



Moral judgments under uncertainty: risk, ambiguity and commission bias

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Abstract

Previous research on moral dilemmas has mainly focused on decisions made under conditions of probabilistic certainty. We investigated the impact of uncertainty on the preference for action (killing one individual to save five people) and inaction (saving one but allowing five people to die) in moral dilemmas. We reported two experimental studies that varied the framing (gain vs loss), levels of risk (probability of gain and loss) and levels of ambiguity (imprecise probability information) in the choice to save five individuals by sacrificing one. We found that participants preferred actions with uncertainty (risk/ambiguity) over inaction. Specifically, we found that participants preferred actions with precise probability information (risk) over inaction, and they preferred actions with modest or high levels of ambiguity over actions with precise probabilities, especially when moral dilemmas had a loss frame. We also observed commission bias in Study 2. We discussed the implications for research in moral decision-making.

Keywords Moral judgements · Moral Dilemmas · Ambiguity · Risk · Commission Bias

Introduction

Psychological investigations of moral reasoning frequently employ dilemmas that involve conflict between moral requirements. For example, the well-known trolley dilemma requires one to choose between two options: killing one person to save five people or doing nothing and letting the five people die. These two options seem to contrast the desire to maximize

the number of lives saved and, on the other hand, injunctions against directly causing harm and other negative feelings that direct intervention in the dilemma may cause in the decision maker. While many studies have explored various factors relating to both the decision maker and the dilemma itself that can influence the proclivity for certain moral judgements in these kinds of dilemmas (Greene, 2009; Moore et al., 2011; Patil, 2015), one factor that has received less attention is the influence of uncertainty and the impact it can have on moral judgments.

One of the central goals of moral psychology is to establish a workable framework for modelling moral reasoning (Cushman, 2013). The rationalist model of moral judgments argues that moral judgments are the products of System 2—a controlled, effortful and slow process of reasoning system (Kukolja et al., 2008; Piaget, 2013). In contrast to the rationalist model, the social intuitionism model of moral judgment (Haidt, 2001, 2012; Turiel, 2022) argues that moral judgments are results of the intuitive process, and conscious reasoning plays the role in providing post hoc justifications for these intuitions. The dual-process model combines the two approaches and argues that utilitarian moral judgments are the result of System 2, whereas the deontological judgements are the result of intuitive, effortless, and fast System 1 processes. The popular dual-process model of moral reasoning

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assumes that moral reasoning and non-moral reasoning share the same foundational structure and therefore it is possible to apply a domain-general model to the moral domain to explain moral judgments (Cushman, 2013; Greene, 2013; Greene et al., 2001; Greene & Cushman, 2009). Ritov & Baron, (1999), on the other hand, indicate that moral choices are unique as deontological moral choices are motivated by protected values that are not subjected to trade-offs with other values. However, more research is needed to understand the extent to which moral reasoning is comparable to non-moral reasoning and in what ways they are distinct. Attitudes toward uncertainty are one of the best studied cognitive processes in psychology and therefore further determining how uncertainty and moral decision-making interact may contribute toward a workable model of moral reasoning.

Attitudes toward uncertainty are closely linked to how we make judgements and decisions because they refer to how we deal with incomplete information. Among the various forms of uncertainty, risk and ambiguity are two widely studied conditions. Risk refers to a situation in which the precise probability of the outcome in each option is known. Ambiguity, however, refers to a situation in which the precise probability of the outcome in each option is unknown to the decision maker and is therefore considered a higher level of uncertainty than risk (Einhorn & Hogarth, 1986; Ellsberg, 2001). Indeed, there is robust empirical evidence that people exhibit an aversion to ambiguous choices in comparison to risky choices (Binmore et al., 2012; Butler et al., 2014; Han et al., 2009; Keren & Gerritsen, 1999; Kocher et al., 2018). This model of ambiguity-aversion has been applied to explain a wide range of behavioural phenomena that are inconsistent with traditional expected utility theory.

An important factor that can moderate the relationship between uncertainty and decision-making is whether the consequences are framed as a gain or as a loss. Previous research in the financial domain for monetary outcomes has found that people tend to be risk-averse when the outcome is a gain and risk-seeking when the outcome is a loss, a well-established finding known as valence framing effects (Kühberger, 1998; Osmont et al., 2015; Tversky & Kahneman, 1981). However, the literature on whether ambiguity produces a consistent valence framing effect is equivocal. Some studies have found that people are ambiguity-seeking for losses and ambiguity-averse for gains (Baillon & Bleichrodt, 2015; Casey & Scholz, 1991; Chakravarty & Roy, 2008; Ho et al., 2002; Kothiyal et al., 2014). On the other hand, other studies have found that people are ambiguity-averse for both gains and losses (Inukai & Takahashi, 2009; Keren & Gerritsen, 1999). It is possible that ambiguity aversion is less obvious in losses than it is in gains because losses are more difficult for subjects to process than gains and losses produce more noise (de Lara Resende & Wu, 2010).

The effects of valence framing have been explored in the moral judgment literature. Some indirect empirical evidence

supports the likelihood of observing a framing effect across the gain and loss frame in the moral domain. In the famous Asian disease problem in which the options are framed in terms of people dying (i.e., loss), most people prefer Program B with a known probability instead of Program A with a certain outcome – this demonstrates the well-known risk-seeking for losses effect (Tversky & Kahneman, 1981). The valence framing effect has also been observed in other moral contexts (Cao et al., 2017; Fagley et al., 2010; Reyna et al., 2014; Ritov & Baron, 1999; Spence & Pidgeon, 2010). McDonald and colleagues (2021) conducted a meta-analysis of 109 relevant published articles using between-subjects designs and found robust and consistent moderate valence framing effects in moral judgments. However, some scholars have argued that many of the studies that found valence framing effects suffer from methodological shortcomings. Indeed, Gosling and Trémolière (2021) found no valence framing effects in trolley dilemma-type moral dilemmas when fixing these methodological shortcomings.

Whether valence framing effects are present in ambiguous moral situations is at this point unknown. There is some evidence to suggest that judgements and decision-making in the moral domain resemble the non-moral domain in that perceived risk and expected value can play a significant role in determining the decisions people make in dilemmas. That is, reducing the outcome probability and expected value of a given choice in a moral dilemma can reduce people's preference for that choice – both in the moral and non-moral domain (Ryazanov et al., 2021; Shou & Song, 2017; Shou et al., 2020). How decision-making is influenced by ambiguity in the moral domain is less clear. Given the correlation between perceived outcome probability and moral choice (Ryazanov et al., 2021; Shou & Song, 2017; Shou et al., 2020) and the correlation between risk attitudes and ambiguity attitudes (Abdellaoui et al., 2011; Butler et al., 2014; Charness et al., 2013; Dimmock et al., 2013), it is possible the level of ambiguity present in a moral dilemma could have a significant impact on moral choice. On the other hand, evidence also shows that moral reasoning is distinct from non-moral reasoning. For example, people use less expected value maximization in affect-rich settings, such as in the health domain, than in monetary settings (Lejarraga et al., 2016; Pachur et al., 2014). It suggests that although ambiguity could have a significant impact on moral reasoning, its impact may be different across life domains.

The current investigation

The purpose of the current studies is to explore the effects of uncertainty and framing in the moral domain and thus fill an important gap regarding the shared features of moral and non-moral reasoning when there is missing information. The current studies are based on previous work on attitudes toward uncertainty in monetary scenarios. In

monetary scenarios, studies frequently investigate attitudes toward uncertainty and framing effects in the gain and loss domains. This project examines whether moral reasoning is similarly influenced by uncertainty as prior research demonstrates for non-moral reasoning and how attitudes toward uncertainty predict moral judgments. Specifically, we are interested in whether risk aversion predicts moral choice (i.e., inaction choice with certainty is preferred over action with uncertainty), whether the degree of ambiguity in an outcome influences moral choice, and whether the valence of framing effects can be observed in the moral domain.

We used a probability interval to represent ambiguity for two reasons. First, it is widely used by researchers in the literature of ambiguity attitudes as a valid representation of ambiguous information (Di Mauro & Maffioletti, 1996; Halevy, 2007; Smithson, 2015; Smithson et al., 2019). Second, probability intervals are a convenient way to examine the association between moral judgments and varying degrees of probability.

The following hypotheses were proposed:

H1: Participants would prefer the inaction choice under conditions of certainty to an action choice under conditions of uncertainty (risk or ambiguity).

H2: Participants would prefer an action choice with a precise probability over an action choice with an ambiguous probability when outcomes are framed as a gain.

H3: Participants would prefer an action choice with an ambiguous probability over an action choice with a precise probability when outcomes are framed as a loss.

In addition, we tested if the level of risk and ambiguity influence moral decisions and hypothesized that:

H4: Participants would be more likely to rank inaction as more preferred in both the gain and loss conditions when the action with a precise probability was riskier (i.e., a lower probability of five people surviving or a higher probability of five people dying) than when the action with a precise probability was less risky.

H5: Participants would be more likely to rank inaction as more preferred in both the gain and loss conditions when the action had higher levels of ambiguous uncertainty (i.e., has a larger probability interval) than when the action had lower levels of ambiguous uncertainty.

H6: The likelihood of preferring the action with a precise probability in the gain condition would be higher when the action with ambiguous uncertainty has a larger probability interval than when the action with ambiguous uncertainty has a lower probability interval.

H7: The likelihood of preferring the action with ambiguous uncertainty in the loss condition would be higher when the action with ambiguous uncertainty has a larger

probability interval than when the action with ambiguous uncertainty has a lower probability interval.

Study 1

Methods

The ethical aspects of this research project were approved by the Committee on Research Ethics and Safety of Lingnan University. Research was carried out in accordance with Lingnan University Research Ethics and Safety policies. Informed consent was obtained from all participants.

A total of 594 US participants recruited via Prolific consented and completed Study 1. Forty-two participants were excluded due to not passing attention checks ($n=27$), self-reported to not have understood or did not pay attention to most of the study ($n=9$) or were identified as a potential bot/fraud response by various Qualtrics fraud detection methods ($n=9$). The remaining 549 participants (273 females) were aged between 18 and 81 ($M=42.40$, $SD=15.01$), of which 66.3% had a tertiary or above education and 96.6% spoke English as their first language.

The study had a 2 (framing: gain, loss) \times 2 (risk level: modest or low) between-subjects design. For the modest risk level (50% gain/loss), we also manipulated a between-subjects factor that varied the level of ambiguity (wider range/higher ambiguity, narrower range/lower ambiguity). Thus, there were six conditions in total. Participants were randomly assigned to one of the six conditions.

Materials

Moral judgment tasks The moral judgment task randomly presented participants with seven moral dilemmas that are commonly used in the literature (see the supplementary material S1 for the full list of the dilemmas). A common way to categorize dilemmas is whether they are “personal” or “impersonal” moral dilemmas. That is, whether the harmful action that is performed to save the group is inflicted through personal force, such as pushing someone from an overpass to stop a train, or in a more impersonal way such as flicking a switch to divert a train onto another track (Greene et al., 2001; Greene & Cushman, 2009). Our research project included only impersonal dilemmas. The first reason for this being that it is a robust empirical finding that impersonal dilemmas generally induce higher rates of choosing to sacrifice the individual for the group (i.e., action choice) and this is thought to be undergirded by reasoning strongly influenced by outcome-based valuations (Cushman, 2013; J. D. Greene, 2007). Thus, a reasonable speculation is that we should be more likely to detect sensitivity to uncertainty in impersonal dilemmas given that people are more likely

to apply the type of reasoning that includes outcome-based valuations (i.e., expected value).

The second reason is that it is commonly assumed that responding to personal dilemmas involves more emotional processes than impersonal dilemmas (Cummins & Cummins, 2012; Greene, 2013; Greene et al., 2001; Greene & Cushman, 2009; Moll & de Oliveira-Souza, 2007), and ambiguity aversion and framing effects are also strongly underpinned by emotional processes (Butler et al., 2014; Yang et al., 2013). Given that, including only impersonal cases in this design is to increase the likelihood that the detection of ambiguity aversion and framing effects are independent of the emotional processes triggered by the type of moral dilemma. A reasonable speculation is that stronger ambiguity aversion and framing effects might be exhibited in personal cases. That personal dilemmas may elicit greater ambiguity aversion and framing effects will be examined in our future studies.

In each moral dilemma, participants were given three options and were asked to rank the choices from most (= 1) to least (= 3) morally preferred. One of the options was the traditional inaction choice where the majority of the victims will die.¹ The wording of the other two options depended on the framing condition, risk level and ambiguity level. For example, in the loss, low risk and low ambiguity condition, participants were presented with the following options for the trolley case:

- *Inaction*: “if one chooses to do nothing, the outcome would be certain (100%) that the 5 people will die while it is impossible (zero chance) that the single individual will die.”
- *Action with precise probability* (i.e., risk): “if one chooses to kill the single individual, there is a 20% chance that five people will die while it is 100% certain that the single individual will die.”
- *Action with ambiguous uncertainty*: “if one chooses to kill the single individual, there is a 10–30% chance that the five people will die while it is 100% certain that the single individual will die.”

¹ A preregistered study piloted moral dilemmas with low risk level and four options including the traditional action choice (the majority will certainly be saved) revealed that the certainty option was strongly preferred over all other options while inaction was least preferred. The choice of action with certainty has the greatest expected value and the results implied the possibility of incomplete pairwise comparisons during the ranking process. That is, participants first compared the action (all three action choices) and inaction choices first and then compare the three action choices (certainty/risk/ambiguity) against each other. To rule out the possibility of incomplete pairwise comparisons, we chose to present three options as described in this study.

In the gain, low risk and low ambiguity condition, participants were presented with the following options for the trolley dilemma:

- *Inaction*: “if one chooses to do nothing, it is impossible (zero chance) that the 5 people will survive while it is 100% certain that the single individual will survive”
- *Action with precise probability* (i.e., risk): “if one chooses to kill the single individual, there is an 80% chance that the five people will survive while it is impossible (zero chance) that one person will survive.”
- *Action with ambiguous uncertainty*: “if one chooses to kill the single individual, there is a 70–90% chance that the five people will survive while it is impossible (zero chance) that one person will survive.”

The probability was 50% for the modest-risk condition which had a low ambiguity (probability interval = 20%, e.g., 40–60%) and a high ambiguity (probability interval = 60%, e.g., 20–80%) condition.

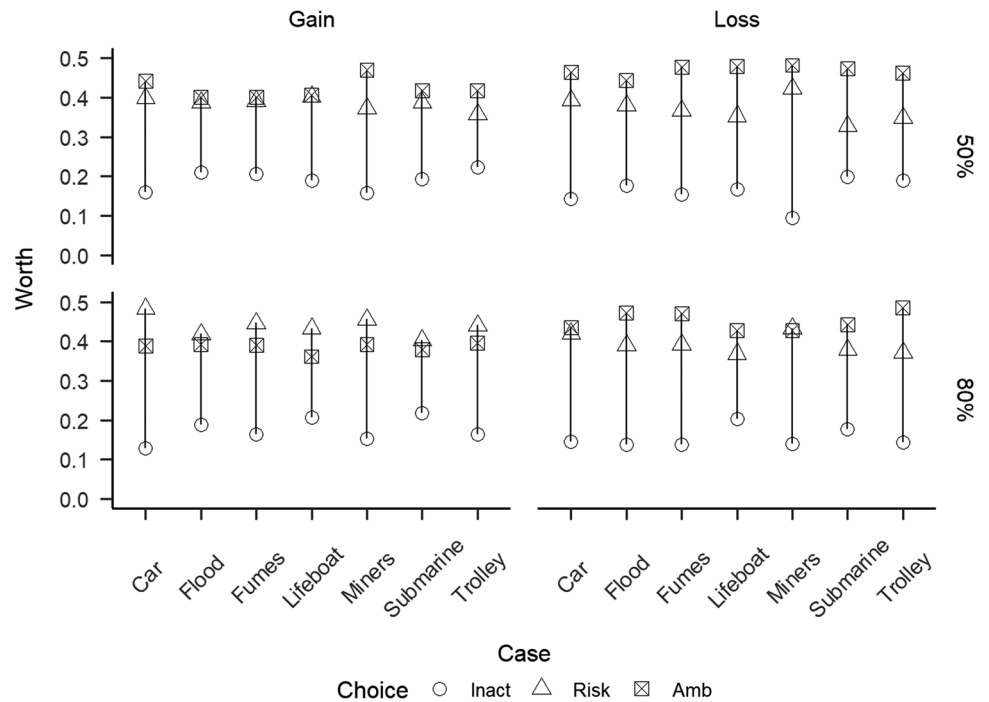
Multi-domain risk tolerance scale (MDRT) The ethical and social domain subscales of the MDRT (MDRT-E and MDRT-S) were used to assess the risk attitudes of subjects in the ethical and social domains (Shou & Olney, 2021). Each of the two subscales has six items that cover a range of risky situations and participants are asked to rate their affective response on a 7-point scale from *extremely unpleasant* to *extremely pleasant* to each of these situations. The internal consistency of the two scales was excellent in the current study ($\alpha = 0.9$ and 0.84 for MDRT-E and MDRT-S, respectively).

Multidimensional attitudes toward ambiguity scale (MAAS) The discomfort with ambiguity (DA) and moral absolutism/splitting (MA) subscales of the MAAS were used to assess ambiguity attitudes (Lauriola et al., 2016). The DA subscale captures unpleasant feelings associated with ambiguous situations, while the MA subscale captures rigid, “black and white” thinking associated with intolerance of ambiguity. The items in the two scales were rated on 7-point scales from *strongly disagree* to *strongly agree*. The internal consistency of the two scales was satisfactory in the current study ($\alpha = 0.82$ and 0.84 for DA and MA, respectively).

Procedure

The survey was programmed and hosted on the Qualtrics platform. Participants were invited to participate in the study from the Prolific platform and were randomly assigned to one of the framing conditions. Consenting participants completed demographic information, the moral judgment task, and the covariate scales.

Fig. 1 Worth parameters of the three options in Study 1 across risk levels



Data analysis

To summarise and examine the overall ranking of the choice options across dilemmas, we applied the pattern model for ranking data (Dittrich et al., 2007).² The pattern model is an extension of the Bradley-Terry model based on the log-linear model framework. This model transforms the rankings into pairwise comparisons among choices and formulates joint probability distributions of the preferences. We used the pattern model for repeated data and estimated the ranking by treating different dilemmas as different repeats. We performed the analysis separately for each of the six between-subject conditions using the “prefmod” package (Hatzinger & Dittrich, 2012) in R program. The average or effect sizes of preferences across the options are estimated via the normalized exponentials of the model coefficient (also called the worth parameter).

To test our hypotheses and to explore the influence of the individual difference covariates, we applied mixed-effects logistic regression for the following three paired comparisons: Action (Risk) vs Inaction, Action (Ambiguity) vs Inaction, and Action (Risk) vs Action (Ambiguity). We modelled each pair to test the main and interaction effects of the experimental factors and the main effects of the individual difference covariates. We used the “lme4” package (Bates

et al., 2015) and “car” package (Fox & Weisberg, 2019) for the analyses.

Results

Effect of midpoint probabilities

To test the effect of risk level (probability of the gain/loss), we first analysed the data of participants in the low ambiguity condition. Figure 1 shows the estimated preferences of the three options represented by the worth parameters. Participants ranked inaction as the least preferred option across all dilemmas and preferred both the action with precise probability and action with ambiguous uncertainty over inaction. Participants also showed a greater preference for the ambiguous choice over the risky choice in the loss condition.

Supplementary material S2 contains the results of the significance tests for the terms in the mixed effects logistic regression. The final models included only the significant terms, and the results are presented in Table 1. The significant positive intercepts of the models for Action (Risk) vs Inaction and Action (Ambiguity) vs Inaction indicate that participants significantly preferred risky/ambiguous options over inaction. Thus, H1, that inaction would be preferred, was not supported.

The framing ($\chi^2 = 1.51, p = 0.219$) and probability level ($\chi^2 = 0.41, ps = 0.521$) did not have significant main or interaction ($\chi^2 = 0.16, ps = 0.689$) effects for the Action (Risk) vs Inaction comparison and therefore H4, that inaction would

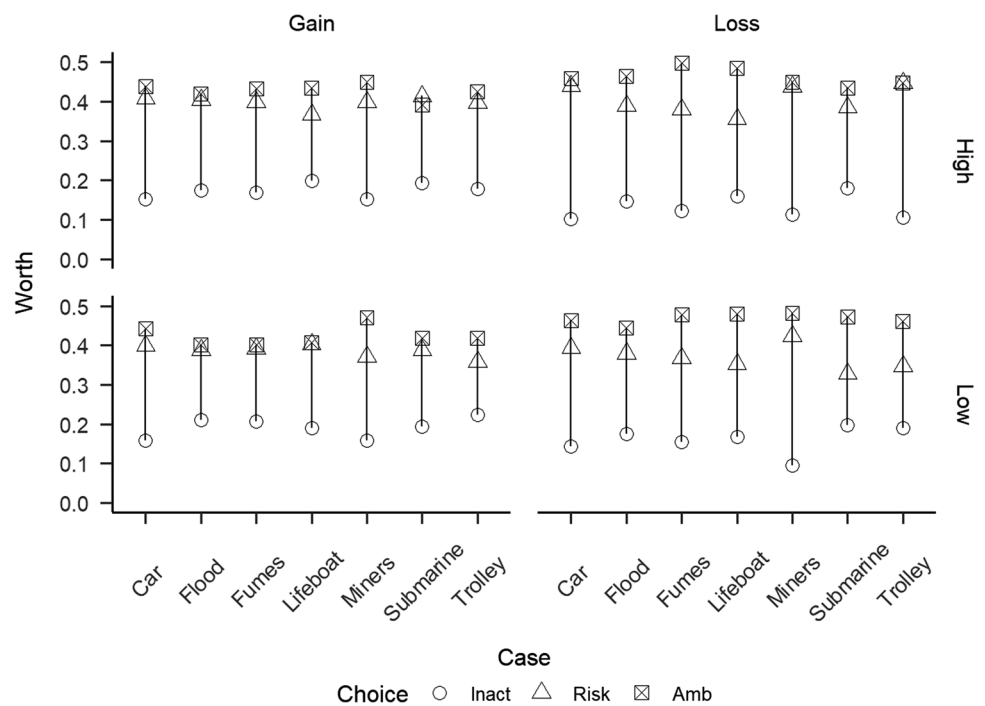
² Due to limitations with the current version of the “prefmod” package in terms of efficiently evaluating repeated data structures with covariates, pattern models were not used for main hypothesis testing.

Table 1 Mixed-effects logistic regression predicting moral preference in Study 1

Parameter	Risk vs. inaction		Ambiguity vs. inaction		Risk vs. ambiguity	
Testing the effect of risk level (<i>N</i> = 360)						
	Coef.(SE)	<i>p</i>	Coef.(SE)	<i>p</i>	Coef.(SE)	<i>p</i>
Intercept	2.37(0.20)	< .001	2.42(0.22)	< .001	-0.33(0.19)	.091
Framing	-		-		-0.45(0.19)	.021
RE	7.11		8.05		11.39	
Testing the effect of ambiguity level (<i>N</i> = 371)						
Intercept	2.35(0.19)	< .001	2.54(0.21)	< .001	-0.49(0.18)	.005
MA	-		-0.42(0.17)	.016	-	
RE	6.36		7.68		9.54	

Standard errors are presented in parentheses. Framing condition was coded as 1 for loss and -1 for gain. MDRT-E = MDRT ethical subscale. MA = MAAS moral absolutism/splitting subscale. Covariate scales were standardized. RE = random intercept variance

Fig. 2 Worth parameters of the three options in Study 1 across ambiguity levels



be preferred more in the low probability condition, was also not supported (higher risk).

There was a significant main effect of framing condition for the Action (Risk) vs Action (Ambiguity) pair ($\chi^2 = 4.92, p = 0.027$). The results in Table 1 suggest that participants' preference between risky and ambiguous options were not significantly different in the gain condition (odds ratio between risk and ambiguous options = $\exp(-0.33 + 0.45) = 1.13$), and therefore H2 (ambiguity aversion in the gain condition) was not supported. However, participants' preferences for ambiguous options were significantly increased in the loss condition (odds ratio = $\exp(-0.33 - 0.45) = 0.46$), supporting H3 (ambiguity seeking in the loss condition).

Effect of ambiguity levels

Figure 2 shows the estimated average rank effects of the three options across conditions. Inaction was ranked as least preferred for all dilemmas. Supplementary material S2 includes the results of significance tests of terms of mixed effects logistic regression. The results of the final mixed effects logistic regression model are displayed in Table 1. Similar to the results for the low ambiguity conditions in the previous section, the significant positive intercepts of the models for Action (Risk) vs Inaction and Action (Ambiguity) vs Inaction indicated that participants significantly preferred risky/ambiguous options over inaction.

The framing ($\chi^2 < 2.68$, $ps > 0.101$) and ambiguity level ($\chi^2 < 1.84$, $ps > 0.175$) did not have significant main or interaction ($\chi^2 < 0.33$, $p > 0.565$) effects for the three paired comparisons and therefore H5, that participants would have greater preferences for inaction when the action is more ambiguous, was not supported.

The significant negative intercept of the models for Action (Risk) vs Action (Ambiguity) indicated that participants significantly preferred ambiguous options over risky options. As the ambiguity level did not have a significant main effect or interaction with framing, H6 (ambiguity aversion in the gain condition being strengthened in the high ambiguity condition), and H7 (ambiguity seeking in the loss condition being strengthened in the high ambiguity condition) were not supported. Regarding covariate effects, preference for ambiguous the choice over inaction was significantly reduced among participants who had a high intolerance of ambiguity.

Discussion

We found no evidence supporting H1, which hypothesized that inaction would be preferred over uncertain action options in impersonal moral dilemmas. This indicates that people consistently apply a utility-maximizing approach to moral decision-making, even in the presence of risk and ambiguity. Contrary to our expectations, we did not observe any ambiguity aversion in the gain frame (H2), however ambiguity seeking in the loss frame (H3) was observed in the analysis involving a higher level of risk. The inconsistency of our results and those of prior research involving monetary scenarios may suggest that processing gains and losses is more complex and involves more noise in moral dilemmas than in monetary scenarios. Choice theory in behavioural decision theory usually assumes that rational agents seek to obtain optimal outcomes. The outcome is evaluated in terms of utilities that are tradable (Kahneman & Tversky, 1979; Savage, 1954). The main difference between monetary and moral decision-making is that moral choices are sometimes driven by protected values, which are believed to be non-tradeable with other values (Baron & Leshner, 2000; Ritov & Baron, 1999). In moral dilemmas, gain and loss involve life and death, and different individuals may evaluate life and death differently. Some may believe that lives possess infinite value, and thus are incommensurable and exempt from trade-offs with other values (Baron & Ritov, 2009; Ritov & Baron, 1999). Others may believe that lives contain high but finite value, and it can be traded off with other values on some occasions (Baron & Leshner, 2000; Bartels, 2008; MacKinnon, 1986). The heterogeneity in how people may evaluate the loss and gain involving life and death may be an important determinant of the non-significant effect of valence framing in the current study.

We also did not find evidence to support H4 in that both low (20%) and modest (50%) levels of risk did not seem to induce enough risk aversion for participants to prefer inaction over the risky action. The results suggest that the maximization of expected value is still the dominating factor determining moral judgments. We propose two possible explanations for these findings. The first is that there is no aversion to risk involved in action choices, as action choices are always strictly preferred over inaction, morally speaking, no matter the level of risk. The second possible explanation is that any aversion to risk is being masked by the expected value differential between the choice options. That is to say, the expected value of the action choice when the probability of the five people dying is 20% and 50% is still higher than that of inaction and thus any aversion to uncertainty present may be hidden by moral reasoning that continues to maximize expected value. To test which explanation is true, we conduct Study 2 in which we increase the magnitude of risk that the five people die to 80%, thus making the expected values of inaction and the action with risk equivalent. Similarly, we found that at a 20% and 50% probability interval, ambiguity did not have a significant impact on moral judgments. Study 2 further tests if ambiguity can have a significant impact on moral judgments at greater levels of ambiguity.

Study 2

Methods

A total of 391 US participants recruited from Prolific consented and completed Study 2. Thirty-six participants were excluded due to not passing attention checks ($n = 21$), self-reported to not have understood most of the study or did not pay much attention ($n = 9$) or were identified as a bot by Qualtrics fraud detection ($n = 6$). The remaining 355 participants (176 females) were aged between 18 and 81 ($M = 40.35$, $SD = 14.71$), of which 62.8% of the participants had a tertiary or above education and 96.6% spoke English as their first language.

The study had a 2 (ambiguity level: high [e.g., 0–40%], low [e.g., 10–30%]) \times 2 (framing conditions: gain, loss) between-subjects design. Participants were randomly assigned to one of the conditions. The procedure of Study 2 was identical to Study 1. The moral judgment task was also identical to the conditions in Study 1 that compared high versus low risk, except that the risk level was increased from 50% loss/gain to 80% loss or 20% gain. The low ambiguity condition had a probability interval of 20% and the high ambiguity condition had a probability interval of 40%. We also included the same covariate scales as Study 1. The internal consistency of the scales was high ($\alpha = 0.90$, 0.85, 0.84, and 0.85 for the MDRT-E, MDRT-S, DA and MA, respectively).

Fig. 3 Worth parameters of the four options in Study 2 across ambiguity levels

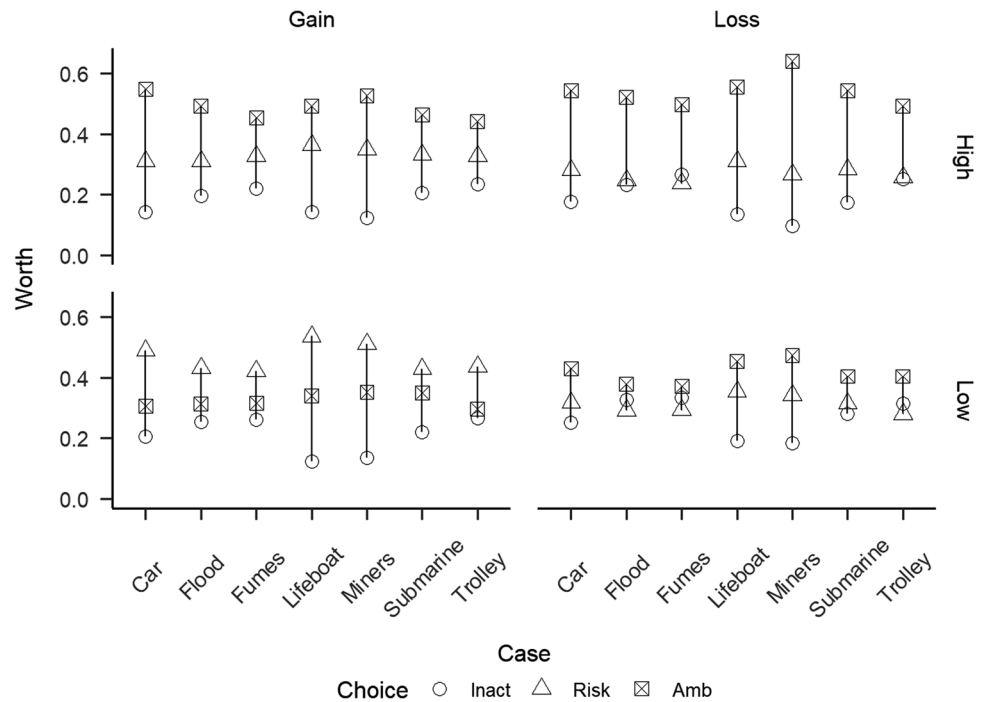


Table 2 Mixed-effects logistic regression predicting moral preference in Study 2

	Risk vs. inaction		Ambiguity vs. inaction		Risk vs. ambiguity	
	Coef.(SE)	<i>p</i>	Coef.(SE)	<i>p</i>	Coef.(SE)	<i>p</i>
Intercept	1.25(0.13)	< .001	1.40(0.14)	< .001	-1.19(0.23)	< .001
Framing	-0.29(0.13)	.023			-1.12(0.23)	< .001
Ambiguity level (high vs low)			0.34 (0.13)	.011	-1.37(0.23)	< .001
RE	3.95		4.41		12.06	

Standard errors are presented in parentheses. Framing condition was coded as 1 for loss and -1 for gain. Ambiguity condition was coded as -1 for the condition with narrower range/low ambiguity and 1 for the condition with wider probability range/high ambiguity. RE=random intercept variance

Results

Pattern models on rankings

Pattern models were used to estimate the average preference for the seven dilemmas and analysis was performed separately for each of the four conditions. Results are displayed in Fig. 3. Inaction was ranked either least preferred or of similar preference level to the other two options across the dilemmas. We also noticed that when the ambiguity level was low, the ranking of the action with ambiguity option was similar to inaction for the flood, fume and trolley cases in both the gain and loss conditions. In addition, in the loss condition we found that the ranking of the action with risk option was similar to inaction for the flood, fume and trolley cases regardless of the ambiguity level.

Supplementary material S3 contains the results of the significance tests for the terms in the mixed effects logistic regression. The final models included only the significant terms, and the results are presented in Table 2. The significant positive intercepts of the models for Action (Risk) vs Inaction and Action (Ambiguity) vs Inaction indicated that participants significantly preferred risky/ambiguous options over inaction, again not supporting H1.

Ambiguity had a significant main effect on Action (Ambiguity) vs Inaction preferences ($\chi^2=6.46, p=0.011$), where participants' preference of ambiguous choice compared to action increased when ambiguity was higher. H5 (preference of inaction would be stronger in the high ambiguity condition) was not supported.

For the Action (Risk) vs Action (Ambiguity) comparison, both ambiguity level ($\chi^2=33.11, p<0.001$) and framing ($\chi^2=25.69, p<0.001$) had significant main effects on participants' preference. Participants significantly preferred

ambiguous options over risky options in the loss condition (odds ratio between risk and ambiguous options = $\exp(-1.19-1.12)=0.10$) but not in the gain condition (odds ratio = $\exp(-1.19+1.12)=0.93$). H2 (ambiguity averse in the gain condition) was not supported while H3 (ambiguity seeking in the loss condition) was supported. For both gain and loss conditions, participants significantly preferred ambiguous options over risky options in the high ambiguity condition (odds ratio between risk and ambiguous options = $\exp(-1.19-1.37)=0.08$) but not in the low condition (odds ratio = $\exp(-1.19+1.37)=1.20$). H6 (ambiguity aversion in the gain condition being strengthened in the high ambiguity condition) was not supported while H7 (ambiguity seeking in the loss condition being strengthened in the high ambiguity condition) was supported.

In addition, we noticed that the preference for risky/ambiguous actions over inaction reduced with increasing probability of loss. The odds ratios reduced from approximately $\exp(2.4)$ (see Study 1) to around $\exp(1.3)$, suggesting that the preference for inaction decreased when the loss probability increased to 80% in Study 2. However, such an increase was not sufficient to be preferred over the actions option with risk or ambiguity.

Discussion

Study 2 found that participants continued to prefer uncertain action over inaction in most cases. This has special significance compared to similar results in Study 1, as such a preference can no longer be explained by a higher expected value of the preferred choice. Given that the expected values of action and inaction were equivalent in Study 2, participants' continued preference of action choices with uncertainty over inaction with certainty suggests that they displayed commission bias—the tendency towards action rather than inaction—in these five scenarios. This finding is unexpected as the omission bias is the more commonly reported cognitive bias in moral psychology (Ritov & Baron, 1999).

Study 1 and Study 2 found general ambiguity seeking in the domain of loss at both moderate (i.e., 50%) and high levels of risk (i.e., 80%), although no ambiguity aversion in the gain domain was found in Study 1 or Study 2. Along with the results from Study 1, the fact that H7 was supported where the level of midpoint probability was higher (80%) but was not supported where the midpoint probability was lower (50%) suggests that the level of midpoint probability affects participants' sensitivity to ambiguity. In short, higher numerical values of probability resulted in greater participant sensitivity to ambiguity, regardless of the conditions.

General discussion

This paper explores whether moral reasoning is sensitive to uncertainty. Two studies found consistent evidence that supported the notion that people are sensitive to ambiguity in moral dilemmas. However, our results also reveal the distinctiveness of moral reasoning. A significant number of studies on ambiguity in the monetary domain have found a complete reversal of ambiguity attitudes between modest-likelihood gains and losses (Baillon & Bleichrodt, 2015; Casey & Scholz, 1991; Chakravarty & Roy, 2008; Ho et al., 2002; Kothiyal et al., 2014). In our studies on moral dilemmas, general sensitivity to ambiguity was only found in the loss and gain conditions when the likelihood of the outcome was high (80%), but no sensitivity was detected in situations with a more modest probability. Furthermore, the effect of ambiguity level was also only detected in high-probability loss scenarios (80% of loss) in that participants were more likely to display ambiguity seeking when the probability interval was larger.

This distinctiveness of moral reasoning from non-moral reasoning may be explained by how value commitments tested in moral dilemmas differ from that in the monetary domain. In monetary scenarios, gains and losses can be numerically traded off. Yet, such quantification and trade-offs can only be contentiously applied to objects of moral value, such as the value of human life. In certain moral doctrines, human life is regarded as *invaluable* – meaning that they should not be sacrificed and traded off, no matter how great the benefit (Baron & Hershey, 1988; Baron & Ritov, 2009).

This paper also explored people's attitudes toward uncertainty in moral dilemmas and if these attitudes predict moral judgments. As expected, preference for action under conditions of uncertainty decreases with increasing levels of uncertainty. Yet, comparing an action choice with risk and inaction choice with certainty, strict moral preference of action is observed at all levels of risk studied. This is especially striking in Study 2, as the expected value of the action and inaction alternatives are equivalent. This seems to be the first observed instance of commission bias in moral decision-making research, where *omission* bias is usually observed. Commission bias studies are mostly found in the medical decision-making literature and can be detected among over-confident doctors (Baron & Ritov, 2009; Ritov & Baron, 1999). The potential reasons for commission bias in moral decision-making is a phenomenon that requires further study.

The finding of ambiguity seeking in the domain of loss is consistent with the existing literature. Bouchouicha et al., (2017) found that high stakes induce stronger ambiguity seeking for moderate-to-large probabilities of losses. The

finding of ambiguity insensitivity is also partially consistent with the existing finding of no ambiguity aversion in low probabilities of gain; whereas it is inconsistent with the finding of ambiguity aversion in moderate probabilities (Bouchouicha et al., 2017). We have suggested that this may be due to the distinctive ways in which states of affairs (such as saving lives or losing lives) are morally valued. The finding that increasing levels of ambiguity induce ambiguity seeking in the loss domain also suggests that a high potential loss threshold exists for ambiguity attitudes to be triggered in moral scenarios compared to monetary scenarios. All these findings imply that although it is natural to think that moral judgments are one sub-type of decision-making, phenomena, such as sensitivity to uncertainty or cognitive bias, that generally occur in nonmoral judgments and decisions may only appear in high-likelihood situations in moral scenarios.

The finding of commission bias has important implications. Past research has considered the empirical finding that subjects prefer action to inaction in moral dilemmas solely due to outcome-based considerations (i.e., maximization of expected utility) alone. Yet, having discovered the existence of commission bias in Study 2, this may indicate similar mechanisms at work also in seemingly value maximizing choices. In contrast to numerous studies on omission bias in moral judgments, commission bias in moral judgments has mostly been ignored in the literature. This may be due to how these studies often use moral dilemmas in which the expected value of inaction is lower than the expected value of action and thus masks the effect of a potential commission bias. Future research can focus on what factors may trigger the commission bias, and also test if there is an association between probabilistic information provided in the context and commission bias.

Some limitations of the current studies should be noted and addressed in the future research. First, it is worth noting that we used percentage (e.g., 50%) instead of natural frequencies in framing the options. There is much research that shows that people are less cognitively taxed when making decisions based on natural frequencies (Hoffrage et al., 2015a, b). It is possible that the moral decisions may be confounded by the way that the frequencies (i.e., numerical) are presented. This possibility can be tested in future studies. Second, the results of the individual covariate effects were not consistent across the studies. One general finding is that there were no significant main effects that were associated with the individual difference covariates in most of the conditions. Whether there are any underlying reasons that explains these findings is to be further studied. Moreover, the current research only focused on impersonal cases. Future research can further test if commission bias is a general phenomenon across both personal and impersonal cases.

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Data availability The datasets generated during and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical approval The ethical aspects of this research project were approved by the Committee on Research Ethics and Safety of the Lingnan University (Reference no. EC013/2122).

Informed consent Informed consent was obtained from all participants in the study.

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