Decision-making in Black-Swan Situations

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Declaration

I, Winky Lee, declare that this thesis is my own work, except where acknowledged, and that the research reported in this thesis was conducted in accordance with the principles for the ethical treatment of human subjects as approved for this research by the University of Melbourne Human Research Ethics Committee.

Winky Lee

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Abstract

Black-swan events, such as plane crashes, are statistically unlikely, but catastrophic if they happen. Given their rarity and impact, how do people judge their importance in decision-making? Past studies have found that people do not precisely internalize probabilistic information, and tend to overweight small probabilities in decision-making. Perfors and Van Dam (2018) extended these observations to numerical gambles that involve black-swan losses. They found that participants were risk averse towards black-swan losses when the alternative option was riskless, but were significantly more risk seeking when the alternative also included a black-swan risk. To examine whether Perfors and Van Dam's (2018) observations extend to more naturalistic black-swan situations, we ran a survey where participants (N = 1822) made decisions in hypothetical vignettes of real-world situations with a set-up that was analogous to their experiment. Unlike the previous findings, our results indicate that irrespective of how alternative options were framed, there was no consistent risk taking or risk avoidant decision in the hypothetical situations. Our findings are suggestive of different decision processes in numerical gambles versus hypothetical contexts of real-world problems, and may highlight the complexity of human decision-making, especially in black-swan situations.

Keywords: decision-making; black-swan; rare events; Prospect Theory; overweight; risk averse

Should you worry about terrorist attacks, nuclear disasters, or a sudden collapse of the stock market? These are examples of *black-swan* events, which have two distinct attributes: first, they are extremely rare and lie outside of regular expectations; second, they are highly consequential (Aven, 2013; Kahneman, 2011; Taleb, 2007). Although black-swan events are improbable, intuition suggests that they should attract a reasonable and finite degree of consideration due to their impact.[1] Yet how much do people really worry about a black-swan event? Do they pay too much, or too little attention to a black-swan event in decision-making? Much work has been done to understand decision-making under risk and uncertainty using numerical experiments (e.g., Hertwig, Barron, Weber, & Erev, 2004; Yechiam, Rakow, & Newell, 2014), but very few studies have specifically examined decision-making in black-swan situations, which is substantially more difficult. This study aims to address how people make decisions in real world contexts that involve black-swan risks (i.e., catastrophic black-swan events).[2]

In Section 1.1, Prospect Theory (PT; Kahneman & Tversky, 1979) is discussed in relation to empirical observations of decision-making under *rare events*. In Section 1.2, we discuss the differences between rare events and black-swan events. We argue that most existing studies of decision-making under rare events fall short on providing insights into the black-swan problem. In Section 1.3, we discuss a recent study by Perfors and Van Dam (2018), which provides a preliminary glimpse into decision-making in black-swan situations by using numerical gambles that involve black-swan losses. Finally, Section 1.4 explains how the present study builds on Perfors and Van Dam's (2018) work to understand decision-making in black-swan situations that are more naturalistic and grounded in everyday life.

[1] See Buchholz and Schymura (2012) for the *Tyranny of Catastrophic Risks*.

[2] Black-swan events are highly consequential events that can be either extremely good, or catastrophic. This study focuses on decision-making in negative black-swan situations.

1.1 Prospect Theory and Decision-making under Rare Events

Kahneman and Tversky's (1979; 1984) Prospect Theory (PT) provides important implications for understanding decision-making under risk and uncertainty. The researchers posit that decision-making is driven by an individual's valuation of possible outcomes (i.e., perceived desirability of possible gains or losses), weighted by subjective decision weights, which can be thought of as the perceived likelihood of a possible outcome with respect to its priori (stated) probability of occurrence. Subjective decision weights are hypothetically represented by the weighting function shown in Figure 1.

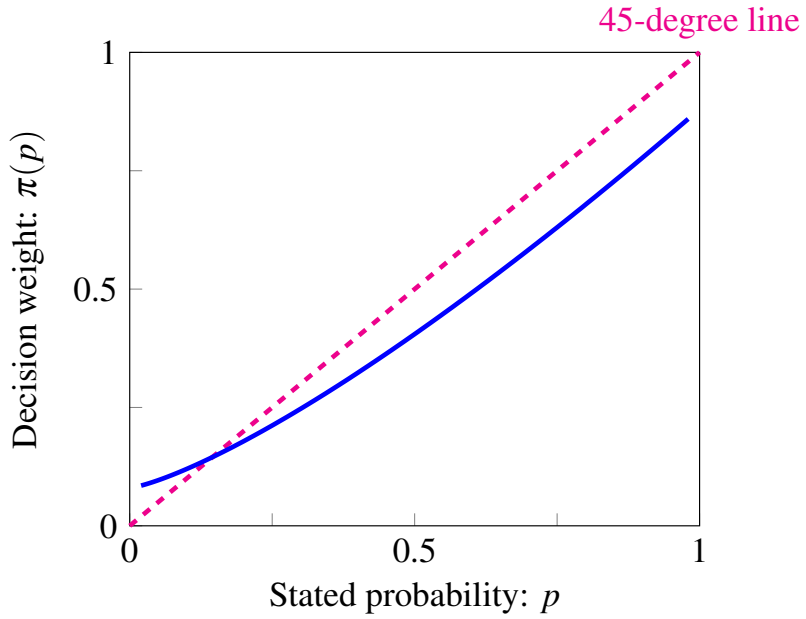

Figure 1. A hypothetical probability weighing function (the solid line) adopted from Tversky and Kahneman (1981). The stated probability is the objective, or statistical likelihood of a possible outcome. The precise function of decision weights with respect to stated probabilities can vary across individuals. The function shown here is hypothetical and is presented for illustrative purposes.

The theorists postulate that although the precise functional form of the subjective decision weights with respect to stated probabilities (i.e., the objective likelihood) can vary across individuals, they generally exhibit a non-linear relationship as depicted in the hypothetical function. For low probabilities, decision

weights are higher than the stated probabilities (the weighting function lies above the 45-degree line for low probabilities). This means that low probabilities tend to be *overweighted*. In contrast, decision weights are lower than the stated probabilities for moderate to high probabilities, meaning that moderate and high probabilities are *underweighted*. Kahneman and Tversky (1984) postulate that people's tendency to overweight low probabilities contributes to their aversion towards unlikely losses, and the attractiveness of unlikely gains. They argue that this explains the desirability of insurance or gambles; people are willing to pay a high premium to insure against small risks, or invest more than they should for a lottery. On the other hand, the underweighting of moderate or high probabilities leads to *risk aversion* for gains. For example, when offered a choice between a gamble that provides a larger gain (e.g., 50% chance of winning $100) versus a sure but smaller gain (e.g., win $50 for sure), risk averse individuals have a propensity to choose the sure gain, even when both options offer the same expected payoff.[3] This is because by underweighting moderate or high probabilities, the attractiveness of the larger probable gain in the gamble is reduced, whilst the desirability of the sure gain is magnified. The preference for a sure gain is often observed even in cases where the gamble option offers a higher expected payoff, and this phenomenon is known as the *certainty effect* (Kahneman & Tversky, 1979).

Consistent with PT, experimental studies using numerical gambles found that when people were confronted with descriptive information of probabilities (likelihoods of occurrence), they tended to overweight rare events in decision-making, compared to when the information was learnt from *experiential sampling* (e.g., Erev, Glozman, & Hertwig, 2008; Fox & Hadar, 2006; Hertwig, 2012; Hertwig et al., 2004; Hertwig & Erev, 2009; Ludvig & Spetch, 2011; Yechiam et al., 2014). Consider the following example adopted from Hertwig et al. (2004):

[3] Expected payoffs are calculated as the sum of payoffs of all possible outcomes weighted by the respective probabilities. E.g., for a gamble that has a 60% chance of gaining $100 but losing $10 otherwise, the expected payoff is $.6 \times 100 + .4 \times 10 =$ $56.

Table 1

An example choice problem with descriptions of priori probabilistic information.

Option A: Get $4 with probability .8, $0 otherwise. [Expected payoff = $3.2]
Option B: Get $3 for sure.

Adopted from Hertwig et al. (2004).

The researchers found that in conditions where participants acquired information about the outcome probabilities by making repeated choices and receiving feedback (i.e., through experiential sampling), more chose Option A, which offers a higher expected payoff. However, when choices were made based solely on descriptive statements of probabilistic information, more people preferred Option B, which offers a sure, but lower expected gain. These findings are robust in the literature; they indicate that when decisions are made based on descriptive information rather than experience, people tend to pay more attention to a rare event (e.g., the 20% chance of gaining $0 in Option A) than warranted by the event's objective probability (Hertwig et al., 2004).

Why might people overweight rare events in decision-making when the probabilistic information is explicitly stated? According to Fox and Tversky's (1998) *two-state model* of decision-making, decision makers first assess the priori (stated) probability of an uncertain event, and then transform their valuations of the event using decision weights that follow the hypothetical weighting function (Figure 1). This proposition was supported as the researchers found that even when people were able to report the stated probabilities of an event fairly accurately, they still overweighted unlikely events in decision-making (Fox & Hadar, 2006; Fox & Tversky, 1998). This finding indicates that small probabilities may not be precisely internalized during decision processes, despite knowing the quantitative details. Consistent

with this idea, the *Fuzzy-Trace Theory* asserts that people do not actually implement the precise actuarial details of probabilistic information in decision-making (Reyna, 2004; Reyna & Brainerd, 2008). Instead, they tend to rely on a fuzzy, gist-like, and intuitive representation of the numerical information, even when they can remember the quantitative details (Brainerd & Reyna, 2001; Reyna, 2004; Reyna & Brainerd, 2008; Wolfe, Reyna, & Smith, 2018). In light of the Fuzzy-Trace Theory, Wolfe et al. (2018) argue that people often engage in *approximately equal judgments*, which is the tendency to encode only the qualitative distinctions between quantities in order to discern useful groupings of numerical information during cognitive processes. It follows that there may be circumstances where a small probability and a moderate probability are judged to be approximately equal, as if there is no meaningful difference between them. For example, if '1 in 10' and '1 in 50' are encoded to be approximately the same, the '1 in 50' chance event may be overweighted. Therefore, the overweighting of rare events might be a result of a reliance on vague mental representations of small numbers in decision processes.

The way people implement probabilistic information from descriptive statements in judgments of risks has important implications for decision-making in black-swan situations. Black-swans are by definition seldom experienced in everyday life. Thus, rather than from experience, one must rely on descriptive statistical information when making decisions in black-swan situations (e.g., deciding whether to perform a promising but difficult surgery involves considering the success rate suggested by the doctor). Previous findings of a tendency to overweight rare events suggest that black-swan events may also be overweighted in decision-making. However, black-swan events may be more complicated than the rare events depicted in most past studies. Given the poor representational resolution of small numbers in reasoning processes, it remains unclear how people deal with extremely rare risks, like a black-swan, in decision processes. We elaborate on the complication of black-swans in the following section.

1.2 The Complication of Black-Swans

Rare events depicted in most previous experiments are not fully representative of a black-swan. Low probabilities have been typically defined as 10% to 20% (Hertwig et al., 2004). The lowest, to our knowledge, is a 1 in 200 chance (see Yechiam et al., 2014). These are small probabilities, but black-swans involve even more extreme degrees of rarity. The odds of a plane crash, for example, are around one in a million (Lee, 2018). Whilst small probabilities might be overweighted, it remains unclear how extremely small probabilities might be encoded in decision-making. In discussing the hypothetical weighting function, Kahneman and Tversky (1984) mindfully distinguish between 'low probabilities' and 'very low probabilities'. They postulate that whilst low probabilities are overweighed, the weighting of extremely low probabilities are "unstable" — they can be overweighted, or neglected entirely (Kahneman & Tversky, 1984, p. 345). Are black-swan probabilities, such as a one in a million chance, small enough to be ignored entirely? If extremely small probabilities are small enough to be encoded as effectively zero, people might disregard black-swan risks completely. However, it has also been proposed that people have a heightened sensitivity towards the deviation from a zero probability to small probabilities (Fox & Tversky, 1998; Kahneman & Tversky, 1984). This constitutes the *possibility effect* — just by realizing that it is possible for an event to happen (despite a small probability), the event may receive more attention than its statistical likelihood warrants in decision-making. If so, a black-swan event may be overweighted in decision-making just because it has a non-zero likelihood of occurrence.

Another complication of black-swans is their highly consequential nature. Black-swans are likely to be emotionally impactful, and the role of emotions in influencing decision-making is well recognized in the literature (Burns, Chiu, & Wu, 2010; Lichtenstein, Slovic, Fischhoff, Layman, & Combs, 1978; Lieder, Griffiths, & Hsu, 2017; Madan, Ludvig, & Spetch, 2014). Many have argued that since risks are

often perceived as feelings, judgment of risks is largely influenced by how they are perceived emotionally (Loewenstein, Weber, Hsee, & Welch, 2001; Slovic & Peters, 2006). Slovic and colleagues (2007; 2006) argue that the *affect heuristic*, which refers to the reliance on emotional intuition in decision-making, biases decisions by giving more attention to emotionally salient events. This idea is well-supported by research. For example, Lichtenstein et al. (1978) found that people tend to overestimate the probabilities of causes of death by sensational events, such as natural disasters and accidents, when compared to other less sensational events, like illnesses. Rottenstreich and Hsee (2001) found that the degree of overweighting of rare events increased for affect-rich outcomes. That is, people were found to be more sensitive to small probabilities when the associated outcome is more emotionally disturbing. In addition, Mellers and McGraw (2001) argue that decision-making is a process of anticipating the desirability of potential consequences that follow the chosen actions. Since desirability is inseparable from anticipated feelings of pleasure, decision-making is influenced by anticipated emotions of future possible events (Mellers & McGraw, 2001). Thus, if the anticipated adversity of a black-swan risk is overwhelming enough, the risk is likely to be overweighed in decision-making rather than ignored.

Most existing studies also do not capture the effects of a high-impact consequence on decision-making. Losses and gains are typically represented by only some fraction of the participants' initial points, which falls short from being catastrophic. To understand decision-making in black-swan situations, experimental choice settings must incorporate the extreme rarity, as well as the highly consequential attribute of a black-swan event. This is what Perfors and Van Dam (2018) considered in studying black-swan decision-making in an experimental context. Section 1.3 describes their work in more detail.

1.3 Perfors and Van Dam's (2018) Paradigm

Perfors and Van Dam's (2018) study provides a preliminary understanding of decision-making in black-swan situations. They examined people's choices in some gamble conditions, where participants started with different points, and could gain or lose points depending on their choices.[4] Black-swan events were represented by a very small probability (e.g., a 1 in 1,000 chance) of "losing all points".

To examine whether people would ignore or overweight the black-swan losses, Perfors and Van Dam (2018) examined responses to the first gamble condition (denoted as the ONERISK condition) which contrasts two choices, the MORERISKY option versus the LESSRISKY option, where the MORERISKY option contains a black-swan component, as shown in Table 2.

Table 2

ONERISK condition:
MORERISKY option: 1 in 2 chance of gaining 15 points, and 1 in 1,000 chance of losing all points.
LESSRISKY option: 1 in 2 chance of gaining 5 points.

Adopted from Perfors and Van Dam (2018).

Since participants in the study started with different points, ranging from 3,000 to 7,000 (in steps of 1,000 points), the expected payoffs of each option would differ depending on a participant's starting point. The break-even point where all options give identical expected payoffs is at 5,000. That is, for a person who has 5,000 points, both the MORERISKY and LESSRISKY options give an expected payoff of 2.5 points in the ONERISK condition (Table 2). The researchers suggested that if the extremely small likelihood of the black-swan risk is encoded as effectively zero, individuals with less than 5,000 initial

[4]The points translated into additional real-life dollars, and so participants were incentivized to maximize their expected payoffs from the gambles.

points should display a preference for the MORERISKY option as it gives a higher expected payoff. However, if the black-swan risk was not ignored, a preference for the LESSRISKY option would reflect an overweighting of the black-swan risk.

The researchers were also interested in whether people would encode differences between extremely small probabilities. Hence, they investigated responses to the second gamble condition (TWORISK condition) which again consists of two options, the MORERISKY and the LESSRISKY option, where both options now contain a black-swan component of different magnitudes, as shown in Table 3.

Table 3

TWORISK condition:
MORERISKY option: 1 in 2 chance of gaining 20 points, and 15 in 10,000 chance of losing all points.
LESSRISKY option: 1 in 2 chance of gaining 6 points, and 1 in 10,000 chance of losing all points.

Adopted from Perfors and Van Dam (2018).

Similar to the ONERISK condition, participants started with different points, and the MORERISKY option offers a higher expected payoff for individuals with less than 5,000 points. Perfors and Van Dam (2018) proposed that if small probabilities were encoded to be identical (as the Fuzzy-Trace Theory suggests), participants who began with less than 5,000 points should disregard the black-swan components in the two options, and should show a preference for the MORERISKY option. Choosing the LESSRISKY option instead would indicate that they internalized the larger risk in the MORERISKY option during decision-making.

Perfors and Van Dam (2018) found that regardless of the amount of starting points, significantly more people chose the LESSRISKY option in the ONERISK condition. This indicates that people do

not in fact treat extremely small probabilities as negligible. Consistent with previous findings of an overweighting of rare events in decision-making, people also overweight the black-swan risk.

In the TWORISK condition, the preferences reversed — significantly more people chose the MORERISKY option than the LESSRISKY option. This finding indicates that whilst people did not precisely internalize the magnitude of extremely small probabilities, they encoded the black-swan components in the TWORISK condition as qualitatively identical, despite a fifteen-fold difference in risk probabilities (the MORERISKY option is fifteen-times riskier). The difference in preferences between the two risk conditions was also observed regardless of how many points the participants had initially.

The researchers carried out a second experiment to test the robustness of their observations by changing the payoffs and risk probabilities, with larger black-swan risks in both risk conditions (i.e., ONERISK: 1 in 100 instead of 1 in 1,000; TWORISK: 15 in 1,000 vs. 1 in 1,000 instead of 15 in 10,000 vs. 1 in 10,000 as before). In experiment 2, respondents no longer displayed a preference for the MORERISKY option in the TWORISK condition. This suggests that they were encoding some difference in the black-swan probabilities. However, the difference in preferences between the ONERISK and TWORISK conditions was still significant; the MORERISKY option was still chosen by significantly more people in the TWORISK condition than in the ONERISK condition. Taken together, these findings showed that black-swan losses were not ignored when stated explicitly, and that decision-making in black-swan situations depended on how situations were framed; i.e., choices depended on whether the LESSRISKY option also entailed a black-swan component.

Perfors and Van Dam's (2018) findings are consistent with Kahneman and Tversky's (1979) observations of *framing effects* in decision-making. The preference for the LESSRISKY option in the

ONERISK condition reflects risk aversion: people were risk averse and preferred the riskless option,[5] even though the alternative gives a higher expected payoff (Kahneman & Tversky, 1979, 1984). The preference for the MORERISKY option in the TWORISK condition reflects an *isolation effect*, where the shared black-swan components appear to be disregarded, allowing the participants to focus only on the gains of the prospects (Kahneman & Tversky, 1979).

These findings elicit important practical implications for improving people's judgment and decision-making under black-swan risks. For example, it may inform how public health promotions, such as vaccines or new medications that are expected to be highly beneficial but controversial due to a very small risk of side effects, can be optimally designed.

However, Perfors and Van Dam (2018) acknowledged that their study is limited in the generalizability to instances of real-life black-swan situations; numerical gambles and "losing all points" may not be representative of a black-swan event in reality. To examine whether the influence of the framing difference between the ONERISK and TWORISK conditions extends to more realistic, real-world situations not involving numerical gambles, this study builds on Perfors and Van Dam's (2018) work by using hypothetical vignettes of real-life situations. We explain how this study addresses the limitation in their study in the next section.

1.4 The Present Study, Aims and Hypotheses

Similar to Perfors and Van Dam's (2018) study, we randomly assigned participants to either the ONERISK or TWORISK condition, where they were asked to choose between two options, either

[5] Note that this almost reflects the certainty effect, except that the LESSRISKY option in the ONERISK condition does not offer a sure gain, but a probable (1/2 chance) gain. Tversky and Kahneman (1986) call this the *pseudocertainty effect*.

one of which or both of which incorporated black-swan elements. Unlike their work, our experiment involved vignettes of real-world situations rather than numerical gambles. The MORERISKY option offered a recommended but risky solution to a hypothetical problem, whereas the LESSRISKY option offered not to carry out the action. We aimed to address two main questions. First, whether people would ignore black-swan risks in decision-making (e.g., 1 in 10,000 in the ONERISK and TWORISK conditions respectively). Second, whether choices would change depending on the risk conditions, which differed in how the options were framed. Given the high impact nature of a black-swan event, it is plausible that people would be more reluctant in choosing the MORERISKY option in the ONERISK condition. Thus, it was first hypothesized that in the ONERISK condition, more people would choose the LESSRISKY option than the MORERISKY option (Hypothesis 1). However, by presenting an alternative that also contains a black-swan risk, people should be able to isolate the benefits of the MORERISKY option. Hence, it was also hypothesized that in the TWORISK condition, more people would choose the MORERISKY option than the LESSRISKY option (Hypothesis 2).

Methods

2.1 Participants

2.1.1 Recruitment

Participants were recruited on Amazon Mechanical Turk (AMT), an online crowdsourcing service where anonymous individuals (known as workers) are recruited to complete human intelligent tasks (HITs) posted by requesters (see Crump, McDonnell, & Gureckis, 2013). AMT workers have been found

to be at least as representative of the US population as traditional recruitment pools (Paolacci, Chandler, & Ipeirotis, 2010), and have turnover rates similar to that of new university students (Stewart et al., 2015). Moreover, AMT protects confidentiality by ensuring the anonymity of workers. Participants in this study were paid $0.50USD ($10USD/hour) for completing the survey, which took three to five minutes.

2.1.2 Ethics Approval and Consent

Ethics approval was granted by the Human Research Ethics Committee at the University of Melbourne. All participants provided informed consent by indicating that they agreed to the terms and conditions as stated on the Plain Language Statement (Appendix A) and the Consent form (Appendix B). The PLS and consent form were available for download at the start of the survey. All participants were also debriefed at the end of the survey (Appendix C).

2.1.3 Inclusion Criterion

Only US AMT workers, aged 18 or above, were recruited.

2.1.4 Demographic Information

A total of N = 1920 US participants were recruited on AMT. Of the 1920 initial participants, $N = 1822$ were retained for data analysis.[6] Ages ranged from 18 to 82 years (mean age = 37.05) and 975 (53.51%) were males.

[6] Twenty-four participants were excluded for incomplete responses. Responses to Item C1.8 (Appendix D) for both risk conditions were also removed due to an error in setting up the survey for that question (N = 74). Twenty responses were pilot data that was not analyzed or included in the full sample.

2.2 Materials

2.2.1 Design

This study utilized two risk conditions (ONERISK vs. TWORISK) similar to the design of Perfors and Van Dam's (2018) study. Table 4 provides an example (Item A4.4) for the two risk conditions. Unlike the previous study, choice settings in this experiment involved hypotheticals based on real-life situations instead of numerical gambles involving points. Both conditions involved presenting participants with a MORERISKY and a LESSRISKY option, but the conditions differed in whether the LESSRISKY option also involved a risk component.

In the ONERISK condition, the MORERISKY option offered an action that was intended to be beneficial to the described situation (see Table 4; for example, taking the anti-malarial medication was considered the beneficial action), but contained a risk of a highly negative outcome with a 1 in 10,000 chance of occurrence. The LESSRISKY option offered the option to take no action, thus avoiding the potential benefits as well as the low-probability risk of the highly negative outcome. If people consider small probabilities to be negligible, there should be a preference for the MORERISKY option.

In the TWORISK condition, the MORERISKY option was a beneficial action that contained a black-swan risk with an 11 in 100,000 chance. The LESSRISKY option again offered the option to take no action, but now contained a black-swan component with a 1 in 100,000 chance.

Table 4

Item A4.4; see Appendix D for the full list of items.

Hypothetical situation:
You are visiting a tropical country that occasionally has outbreaks of malaria, though they are pretty uncommon. The recommended anti-malarial medication has potentially severe side effects. Do you:
OneRisk condition:
MORERISKY option: Take the medication, with 1 in 10,000 chance of having severe side effects. **LESSRISKY option:** Do not take the medication.
TwoRisk condition:
MORERISKY option: Take the medication, with 11 in 100,000 chance of having severe side effects. **LESSRISKY option:** Do not take the medication, with 1 in 100,000 chance of having severe side effects from malaria anyway.

There was no practical method for calculating the expected payoffs of actions and outcomes in hypotheticals based on real-life situations, because the subjective valuations assigned to the benefits and losses may vary depending on the participants' subjective interpretations. This however did not affect our ability to compare the ONERISK and TWORISK conditions, because the options were qualitatively the same; actions were identical across risk conditions and negative outcomes were identical across options. The options differed only in the probabilities assigned to the negative outcomes. In both conditions, the difference in risk probabilities between the MORERISKY and LESSRISKY options was also identical, at 1 in 10,000. Thus, between-subject responses to the risk conditions could be compared to infer whether the framing of the alternative option (LESSRISKY) influences decisions.

In order to ensure that our results were not driven by idiosyncratic characteristics of any particular

item, we created 24 distinct hypothetical items spanning across many different domains in everyday life, including health, finance, social, society and politics, family, child rearing, transportation, daily life, and the Internet. Each domain had two or three items capturing qualitatively different scenarios.

The survey also presented a GAMBLE item adopted from Kahneman and Tversky (1979), problems 7 and 8, as shown in Table 5. In previous studies using similar numerical items, participants were generally found to be risk averse, and the certainty effect was robust. The GAMBLE item served to provide an indication to whether participants in this study conformed to previous samples of the population. It also served as a benchmark for comparing responses between numerical gambles and hypothetical scenarios.

Table 5

The GAMBLE *condition.*

Would you rather:
MOSTRISKY option: Have an 80% chance of winning $4,000 and a 20% chance of winning nothing.
LESSRISKY option: Receive $3,000 for sure.

2.2.2 Survey

The survey had a 2×24 between-subjects design, where participants were randomly assigned to one of the risk conditions (ONERISK, N = 912; TWORISK, N = 910). In order to minimize demand effects, each participant randomly answered only one of the 24 real-life hypothetical items in either condition (each item was addressed by 40 participants on average in each condition; Min = 38; Max = 43; SD = 1.65).

The survey was coded on Qualtrics by the author. In order to create randomized pairings of participants, risk conditions and items, two blocks were set up on Qualtrics to contain items for the ONERISK and TWORISK conditions respectively. The Block-Randomizer on Qualtrics was used to randomly assign participants into one of the blocks (i.e., one of the risk conditions), where they randomly answered one item within the assigned block (i.e., one item from the assigned risk condition; see survey flow in Appendix D). The following is a link to the survey:

`https://melbourneuni.au1.qualtrics.com/jfe/form/SV_4Id4Rcae4LB3UH3`

2.3 Procedure

Participants provided consent to participate and were asked to answer some optional demographic questions. Participants then read the instructions, which prompted them to provide natural and intuitive responses to the survey items. The instructions in all conditions stated:

> In this experiment we are interested in understanding the kinds of decisions people make in realistic situations. We will therefore ask you a few questions about such situations. Please do your best to imagine that you're actually in that situation, and give your natural and intuitive response for how you would decide. There is no 'correct' answer that we are looking for, so try to resist the temptation to overthink or tell us what you think we want to hear. We are just interested in understanding how people decide things.

After reading the instructions, two attention CHECK items were presented to ensure that the participants had read and understood them (see Appendix D for the CHECK items). Participants were only allowed to proceed to the rest of the study if they responded correctly to both items; those who did not were directed back to the instructions and CHECK questions.

After proceeding, participants were randomly assigned to one of the risk conditions, and were required to answer one randomly drawn hypothetical item from their assigned condition. They were

allowed to provide a reason for their choice in a text box; this was optional and responses were not analyzed. Finally, participants were required to respond to the GAMBLE item. The survey ended with a debriefing section, where the HIT code was provided as an indication of survey completion to receive reimbursement.

To maximize efficiency in data collection and ensure there was a large pool of workers who were responding in good conditions, the study was conducted at approximately 7 o'clock in the evening, Eastern Standard Time (EST), on June 28th, 2018.

2.4 Data Analysis

To examine whether there was a statistically significant difference between the average proportions of people choosing the MORERISKY option versus the LESSRISKY option in each risk condition (ONERISK and TWORISK respectively), we used a chi-square test for equality of proportions. The chi-square test was also used for analyzing the GAMBLE condition.

A chi-square test of independence was used to analyze whether there was an association between choices and the risk conditions (i.e., whether the average proportions of people choosing either option differed between the risk conditions). The effect size was computed using the φ coefficient: $\varphi = \sqrt{\frac{\chi^2}{N}}$, where $N = 1822$.

A within-subject comparison between the ONERISK and GAMBLE conditions was conducted using McNemar's chi-square test to examine whether people were likely to make different choices across the conditions. The effect size was computed using an odds ratio.

Statistical significance was defined at the 5% level.

Results

3.1 Results for the OneRisk and TwoRisk Conditions

Figure 2 shows the mean proportion of participants choosing either the MoreRisky or the LessRisky option in the OneRisk (i.e., one option contained a black-swan component) and TwoRisk (i.e., both options contained a black-swan component) conditions across the 23 hypothetical vignettes of real-world situations.[7] Contrary to our expectations (Hypothesis 1), there was no statistically significant difference in the proportion of people choosing the MoreRisky and LessRisky options under either risk conditions (OneRisk: mean difference in proportions = .046, $\chi^2(1) = 1.934$, $p = .164$; TwoRisk: mean difference = .026, $\chi^2(1) = 0.633$, $p = .426$). That is, within each risk condition, there was no systematic preference for the MoreRisky or the LessRisky option.

Also in contrast to our second hypothesis, there was no evidence for a statistically significant difference in preferences between the two risk conditions, $\chi^2(1) = 0.139$, $p = .709$, $\varphi = .009$. In other words, people in the OneRisk condition did not systematically differ from people in the TwoRisk condition in terms of whether they preferred the MoreRisky option or the LessRisky option.

[7] As noted in the Methods (see footnote 6), one of the hypothetical items was excluded due to an error in the survey set-up.

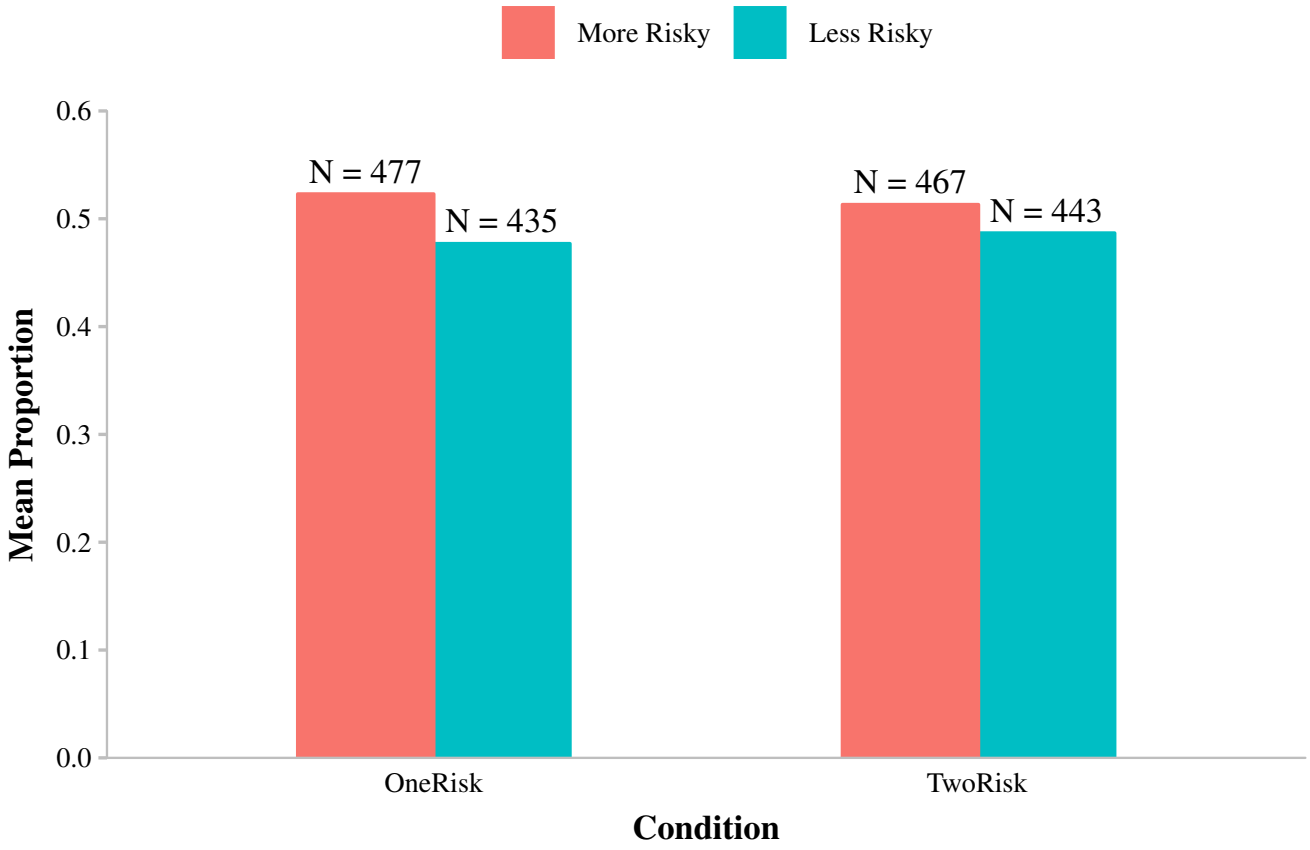

Figure 2. Mean proportion of participants choosing the MORERISKY or the LESSRISKY option in the ONERISK and TWORISK conditions across 23 hypothetical vignettes of real-world problems. There was no statistically significant difference in the proportions of the MORERISKY or LESSRISKY option within or between risk conditions.

3.2 Results for the GAMBLE condition

Figure 3 shows the results for the GAMBLE condition. Consistent with previous findings (Kahneman & Tversky, 1979), substantially more people chose the LESSRISKY option, which offered a sure gain (difference in proportions = .82, $\chi^2(1) = 1218.5$, $p < .01$).

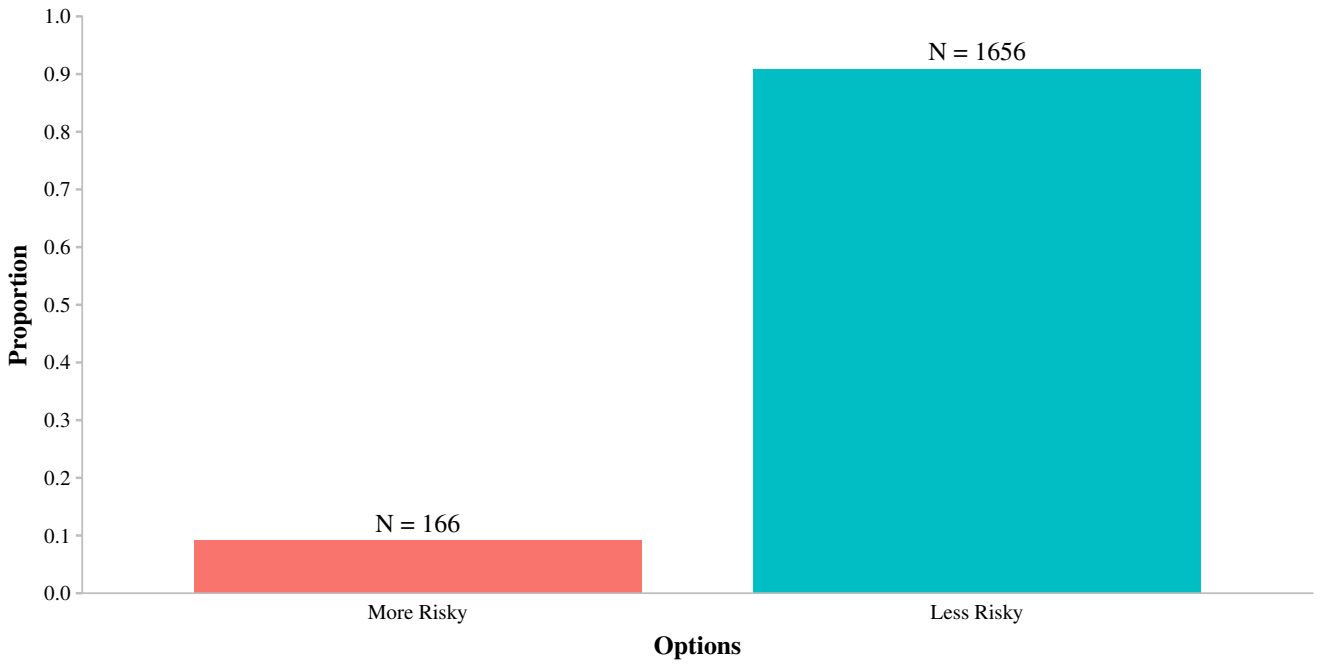

Figure 3. Total proportion of participants choosing the MORERISKY or the LESSRISKY option in the GAMBLE condition. The results showed that most people were risk averse; the sure gain was preferred to the gamble, though the latter offers a higher expected payoff.

3.3 Comparison between the ONERISK and GAMBLE conditions

Figure 4 compares the results for the ONERISK condition and the GAMBLE condition. Note that since there was no corresponding GAMBLE condition for the TWORISK condition, we discuss responses from only the participants who were assigned to the ONERISK condition ($N = 912$). Within the ONERISK condition, significantly more people chose the LESSRISKY option in the GAMBLE condition (difference in proportions = .81, $\chi^2(1) = 600.44$, $p < .01$).[8] A within-subject comparison between the two conditions show that 88% (419 out of 477) of the participants who chose the MORERISKY option in the ONERISK condition chose the LESSRISKY option in the GAMBLE condition, but only approximately

[8]Note that this analysis is post-hoc to the overall analysis for the GAMBLE condition as presented in Section 3.2. The conclusion is robust under Bonferroni adjustments (at an adjusted significance level of 2.5%; Bender & Lange, 2001).

33% (28 out of 86) of those who chose the LESSRISKY option in the ONERISK condition switched to the MORERISKY option in the GAMBLE condition. This difference is substantial, and statistically significant, McNemar's $\chi^2(1) = 340.27$, $p < .01$, odds ratio = 10.53. The odds ratio indicates that participants who chose the MORERISKY option in the ONERISK condition are approximately 11 times more likely to switch to the LESSRISKY option in the GAMBLE condition, compared to the reverse. This result shows that participants were much less risk taking in the GAMBLE condition than in the ONERISK hypothetical situations.

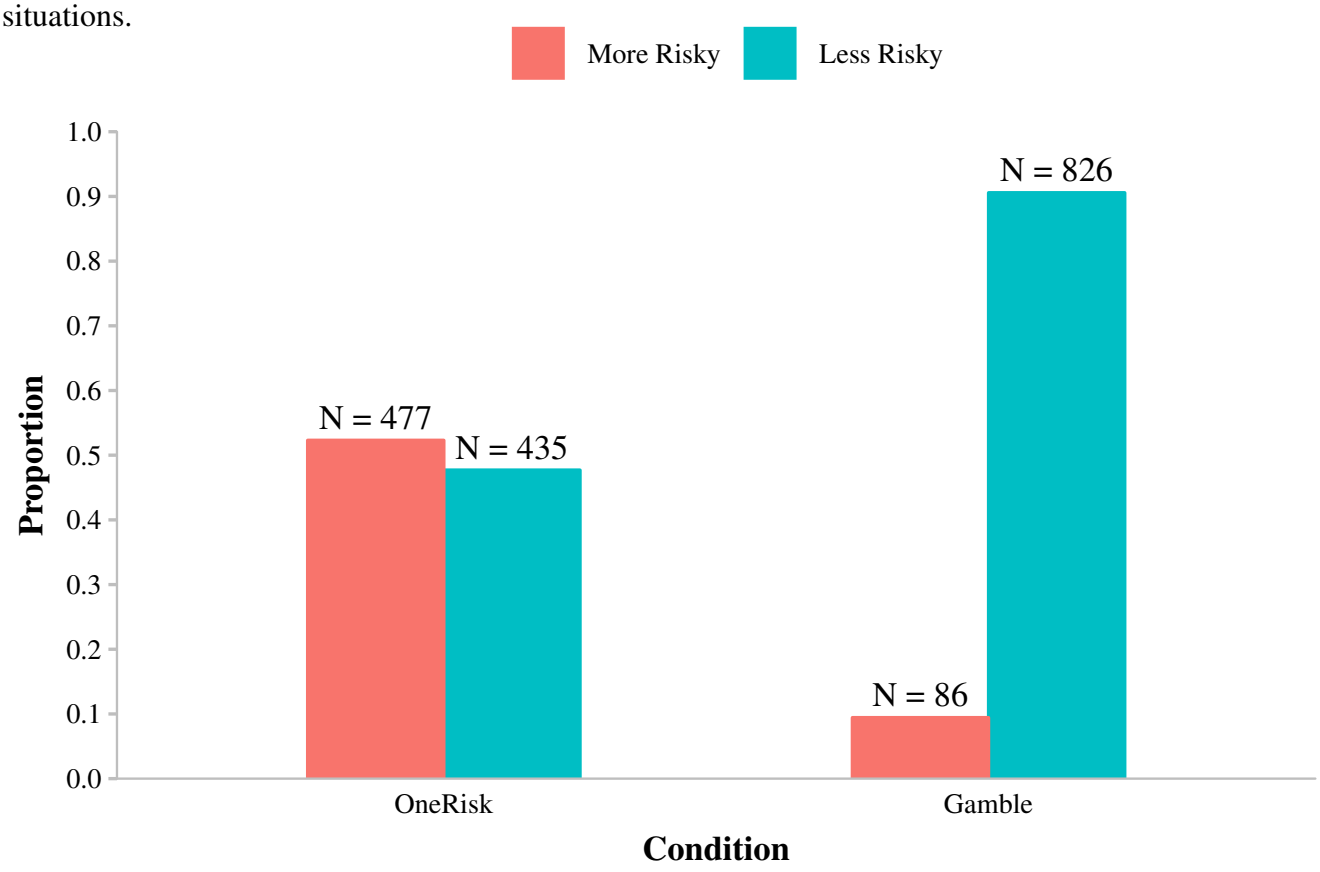

Figure 4. Proportion of participants choosing the MORERISKY or the LESSRISKY option in the ONERISK and GAMBLE conditions. Note that these responses were from participants who completed the ONERISK condition, hence this presents a within-subjects comparison. The results show that people responded very differently in these two conditions even though the conditions were structurally similar — people were to choose between a 'riskless' and a 'risky' choice.

3.4 Item-by-item Exploration

To examine the extent to which these results depend on the specific hypothetical scenario, item-level variability was also explored. Figure 5 shows the difference in the proportions of people choosing the MOSTRISKY and the LESSRISKY option for each risk condition, for every item.

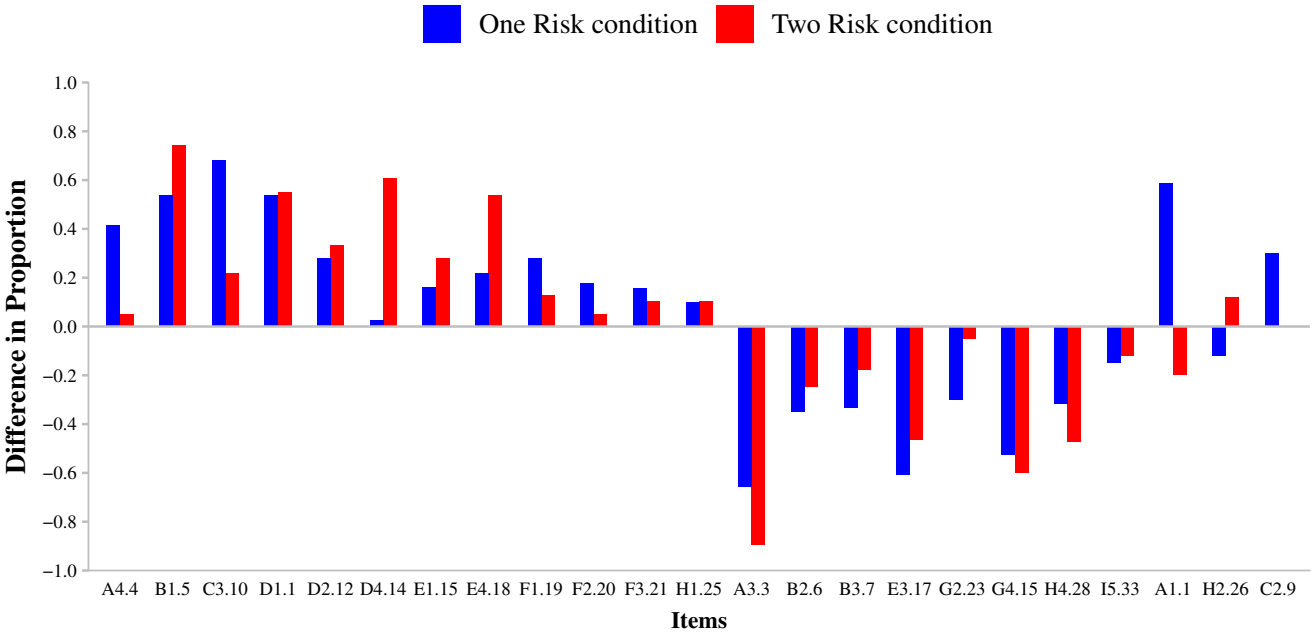

Figure 5. The difference in proportions between the MOSTRISKY and LESSRISKY option for each risk condition (ONERISK and TWORISK) for the 23 items (the *x*-axis contains all the items, indicated by item labels that correspond to the full item list in Appendix D). The differences in proportions were calculated by subtracting the proportion of the LESSRISKY option from the MOSTRISKY option, so a positive bar means that more people chose the MOSTRISKY option than the LESSRISKY option within a risk condition. One positive bar and one negative bar for a hypothetical item indicates a change in choice preference between the two risk conditions. Only two items showed an inconsistent choice preference across the risk conditions, suggesting that for most hypothetical items, decisions were driven by the nature of the particular scenario rather than the risk condition.

As shown, twelve items had a higher proportion of people choosing the MOSTRISKY option in both risk conditions (mean difference in proportions between the two options = .103; *SD* = 0.093).

Eight items had a higher proportion of people choosing the LESSRISKY option in both risk conditions (mean difference = .073; *SD* = 0.036). Only two items (Items A1.1 & H2.26) showed a reversal in preferences between the risk conditions. One item (Item C2.9) had a higher proportion of people choosing the MORERISKY option in the ONERISK condition, but an exactly even proportion in the TWORISK condition. It should be noted that since this study aimed to examine decision-making in black-swan situations more generally, preferences were not specifically examined for any item with relation to its content.

This indicates that for most hypothetical items, there was no reversal in preferences across the risk conditions (as indicated by the consistency in the signs of the frequency bars). Thus, participants seemed to reliably choose either the MORERISKY or LESSRISKY option across the risk conditions (ONERISK vs. TWORISK) in most hypothetical situations, suggesting that decisions were mainly driven by the nature of the particular item rather than the risk condition.

Discussion

The overweighting of rare events and framing effects in decision-making are commonly recognized in the existing research (e.g., Hertwig et al., 2004; Kahneman & Tversky, 1979). Perfors and Van Dam (2018) extended these observations to decision-making in numerical gambles involving black-swan losses. In light of their findings, this study aimed to understand decision-making in the face of black-swan risks in contexts that were more representative of everyday life situations. We attempted to address two questions. The first was whether people would generally avoid an action recommended for a certain scenario when it came with a black-swan risk. The second was whether decisions would be

influenced by the framing of the alternative option in the hypothetical situations, which was one of the major findings in Perfors and Van Dam's (2018) study. However, in contrast to expectations, there was no statistically significant difference between the proportions of people choosing the MORERISKY or LESSRISKY option in either risk condition across the hypothetical items. There was also no evidence for choices to depend on the risk conditions across the hypothetical items — most items either had a higher proportion of people choosing the MORERISKY option, or a higher proportion of people choosing the LESSRISKY option in both risk conditions. Yet consistent with Kahneman and Tversky's (1979) findings, participants exhibited risk aversion in the GAMBLE condition, where they displayed the classic certainty effect (i.e., the sure gain was preferred to the gamble, even when the latter offered a higher expected pay-off). Comparison of responses between the ONERISK and GAMBLE conditions showed that people were significantly less risk taking in the GAMBLE condition than in the hypothetical situations (see Figure 4). These results indicate that participants conformed to the samples of individuals in past studies in showing a general tendency of risk aversion when dealing with numerical (or monetary) payoffs. Taken together, our observations may be indicative of a difference in decision processes between numerical gambles and hypotheticals of real-life situations. Our findings also highlight the challenges that researchers may face in studying decision-making using more naturalistic, non-numerical experimental designs.

In the following, we first address the hypotheses, discuss the differences between the current and previous findings, and propose plausible reasons for the discrepancies (Section 4.1). We then discuss potential implications of our findings (Section 4.2). Finally, we suggest possible directions for future research, and how current limitations may be addressed (Section 4.3).

4.1 Contrasting the Current and Previous Findings

Hypothesis 1 — Risk Aversion in the ONERISK Condition

Given the extremely negative consequence of a black-swan, it was hypothesized that the participants in the ONERISK condition would be reluctant to choose the MORERISKY option, which contained a black-swan risk, and would instead opt for the LESSRISKY option, which avoided the risk. However, our results showed that on average, there was no significant difference in the proportion of people choosing the MORERISKY or LESSRISKY option in either risk condition across the hypothetical items. This indicates that participants were not particularly avoidant towards the black-swan risk, which is puzzling when the tendency to overweight rare and emotionally impactful events is well-recognized in the existing literature (Burns et al., 2010; Mellers & McGraw, 2001; Rottenstreich & Hsee, 2001).

4.1.1 Perceived Impact of Black-Swan Risks

It is worth noting that our hypothesis about avoiding the MORERISKY option in the ONERISK condition rests on the assumption that people would accurately internalize the catastrophic impact of the black-swan risk in the option. However, unlike numerical gambles, magnitudes of benefits or negative outcomes in the hypothetical situations cannot be objectively quantified with numerical quantities. As a result, it is unclear how the (intended) benefits of the MORERISKY option were translated into magnitudes of gains, or how the perceived gains were evaluated against the anticipated impact of the black-swan risk. Thus, one possible reason for why there was not a consistent risk avoidant preference in the ONERISK condition is a mismatch between the perceived and intended catastrophic losses depicted in the MORERISKY option. For instance, in the example item illustrated in Table 4, the recommended

anti-malarial medication had an extremely small risk of triggering severe side effects. However, some individuals might not interpret the "severe side effects" to be catastrophic enough to avoid the recommended medication. They might then prefer the MORERISKY option. If there were mismatches between the intended and perceived adverse impact of the black-swan risks in some hypothetical situations but not the others, there would not be consistent risk avoidant or risk taking preferences in the ONERISK conditions across items, as indicated in our results.

A lack of objectively quantified benefits or losses in the hypothetical items limits our ability to draw inferences about participants' risk avoidant or risk taking tendencies in decision-making. As an example, we have discussed how the risk in the malarial item might not be perceived to be catastrophic. Likewise, the medication might not seem beneficial to individuals who are ill-disposed to taking medications in the first place. This individual might have preferred not to take the medication only because they generally disliked medications, but not because they were risk averse. If there were variabilities in the subjective evaluations of the costs and benefits in the hypothetical scenarios, it would be ambiguous whether choices were driven by risk aversion, or by other more subjective factors, such as personal preferences. One way for future studies to control for this issue is to ask participants to provide an indication of their perceptions of the benefits or risks on a numerical scale. This will allow experimenters to map out participants' valuations of benefits or risks, and examine their preferences accordingly.

The trade-off between objective experimental control and ecological validity is a persistent challenge researchers face in studying human behaviour (Payne, Bettman, & Johnson, 1992). The merit of using numerical gambles to study decision-making is the ability to precisely manipulate the expected payoffs of options on an objective numerical scale. By having an objective measure of payoffs, decision makers' subjective preferences would reflect how their valuations of the payoffs differed from the

objective measures, allowing conclusions about their level of risk aversion to be drawn. However, using numerical experimental set-ups to infer everyday decision-making may lack ecological validity. This was the reason why the present study attempted to build on Perfors and Van Dam's (2018) work to understand decision-making in black-swan situations that are grounded in more realistic, everyday-life contexts. It is acknowledged that non-numerical hypothetical items lack experimental control over evaluations of benefits and losses, but we have attempted to address this issue by having a variety of items, covering nine major domains in life. In doing so, we hoped to minimize noise from subjective evaluations of benefits or risks across the hypothetical scenarios.

Hypothesis 2 — Framing Effects of the Risk Conditions

Another major question in the present study was how decisions might be influenced by the framing of alternative options, which was motivated by Perfors and Van Dam's (2018) study, where a significant reversal in preferences between the ONERISK and TWORISK conditions was found. This observation implies the isolation effect, where the difference in the magnitudes of risks tends to be disregarded when the risks are the common components across the available choices (Kahneman & Tversky, 1979). We examined whether the finding would extend to hypotheticals of real-world problems framed with analogous risk conditions (see Table 6). As shown in Table 6, the ONERISK condition contrasted the MORERISKY option against one that avoided the risk by not taking the action. Yet in the TWORISK condition, neither option avoided the risk (i.e., a black-swan outcome was still possible even when one had chosen not to carry out the recommended action). Considering past findings of the isolation effect, we predicted that people would be able to focus on the benefits from the recommended action in the TWORISK condition. Hence, it was hypothesized that more people would prefer the MORERISKY option

in the TWORISK condition relative to the ONERISK condition. However, our results did not show a significant difference in preferences between the risk conditions across items. Item-by-item analysis showed that for most items (20 out of 23 items), there was a consistent preference for either the MORERISKY or LESSRISKY option across the risk conditions (see Figure 5). Unlike Perfors and Van Dam's (2018) findings, decisions in the current study were largely driven by the specific hypothetical contexts rather than how the LESSRISKY alternative was framed relative to the MORERISKY option. The question is, why were people found to be susceptible to the framing of choices in numerical gambles in past studies (e.g., Kahneman & Tversky, 1979; Perfors & Van Dam, 2018), but not in hypotheticals of real-world situations with analogous set-ups?

Table 6

A direct comparison between the experimental set-ups of the current study and the previous study by Perfors and Van Dam (2018).

Perfors and Van Dam (2018):	
***OneRisk* condition**	***TwoRisk* condition**
MORERISKY option: 1 in 2 chance of gaining 15 points, and 1 in 1,000 chance of losing all points.	**MORERISKY option:** 1 in 2 chance of gaining 20 points, and 15 in 10,000 chance of losing all points.
LESSRISKY option: 1 in 2 chance of gaining 5 points.	**LESSRISKY option:** 1 in 2 chance of gaining 6 points, and 1 in 10,000 chance of losing all points.
The present study:	
***OneRisk* condition**	***TwoRisk* condition**
MORERISKY option: Take the medication, with 1 in 10,000 chance of having severe side effects.	**MORERISKY option:** Take the medication, with 11 in 100,000 chance of having severe side effects.
LESSRISKY option: Do not take the medication.	**LESSRISKY option:** Do not take the medication, with 1 in 100,000 chance of having severe side effects from malaria anyway.

4.1.2 Noise

The issue of having potential mismatches between the perceived and the intended benefits or catastrophic losses of the MORERISKY option does not explain why the additional risk component in the TWORISK condition did not influence choices relative to the ONERISK condition. This is because the options across risk conditions were qualitatively identical, and differed only in the magnitudes of risks. Nevertheless, another issue stemming from the non-numerically quantified payoffs in the hypothetical scenarios is noise, because subjective evaluations of potential gains and losses can vary largely across individuals, as well as across the hypothetical items. Hence, noise might be another plausible reason for the conflicting results. However, Perfors and Van Dam's (2018) finding of a difference in preferences between risk conditions was statistically significant with a medium effect size ($\varphi = .243$; Cohen, 1992). The level of noise in our data would need to be substantial to fully disguise such an effect (if the effect were true). Having 23-items covering nine domains in life, a sample size near 2,000, and a completely randomized sampling of responses, it seems implausible that noise can fully explain why our results are different from that of Perfors and Van Dam's (2018).

Since the present study had used an exact analogous set-up of risk conditions as Perfors and Van Dam's (2018) study, differences between our results may in fact suggest that people are engaged in different decision-making processes in numerical gambles versus hypothetical situations of real-world problems. This has important implications for the use of numerical experiments in studying human decision-making, or human behaviour in general. The next section elaborates on the implications of the current study.

4.2 Implications

4.2.1 Inferences drawn from Numerical versus Non-numerical Experiments

The contrasting findings indicate that inferences about human decision-making drawn from numerical gambles may not necessarily hold in more naturalistic scenarios. This posses a concern for research which relies on numerical experiments to study human decision-making. It is often assumed that real-life decision-making can be inferred from numerical gambles because decision-making in reality is intrinsically a process of evaluating psychological pain against pleasure, or costs against benefits (Vlaev, 2012). Nonetheless, decision-making in real-world contexts are more intricate than in numerical gambles. In a numerical gamble, people simply need to evaluate the expected numerical gains against the losses, whereas in a hypothetical situation of a real-world problem, they may consider other contextual factors in addition to the potential risks. Real-life costs and benefits, such as social, emotional and physical costs and benefits are beyond what numerical payoffs encompass (Lipshitz, Klein, Orasanu, & Salas, 2001). Thus, it is important for future research to consider the validity of drawing inferences about decision-making from numerical experiments.

4.2.2 Decision-Making in Everyday Life

The complication of decision-making in reality lies in the fact that it is influenced by factors, such as prior experiences, emotions, or goals, that are beyond explicit probabilistic information associated with the risks (Klein, 2008; Simon, 1972; Zinn, 2016). It is therefore plausible that participants' decisions in the real-world hypotheticals were driven primarily by whether the actions offered in the MORERISKY options were judged to be desirable in a scenario, rather than the risks, thereby explaining

why preferences were consistent across the risk conditions for a hypothetical scenario. Several theorists have proposed similar ideas. Simon's (1972) notion of *bounded rationality* argues that thorough information processing is exhausting and potentially futile in everyday decision-making. Hence, decision makers often make choices from learnt experiences, expertise or intuition, without excessive reliance on statistical information. In line with this idea, Zinn (2008, p. 443) also suggests that everyday decisions often have to be made in a "reflex-like", "fateful" manner, without abundant time or knowledge. The author also postulates that an aspect of human decision-making is characterised by the lack of control over negative outcomes. In circumstances where the negative outcomes of a risk are considered uncontrollable, individuals may still choose to take the risk with the mental preparation to avoid the negative outcomes whenever possible, but to "accept fate" otherwise (Zinn, 2008, p. 443). Together, these ideas suggest that it may be adaptive and natural for decision makers to refrain from worrying about small risks or uncertainties, and focus on other more immediate aspects of available choices in real-world situations. This may explain why decisions were found to be driven largely by the hypothetical contexts rather than the risk conditions in this study.

There may be other reasons for why the framing effects in Perfors and Van Dam's (2018) study did not extend to decision-making in the hypothetical scenarios. Framing effects in decision-making under risks are highly multifaceted, and hence a convoluted phenomenon (see Kühberger, 1998, for the complication of framing effects on decision-making under risks). Without investigating framing effects directly with controlled experimental set-ups, participants' decision processes with respect to the framings of the options in the current study can only be conjectured. But as we have proposed, the complication of decision-making in more realistic, everyday contexts may be one plausible reason for why preferences were not found to be influenced by the risk conditions.

4.3 Limitations and Future Directions

4.3.1 Identifying the Threshold of Negligibility

We have proposed a naturalistic perspective to account for why decisions in the hypotheticals of real-life situations might be driven by specific contexts rather than the risk components. However, we have yet to address whether people would judge a black-swan probability to be negligible in decision-making, which was another question of interest. In any numerical gamble, there is a threshold of risk for which a risk averse individual would be willing to take the gamble rather than the sure gain. For example, a slightly risk averse person might prefer a gamble with a 60% chance of winning $100 (winning nothing otherwise) over a sure gain of $50, while a more risk averse person would only take the gamble if it had a 90% chance of winning. Yet, with risk probabilities defined arbitrarily and invariantly in the hypothetical options, the threshold at which the black-swan risk was considered concerning could not be identified. One way to test this is to present risk components with a range of magnitudes. For example, rather than having the risk probability fixed at 1 in 10,000 in the ONERISK condition, it could vary from 1 in 100, 1 in 1,000 to 1 in 10,000, etc. In doing so, one can identify the extent to which decisions depend on the magnitude of the risk. Further, black-swans in reality are usually unpredictable, and hence often unrealized until after their occurrence (Taleb, 2007). To capture this aspect of a black-swan, some items can also contain risk components that are described as “an extremely small risk”, instead of an exact numerical value. Allowing subjective interpretations of the definition of an ‘extremely small risk’ can impose challenges such as increasing noise, but a comparison of decisions under different descriptions of black-swans may provide further insights into how people encode knowledge of very unlikely risks in decision-making.

4.3.2 Aggregating and Averaging Responses

It is also worth nothing that the present analysis was derived by aggregating and averaging responses across the hypothetical items. This is due to the primary aim of drawing more general conclusions regarding the decisions people might make in black-swan situations across various domains in life, rather than preferences specific to a certain hypothetical scenario. This might however be at the expense of identifying important variations in how risk taking or risk avoidant behaviours are influenced by the framing of options between situations, or even between different domains in life. As shown in Figure 5, there are items with large differences in the proportion of people choosing either option across the two risk conditions. However, it is unclear whether these effects were statistically significant, or whether they would be robust. Running multiple tests across hypothetical items was inappropriate in the present study because the number of items under each life domain, and the sample size for each risk condition of a specific item provided limited statistical power to draw domain- or item-specific conclusions. However, future studies can consider examining black-swan decision-making in specific domains, and this can be done by presenting more items that are relevant to the particular domain of interest, and recruiting larger samples of participants for each risk condition.

4.3.3 Hypothetical Choices versus Decisions in Reality

Another practical concern of the current study is whether hypothetical choices are accurate reflections of real decisions (Kühberger, Schulte-Mecklenbeck, & Perner, 2002; Locey, Jones, & Rachlin, 2011). Kühberger et al. (2002) argue that decision-making at its core is hypothetical because real-life decision-making requires people to anticipate hypothetical states of the world, such as potential conse-

quences, and make decisions based on mental comparisons of all imaginable counterfactual possibilities. Therefore, studying decision-making using hypothetical set-ups is justified if real decisions are also largely based on hypothetical projections of realistic situations. However, hypothetical choices do not have a real bearing on one's future. Just by knowing this, hypothetical choices can be unrepresentative of true decisions. It is unclear whether the participants' hypothetical choices would be close reflections of their real decisions when confronted with black-swan risks. Given the complications of black-swans, contemplating the possibilities associated with such events can be particularly challenging.

Decision-making in black-swan situations is difficult because it not only requires individuals to make reasonable judgments about the likelihood of the risk, but also to sensibly anticipate the impact of the possible outcome. One way people may contemplate the importance of a black-swan outcome is through anticipating the emotional impact of the event. However, research has found that people often have poor anticipation of future emotions, which may be due to sources of error that arise from the lack of experience with future events (Böhm & Pfister, 2008; Kühberger et al., 2002; Locey et al., 2011).

One source of error in anticipating future events may be a mismatch between the mental simulation of the event and the actual event (Böhm & Pfister, 2008). People may simulate the event as more or less extreme than what it actually turns out to be, leading to an over- or underestimation of the impact of the event. Another source of error may be the neglect of future contextual factors that may differ from the present. The importance of future contextual factors lies in the fact that they influence decision makers' emotional reactions, but are only realized at the time when future events occur. According to Trope and Liberman's (2003) *construal level theory*, distant events into the future are likely to be represented in abstract features. This implies that unforeseeable, concrete details of the event (e.g., its emotional impact) that are crucial to decision-making, can easily be omitted when people are contemplating the possible

impact of future events. Furthermore, Weber (2006) argues that future contextual factors often have little correspondence to more objective measures of risks, such as their statistical unpredictability and the magnitudes of adverse consequences. Thus, emotional reactions, such as anxiety and fear, establish concern towards future risks more effectively if people are directly exposed to the adverse consequences, but often ineffectively if they are only required to anticipate the adverse consequences based on statistical information. This implies that it is likely for individuals who have never experienced a black-swan event to underestimate its impact, thereby underweighting them in decision-making when choices are made relying on statistical information. In contrast, those who have come across a black-swan event may tend to overweight them in decision-making.

If the anticipations of emotional reactions towards black-swan events can be biased by past experiences, one way to reduce this bias is to encourage people to abstract away from their past experiences during decision-making. A study by Pronin, Olivola, and Kennedy (2008) found that by asking participants to make decisions for psychologically distant selves, which include *others* and *future selves*, the influence from more immediate and subjective factors such as internal thoughts and feelings is reduced, while considerations of future outcomes are amplified. The researchers found that when the potential outcomes involve personal reward or suffering, participants tended to make less selfish and more generous decisions for others and future selves than for present selves. It may be interesting for future studies to examine whether decisions made for more psychologically distant selves in hypothetical situations involving black-swans would be different from decisions made for present selves.

Given that we can never really observe 'real' decisions in black-swan situations directly, an important consideration in this thesis was whether it was possible to study decision-making in more realistic contexts than numerical gambles. We proposed to use an analogous experimental set-up with hypothet-

ical situations of real-life problems, but this involved skepticism about the reliability of hypothetical decisions. Studying decision-making involving black-swan risks in more realistic contexts impose practical challenges; e.g., ethical practice would not permit exposing participants to adverse events. However, future studies can consider collecting retrospective stories of black-swan experiences. For example, participants could report in retrospect what their decisions were, what they would have done differently, and perhaps what they have learnt from the experience. Although studying decision-making in black-swan situations post-hoc may not be the most constructive, it may provide valuable insights into the factors that influence people's anticipation of a black-swan event, and hence their decision-making in black-swan situations.

Conclusion

Dealing with black-swans is difficult because they are rare, often unpredictable, but highly consequential. Perfors and Van Dam's (2018) work provided a preliminary understanding of decision-making in black-swan situations using numerical gambles. This study aimed to extend the understanding of decision-making in black-swan situations to more realistic, everyday life contexts. Despite using an analogous set-up of risk conditions following Perfors and Van Dam's (2018) study, our results did not provide evidence for a systematic framing effect on decision-making as found in their study. Given the complexity of human decision-making, the current findings might be indicative of various discrepancies in how decisions are made in numerical versus non-numerical experiments. This elicits important questions about the validity of drawing inferences about decision-making from laboratory set-ups. Although there may not be a practical way to directly and accurately understand how decisions will be made in the face of black-swan risks, future studies should consider our suggestions for investigating factors that

influence decision-making in black-swan situations. Understanding how people deal with rare risks is important, because it may provide valuable and practical implications, such as how we can better inform the public about issues related to nuclear technology, medical decision-making, or risky financial activities. Paranoia against black-swans is impractical, but complete ignorance may lead to a lack of preparedness or resilience when black-swans do occur.

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Appendix A

Plain Language Statement

(See next page)

THE UNIVERSITY OF MELBOURNE

Melbourne School of Psychological Sciences

Plain Language Statement

PROJECT TITLE: **Decision-making in a black swan environment**

A/Prof Amy Perfors (Responsible Researcher)
Tel: 03 9035 6032; email: amy.perfors@unimelb.edu.au
Dr Nicholas van Dam (co-researcher) email: nicholas.vandam@unimelb.edu.au
Ms Winky Lee (supervisee) email: winkyl@student.unimelb.edu.au

Introduction

This project focuses on understanding the decisions people make in situations with risks or uncertainties. We're interested in understanding the kinds of reasoning people *actually* go through so you should try to give natural and intuitive responses without overthinking.

What will I be asked to do?

After answering some optional demographic questions, you will be randomly assigned to an experimental condition corresponding to a real-life hypothetical situation, where we will ask you to choose between two options with different possible outcomes, and what factors you considered when doing so. There will also be a question regarding a gamble, where we will ask you to again choose between two options with different outcomes.

What are the risks?

Risks are minimal, where some of the hypotheticals that people will be responding to cover mildly negative content. The survey does take 5-10 minutes and thus represents a time investment. If the option you choose does not work out you may be a bit sad. We hope the experiment may be thought-provoking and interesting, but there is some chance you will find it boring.

What are the benefits?

Relatively little is still known about how people reason in situations like those we're looking at, even though situations like them arise often in the real world. Our long-term goal is to identify what people do and why, and see if we can improve how people make this kind of decision. You will be paid for your contribution; payment will consist of $0.5 for completing the experiment.

How would my confidentiality be protected?

As an Amazon Worker, we do not have access to any of your personal details and we will not be tracking any identifying information like IP address. You will be optionally asked to contribute a few demographic details but no effort will be made to link these up with any personal information in any way. Our sample size will be large, making it even more difficult to identify any one person.

What if I want to withdraw from the Research?

Participation in this research is completely voluntary. You are free to withdraw at any time without penalty (other than not getting paid). Your data will not be used in the full sample unless you complete the experiment.

Where can I get further information?

This research project has been approved by the Human Research Ethics Committee of The University of Melbourne. If you have any concerns or complaints about the conduct of this research project, which you do not wish to discuss with the research team, you should contact the Manager, Human Research Ethics, Research Ethics and Integrity, University of Melbourne, VIC 3010. Tel: +61 3 8344 2073 or Email: humanethics-complaints@unimelb.edu.au All complaints will be treated confidentially. In any correspondence please provide the name of the research team or the name or ethics ID number of the research project. Funding is provided by ARC Discovery Project grant DP150103280

How do I agree to participate?

If you wish to participate please read and click 'Next' after reading the consent form on the next page.

Appendix B

Consent Form

(See next page)

Melbourne School of Psychological Sciences

THE UNIVERSITY OF MELBOURNE

Consent form for persons participating in a research project

PROJECT TITLE: **Decision-making in a black swan environment**

Name of Responsible Researcher: A/Prof Amy Perfors
Name of Additional Researchers: Dr Nicholas van Dam
Name of Supervisee: Winky Lee

1. I consent to participate in this project. The purpose of this research is to investigate how people make decisions when faced with two scenarios with different probabilities.

2. I understand that this project is for research purposes only. It is expected that the results of this study will be presented at conferences and published in a peer-reviewed journal.

3. In this project I will be given some optional demographic questions. I will then be randomly assigned to an experimental condition during which I will be asked to make a choice in a simple real-life hypothetical situation (different conditions have different choice descriptions). The details of this have been explained in the statement on the previous page.

4. I understand that there are risks involved in participating in this research project, although they are minimal; the largest risk is of some degree of boredom. The study is estimated to take 5-10 minutes and may be boring.

5. My participation is voluntary and I am free to withdraw from the project at any time without explanation or prejudice and to withdraw any unprocessed data I have provided. Withdrawing from the project will not affect my relationship with any person.

6. I have been informed that the data from this research will be stored at the University of Melbourne.

7. I have been informed that the confidentiality of the information I provide will be safeguarded subject to any legal requirements. My data is anonymous and not linked to any personal information at any time.

Appendix C

Debriefing Statement

(See next page)

Melbourne School of Psychological Sciences
Debriefing Statement

PROJECT TITLE: **Decision-making in a black swan environment**

A/Prof Amy Perfors (Responsible Researcher)
Tel: 03 9035 6032; email: amy.perfors@unimelb.edu.au
Dr Nicholas van Dam (co-researcher) email: nicholas.vandam@unimelb.edu.au
Ms Winky Lee (supervisee) email: winkyl@student.unimelb.edu.au

Thank you for participating in our study!

The study was pretty straightforward so there's not much more to say, but in case you're interested in more of the background, here it is:

As we mentioned at the beginning of this experiment, we are researching how people make decisions in real-life hypotheticals where outcomes have different probabilities. Specifically, we are interested in what people do when faced with so-called "black swan" decisions where one choice has a *very* low probability of a very bad outcome. Some of you saw situations where one choice was a black swan, and some saw two; we want to know if that makes a difference.

As always we are very grateful to the thoughtful data you provide, as it tells us a great deal about how humans think and reason.

This research has been cleared by the Human Research Ethics Committee (HREC 1750812.1. If you have any concerns about this project please contact the Executive Officer, Human Research Ethics, The University of Melbourne (Tel: 8344 2073; Fax: 9347 6739).

Appendix D

The Survey

(See next page)

Decision Making Study

Start of Block: Plain language statement and Consent

Q63 Melbourne School of Psychological Science
Plain Language Statement and Consent form for participation

PROJECT TITLE: Decision-making in a black swan environment

A/Prof Amy Perfors (Responsible Researcher)
Tel: 03 9035 6032 Email: amy.perfors@unimelb.edu.au
Dr Nicholas Van Dam (co-researcher)
email: nicholas.vandam@unimelb.edu.au
Ms Winky Lee (Supervisee)
email: winkyl@student.unimelb.edu.au

Introduction
This project focuses on understanding the decisions people make in situations involving risks or uncertainties.

What will I be asked to do?
After answering some optional demographic questions, we will present you with a real-life hypothetical situation, where you will choose between two options with different possible outcomes. There will also be a question regarding a gamble, where you will again choose between two options with different outcomes.

For more information regarding the risks, benefits, confidentiality protection, and the research study, you can download the full Plain language statement.

How do I agree to participate?
Please provide consent after reading the following consent form. You can also download a copy of this Consent form.

1. I consent to participate in this project. The purpose of this research is to investigate how people make decisions when faced with two scenarios with different probabilities.

2. I understand that this project is for research purposes only. It is expected that the results of this study will be presented at conferences and published in a peer-reviewed journal.

3. In this project I will be given some optional demographic questions. I will then be randomly assigned to an experimental condition during which I will be asked to make a choice in a simple

real-life hypothetical situation (different conditions have different choice descriptions). The details of this have been explained in the plain language statement.

4. I understand that there are risks involved in participating in this research project, although they are minimal; the largest risk is of some degree of boredom. The study is estimated to take 5-10 minutes and may be boring.

5. My participation is voluntary and I am free to withdraw from the project at any time without explanation or prejudice and to withdraw any unprocessed data I have provided. Withdrawing from the project will not affect my relationship with any person.

6. I have been informed that the data from this research will be stored at the University of Melbourne.

7. I have been informed that the confidentiality of the information I provide will be safeguarded subject to any legal requirements. My data is anonymous and not linked to any personal information at any time.

By clicking 'yes' I consent to the terms of the research as outlined above and in the Plain Language Statement.

- ○ Yes (1)
- ○ No (2)

Skip To: End of Survey If Melbourne School of Psychological Science Plain Language Statement and Consent form for particip... = No

End of Block: Plain language statement and Consent

Start of Block: Demographics

Intro We are interested in a few basic demographic questions. Feel free to skip any that you are uncomfortable sharing; you will be paid regardless.

*

Q1 What is your age (in years)?

_____

Q2 What is your gender?

- ○ Male (1)
- ○ Female (2)
- ○ Other (3)

Q3 How many children do you have?

- ○ 0 (1)
- ○ 1 (2)
- ○ 2 (3)
- ○ > 3 (4)

End of Block: Demographics

Start of Block: Short prompt and check questions

Instruction
Instructions to this survey:

In this experiment we are interested in understanding the kinds of decisions people make in realistic situations. We will therefore ask you a few questions about such situations. Please do your best to imagine that you're actually in that situation, and give your **natural and intuitive response** for how you would decide. There is no "correct" answer that we are looking for, so try to resist the temptation to overthink or tell us what you think we want to hear. We are just interested in understanding how people decide things.

Page Break

Check 1 What is this experiment about?

- ○ Learning artificial categories. (1)
- ○ Explaining what words mean. (2)
- ○ Making decisions in hypothetical situations. (3)
- ○ Finding items in visual images. (4)

Skip To: End of Survey If What is this experiment about? != Making decisions in hypothetical situations.

Check 2 What should you do when answering these questions?

- ○ Do your best to identify the correct answer. (1)
- ○ Respond naturally and intuitively without overthinking. (2)
- ○ Act as rapidly as possible. (3)
- ○ Aim to get the highest point total. (4)

Skip To: End of Survey If What should you do when answering these questions? != Respond naturally and intuitively without overthinking.

End of Block: Short prompt and check questions

Start of Block: One Risk Condition

C1.8 You currently have your money invested in a reasonably safe but low-return portfolio. Your bank is offering a new investment opportunity in a set of stocks that is high risk but high reward. Do you:

- ○ Take the new investment opportunity, with 1 in 10,000 chance that the stock market crashes and you lose all your money. (1)
- ○ Do not take the investment opportunity. (2)

C2.9 You are looking to buy a house and have found one that you really like. However, it is in an area that is somewhat more prone to natural disasters than normal. Do you:

- ○ Buy the house, with 1 in 10,000 chance of experiencing a major natural disaster. (1)
- ○ Buy a house somewhere else. (2)

I5.33 You are the president. A specific area in the country is in the path of an oncoming hurricane, although nobody can predict how powerful the hurricane will be. Most people have evacuated but a few people are refusing. Do you:

- ○ Order a forceful evacuation of those residents, with 1 in 10,000 chance of causing a public outrage for having done so. (1)
- ○ Let them stay. (2)

A3.3 You injured your knee some time ago. It no longer hurts but you know that it is more injury prone than your other healthy knee. Do you:

- ○ Get surgery on the injured knee to help its recovery, with 1 in 10,000 chance of a major loss of function in your leg due to complications. (1)
- ○ Perform regular exercises rather than do surgery on the injured knee. (2)

D1.1 A friend that you frequently share space with has extremely unpleasant body odor. Do you:

- ○ Inform them about their body odor, with 1 in 10,000 chance of losing the friendship for bringing it up. (1)
- ○ Do not tell them about their body odor, hoping they figure it out on their own. (2)

F1.19 Scientists have just unveiled a kind of teleportation technology that can allow you to travel several hundred miles in ten minutes. You are visiting a friend who lives that far away. Do you:

- ○ Take the new transportation to go there faster, with 1 in 10,000 chance of dying in a malfunction. (1)
- ○ Take a car to visit your friend. (2)

F3.21 You are contemplating going on a week-long cross-country backpacking trip. You have a lot of hiking experience but know that parts of the trail are far from medical facilities and you will be on your own. Do you:

- ○ Go on the trip, with 1 in 10,000 chance of running into some kind of serious trouble. (1)
- ○ Go on a series of short day trips instead. (2)

H2.26 A controversial issue is being hotly debated on a close-knit Facebook group you belong to. You disagree with most of the opinions that people in the group have on that issue. Do you:

- ○ Share your opinion, with 1 in 10,000 chance of feeling no longer welcome in that group. (1)
- ○ Stay silent. (2)

G2.23 After you cook yourself a delicious chicken meal, your roommate informs you that they had accidentally left that chicken out all day and were about to throw it away. You are very hungry and there is not much other food in the house. Do you:

- ○ Eat the chicken, with 1 in 10,000 chance of getting ill because it has gone bad. (1)
- ○ Scrape together a small meal made of old leftovers. (2)

A1.1 The new recommended vaccination schedule requires you to give your child several new vaccines before they are 12 months old, in order to acquire immunity early. Do you:

- ○ Follow the new schedule, with 1 in 10,000 chance of experiencing severe side effects. (1)
- ○ Follow the old schedule. (2)

A4.4 You are visiting a tropical country that occasionally has outbreaks of malaria, though they are pretty uncommon. The recommended anti-malarial medication has potentially severe side effects. Do you:

- ○ Take the medication, with 1 in 10,000 chance of having severe side effects. (1)
- ○ Do not take the medication. (2)

B1.5 You are at an amusement park and your kids really want to ride a huge roller coaster. Do you:

- ○ Let your children ride the roller coaster, with 1 in 10,000 chance of a major injury. (1)
- ○ Do not let your children ride the roller coaster. (2)

D2.12 You are at a job conference and you come across an extremely influential person in your area of work. Do you:

- ○ Approach them to introduce yourself, with 1 in 10,000 chance of making a fool of yourself. (1)
- ○ Not approach them but hang around and hope you make a good impression. (2)

E1.15 You are nursing a huge crush on one of your very good friends, who has no idea you have any romantic interest in them at all. Do you:

- ○ Ask your crush out, with 1 in 10,000 chance of losing them forever because they don't return your feelings. (1)
- ○ Remain silent about your romantic interest. (2)

B2.6 Your baby is a very poor sleeper. Your friend tells you that co-sleeping (i.e., bringing the child into your bed) has helped a them lot. Do you:

- ○ Start co-sleeping with your baby, with 1 in 10,000 chance of sudden infant death syndrome (SIDS). (1)
- ○ Do not start co-sleeping. (2)

B3.7 Your 8-year-old child wants to walk to school by themselves. They are a responsible child but part of the route requires crossing a relatively busy road (with a crosswalk and signal). Do you:

- ○ Let them walk to school, with 1 in 10,000 chance of them getting hurt crossing the road. (1)
- ○ Do not let them walk to school. (2)

C3.10 You are currently unemployed. You have the skills and contacts to start your own business. In order for the business to succeed, though, you will have to invest most of your personal savings. Do you:

- ○ Invest your savings into starting the business, with 1 in 10,000 chance of losing your money if the business does not work out. (1)
- ○ Invest the money in other ways than a small business. (2)

D4.14 You are out with a group of new friends, but you are feeling a bit unwell. Everyone seems to be having a good time and is happy you are there. Do you:

- ○ Leave early, with 1 in 10,000 chance that your new friends will not invite you out again. (1)
- ○ Stay with them even though you feel badly. (2)

E3.17 You love your career but it is high-stress and comes with expectations of high performance and high work hours. It takes up a substantial amount of time that you could be spending with your family, and it seems to be causing a lot of resentment in your spouse. Do you:

- ○ Maintain your work hours, with 1 in 10,000 chance that your spouse leaves you. (1)
- ○ Cut back on your work hours. (2)

E4.18 Your boss offers you an opportunity to work overseas on the other side of the world for a year. The offer is attractive, but to accept it, you must begin a long-distance relationship with your significant other. Do you:

- ○ Accept the offer, with 1 in 10,000 chance of breaking up due to the difficulty of having a long-distance relationship. (1)
- ○ Do not accept the offer. (2)

F2.20 You are late to an important appointment in another town. You could either get there quickly by going over a treacherous mountain pass, or more slowly by going around the mountain. Do you:

- ○ Go over the treacherous mountain pass, with 1 in 10,000 chance of getting in a car accident. (1)
- ○ Take the route around the mountain. (2)

H1.25 You have been desperately looking for a book you need for an important project. A friend tells you that you can find it on an illegal website, and after logging on you see that it is indeed there. But when you are just about to download the book, you remember that your internet provider has recently been trying to crack down on illegal sites like this. Do you:

- ○ Download the book illegally, with 1 in 10,000 chance of getting into trouble. (1)
- ○ Refrain from downloading the book. (2)

H4.28 You want to buy something that is only available online, and you've found a very cheap one on a website that you've never heard of. Do you:

- ○ Go ahead and buy it, with 1 in 10,000 chance that the website is a scam and all your personal details will be stolen. (1)
- ○ Do not buy it from this website and hope you find it (probably more expensively) elsewhere. (2)

G4.15 You are going shopping when an acquaintance stops you for a friendly chat. They clearly know you and you can kind of remember them. You think their name might be Sam but you aren't certain. Do you:

- ○ Address them as Sam, with 1 in 10,000 chance of calling them by the wrong name. (1)
- ○ Try to fake your way through the conversation without using a name. (2)

End of Block: One Risk Condition

Start of Block: Two Risk Condition

C1.8 You currently have your money invested in a reasonably safe but low-return portfolio. Your bank is offering a new investment opportunity in a set of stocks that is high risk but high reward. Do you:

- ○ Take the new investment opportunity, with 11 in 10,000 chance that the stock market crashes and you lose all your money. (1)
- ○ Do not take the investment opportunity, with 1 in 100,000 chance of losing everything in your current portfolio anyway. (2)

C2.9 You are looking to buy a house and have found one that you really like. However, it is in an area that is somewhat more prone to natural disasters than normal. Do you:

- ○ Buy the house, with 11 in 100,000 chance of experiencing a major natural disaster. (1)
- ○ Buy a house somewhere else, with 1 in 100,000 chance of experiencing a major natural disaster wherever you end up anyway. (2)

I5.33 You are the president. A specific area in the country is in the path of an oncoming hurricane, although nobody can predict how powerful the hurricane will be. Most people have evacuated but a few people are refusing. Do you:

- ○ Order a forceful evacuation of those residents, with 11 in 100,000 chance of causing a public outrage for having done so. (1)
- ○ Let them stay, with 1 in 100,000 chance of causing a public outrage anyway if they die. (2)

A3.3 You injured your knee some time ago. It no longer hurts but you know that it is more injury prone than your other healthy knee. Do you:

- ○ Get surgery on the injured knee to help its recovery, with 11 in 100,000 chance of a major loss of function in your leg due to complications. (1)
- ○ Perform regular exercises rather than do surgery on the injured knee, with 1 in 100,000 chance of major loss of function in your leg due to re-injury anyway. (2)

D1.1 A friend that you frequently share space with has extremely unpleasant body odor. Do you:

- ○ Inform them about their body odor, with 11 in 100,000 chance of losing the friendship for bringing it up. (1)
- ○ Do not tell them about their body odor, hoping they figure it out on their own, when there is 1 in 100,000 chance that you lose the friendship anyway because you can't handle being around their smell. (2)

F1.19 Scientists have just unveiled a kind of teleportation technology that can allow you to travel several hundred miles in ten minutes. You are visiting a friend who lives that far away. Do you:

- ○ Take the new transportation to go there faster, with 11 in 100,000 chance of dying in a malfunction. (1)
- ○ Take a car to visit your friend, with 1 in 100,000 chance of dying anyway in a traffic accident. (2)

F3.21 You are contemplating going on a week-long cross-country backpacking trip. You have a lot of hiking experience but know that parts of the trail are far from medical facilities and you will be on your own. Do you:

- ○ Go on the trip, with 11 in 100,000 chance of running into some kind of serious trouble. (1)
- ○ Go on a series of short day trips instead, with 1 in 100,000 chance of running into some kind of serious trouble on them anyway. (2)

H2.26 A controversial issue is being hotly debated on a close-knit Facebook group you belong to. You disagree with most of the opinions that people in the group have on that issue. Do you:

- ○ Share your opinion, with 11 in 100,000 chance of feeling no longer welcome in that group. (1)
- ○ Stay silent, with 1 in 100,000 chance of feeling no longer welcome because of the comments shared in the debate anyway. (2)

G2.23 After you cook yourself a delicious chicken meal, your roommate informs you that they had accidentally left that chicken out all day and were about to throw it away. You are very hungry and there is not much other food in the house. Do you:

- ○ Eat the chicken, with 11 in 100,000 chance of getting ill because it has gone bad. (1)
- ○ Scrape together a small meal made of old leftovers, with 1 in 100,000 chance of getting ill anyway because they have gone bad. (2)

A1.1 The new recommended vaccination schedule requires you to give your child several new vaccines before they are 12 months old, in order to acquire immunity early. Do you:

- ○ Follow the new schedule, with 11 in 100,000 chance of experiencing severe side effects. (1)
- ○ Follow the old schedule, with 1 in 100,000 chance of experiencing severe complications from unprevented early disease. (2)

A4.4 You are visiting a tropical country that occasionally has outbreaks of malaria, though they are pretty uncommon. The recommended anti-malarial medication has potentially severe side effects. Do you:

- ○ Take the medication, with 11 in 100,000 chance of having severe side effects. (1)
- ○ Do not take the medication, with 1 in 100,000 chance of having severe side effects from malaria anyway. (2)

B1.5 You are at an amusement park and your kids really want to ride a huge roller coaster. Do you:

- ○ Let your children ride the roller coaster, with 11 in 100,000 chance of a major injury. (1)
- ○ Do not let your children ride the roller coaster, with 1 in 100,000 chance of a major injury on other rides anyway. (2)

D2.12 You are at a job conference and you come across an extremely influential person in your area of work. Do you:

- ○ Approach them to introduce yourself, with 11 in 100,000 chance of making a fool of yourself. (1)
- ○ Not approach them but hang around and hope you make a good impression, with 1 in 100,000 chance of making a fool of yourself doing that anyway. (2)

E1.15 You are nursing a huge crush on one of your very good friends, who has no idea you have any romantic interest in them at all. Do you:

- ○ Ask your crush out, with 11 in 100,000 chance of losing them forever because they don't return your feelings. (1)
- ○ Remain silent about your romantic interest, knowing that there is a 1 in 100,000 chance of losing them anyway because you cannot maintain the charade. (2)

B2.6 Your baby is a very poor sleeper. Your friend tells you that co-sleeping (i.e., bringing the child into your bed) has helped them a lot. Do you:

- ○ Start co-sleeping with your baby, with 11 in 100,000 chance of sudden infant death syndrome (SIDS). (1)
- ○ Do not start co-sleeping with your baby, with 1 in 100,000 chance of SIDS anyway. (2)

B3.7 Your 8-year-old child wants to walk to school by themselves. They are a responsible child but part of the route requires crossing a relatively busy road (with a crosswalk and signal). Do you:

- ○ Let them walk to school, with 11 in 100,000 chance of them getting hurt crossing the road. (1)
- ○ Do not let them walk to school, with 1 in 100,000 chance of them getting hurt anyway in a car accident when you drive them. (2)

C3.10 You are currently unemployed. You have the skills and contacts to start your own business. In order for the business to succeed, though, you will have to invest most of your personal savings. Do you:

- ○ Invest your savings into starting the business, with 11 in 100,000 chance of losing your money if the business does not work out. (1)
- ○ Invest the money in other ways than a small business, with 1 in 100,000 chance of losing your money in those ways anyway. (2)

D4.14 You are out with a group of new friends, but you are feeling a bit unwell. Everyone seems to be having a good time and is happy you are there. Do you:

- ○ Leave early, with 11 in 100,000 chance that your new friends will not invite you out again. (1)
- ○ Stay with them even though you feel badly, with 1 in 100,000 chance that you become really ill in front of them and aren't invited out again anyway. (2)

E3.17 You love your career but it is high-stress and comes with expectations of high performance and high work hours. It takes up a substantial amount of time that you could be spending with your family, and it seems to be causing a lot of resentment in your spouse. Do you:

- ○ Maintain your work hours, with 11 in 100,000 chance that your spouse leaves you. (1)
- ○ Cut back on your work hours, with 1 in 100,000 chance that your spouse leaves you anyway. (2)

E4.18 Your boss offers you an opportunity to work overseas on the other side of the world for a year. The offer is attractive, but to accept it, you must begin a long-distance relationship with your significant other. Do you:

- ○ Accept the offer, with 11 in 100,000 chance of breaking up due to the difficulty of having a long-distance relationship. (1)
- ○ Do not accept the offer, with 1 in 100,000 chance of breaking up anyway because you resent having turned down the job. (2)

F2.20 You are late to an important appointment in another town. You could either get there quickly by going over a treacherous mountain pass, or more slowly by going around the mountain. Do you:

- ○ Go over the treacherous mountain pass, with 11 in 100,000 chance of getting in a car accident. (1)
- ○ Take the route around the mountain, with 1 in 100,000 chance of getting in a car accident anyway. (2)

H1.25 You have been desperately looking for a book you need for an important project. A friend tells you that you can find it on an illegal website, and after logging on you see that it is indeed there. But when you are just about to download the book, you remember that your internet provider has recently been trying to crack down on illegal sites like this. Do you:

- ○ Download the book illegally, with 11 in 100,000 chance of getting into trouble. (1)
- ○ Refrain from downloading the book, with 1 in 100,000 chance of getting into trouble just for logging into the website. (2)

H4.28 You want to buy something that is only available online, and you've found a very cheap one on a website that you've never heard of. Do you:

- ○ Go ahead and buy it, with 11 in 100,000 chance that the website is a scam and all your personal details will be stolen. (1)
- ○ Do not buy it from this website and hope you find it (probably more expensively) elsewhere, with 1 in 100,000 chance of having your personal details stolen from the other site anyway. (2)

G4.15 You are going shopping when an acquaintance stops you for a friendly chat. They clearly know you and you can kind of remember them. You think their name might be Sam but you aren't certain. Do you:

- ○ Address them as Sam, with 11 in 100,000 chance of calling them by the wrong name. (1)
- ○ Try to fake your way through the conversation without using a name, with 1 in 100,000 chance that they realise you don't know their name anyway and think you're shady for pretending you do. (2)

End of Block: Two Risk Condition

Start of Block: Optional

Q6 Why did you choose the option you chose? (Optional)

_____

_____

_____

_____

_____

End of Block: Optional

Start of Block: Check Question

Q7 Would you rather:

- ○ have a 80% chance of winning $4000 and a 20% chance of winning nothing. (1)
- ○ receive $3000 for sure. (2)

End of Block: Check Question

Start of Block: Debriefing

Q65
** Thank you for participating in our study! **

Your HIT code is FWX4629NBQ.
Melbourne School of Psychological Sciences
Debriefing Statement

PROJECT TITLE: Decision-making in a black swan environemnt

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The study was pretty straightforward so there's not much more to say, but in case you're interested in more of the background, here it is:

As we mentioned at the beginning of this experiment, we are researching how people make decisions in real-life hypotheticals where outcomes have different probabilities. Specifically, we are interested in what people do when faced with so-called "black swan" decisions where one choice has a *very* low probability of a very bad outcome. Some of you saw situations where one choice was a black swan, and some saw two; we want to know if that makes a difference.

As always we are very grateful to the thoughtful data you provide, as it tells us a great deal about how humans think and reason.

This research has been cleared by the Human Research Ethics Committee (HREC 1750812.1.If you have any concerns about this project please contact the Executive Officer, Human Research Ethics, The University of Melbourne (Tel: 8344 2073; Fax: 9347 6739).

You can also download the Debriefing statement

End of Block: Debriefing