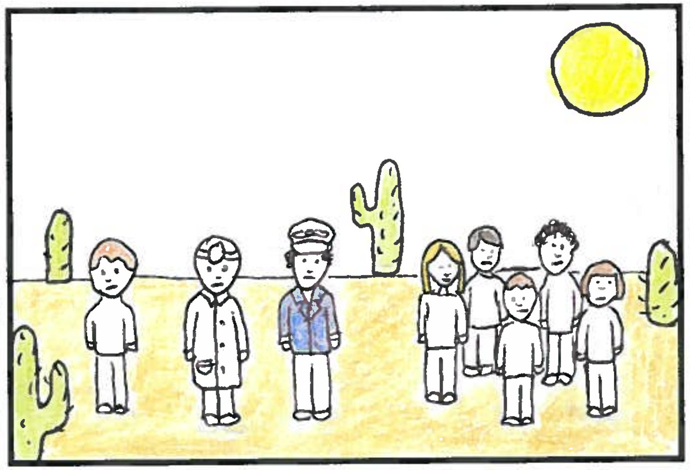
The man does not want you to take his kidney, as although it will not kill him, it will make him poorly



Should you force the man to have his kidney removed in order to save the lives of the six people?



A small plane has had to put down in the desert

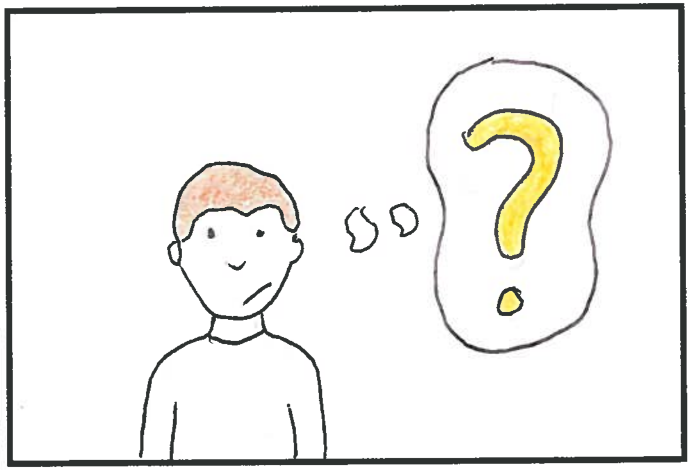


You, a surgeon, and five people with a dangerous vitamin deficiency are stuck in the desert with the Pilot, but you will be rescued in two days

The five people with a vitamin deficiency will die before you are rescued if they do not get the vitamins they need

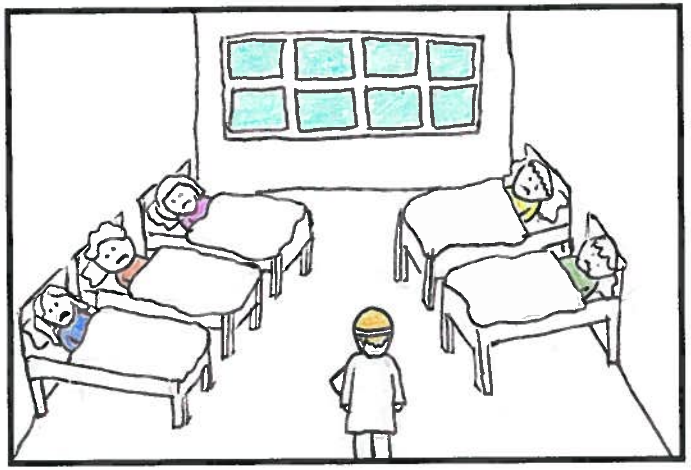
Kidneys contain lots of this vitamin. The only way to save the five people is to have the surgeon remove one of the Pilot's kidneys and extract its vitamins

The pilot does not want you to take his kidney, as although it will not kill him, it will make him poorly



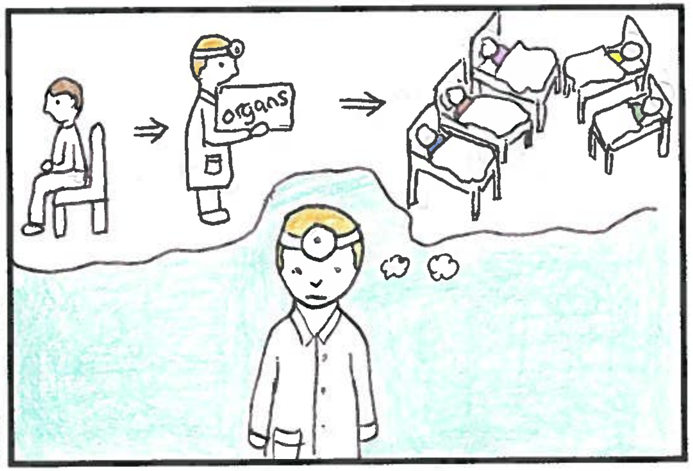
Should you force the pilot to have a kidney removed in order to save the lives of the five people?

Transplant version 1.1 11/01/15



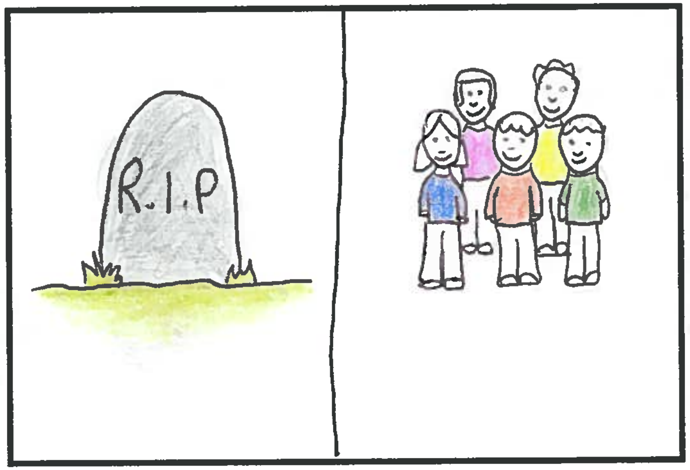
You are a doctor. You have five very poorly patients who are about to die because of various failing organs.

You have another patient who is healthy.

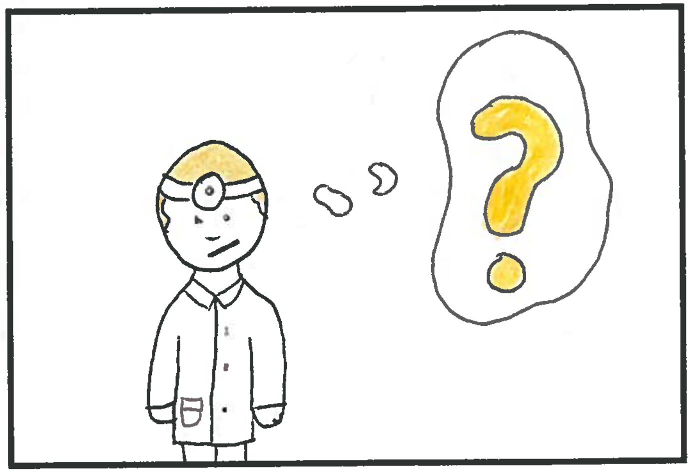


The only way you can save the lives of the first five patients is to remove this man's organs and transplant them into the five poorly patients.

The healthy man does not want to you to take away his organs



If you do this, the healthy man will die, and the five will live.



Should you perform these transplants?

Suplementary data - moral dilemmas pilot

Original dilemmas										**Total intuitive responses**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
A troublesome property	N	y	N	N	N	Y	N	N	Y	0.6667
Footbridge	N	N	N	N	N	N	N	N	N	1.0000
Lie 1	N	y	Y	Y	N	Y	N	N	N	0.5556
mod. Preventing the disease	Y	Y	Y	Y	N	Y	N	Y	N	0.6667
lie 3	N	Y	N	Y	N	N	N	Y	N	0.6667
autonomy 2	Y	N	N	N	Y	N	N	Y	N	0.6667
lie 5	N	Y	N	N	N	N	N	N	N	0.8889
vitamins	N	Y	N	N	N	N	N	N	N	0.8889
enzymes	N	Y	N	N	N	N	N	N	Y	0.7778
transplant	N	N	N	N	N	N	N	N	N	1.0000
Adapted dilemmas (with illustrations)										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
A troublesome property	N	Y	N	N	Y	N	N	N	N	0.7778
Footbridge	Y	Y	N	N	N	N	N	N	N	0.7778
Lie 1	N	N	N	N	Y	N	N	Y	Y	0.6667
mod. Preventing the disease	Y	Y	N	N	Y	Y	Y	N	Y	0.6667
lie 3	Y	Y	N	Y	N	N	N	N	N	0.6667
autonomy 2	Y	N	Y	N	N	N	Y	N	N	0.6667
lie 5	N	N	N	N	N	Y	N	Y	N	0.7778
vitamins	N	Y	N	N	N	N	N	N	N	0.8889
enzymes	N	Y	N	N	N	N	N	N	N	0.8889
transplant	N	N	N	N	N	N	N	N	N	1.0000