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Predictable or Not? Individuals’ Risk Decisions Do Not Necessarily Predict Their Next Ones

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Abstract
This research examines the extent to which people may be free to make choices by testing their consistency in choosing risk options. In two experiments, participants were instructed to make the “same” type of risk decisions repeatedly. Experiment 1 showed that when the information for decision is positively framed in terms of gain, the participant’s choice in a particular decision could not be predicted by his or her choice in another decision (R²’s < .02). Experiment 2 showed a statistically significant predictability when the information is negatively framed in terms of loss, although the predictability was still very low (R²’s < .07). These findings indicate the existence of a large room of variations in which a person may freely choose.

Introduction
Scientific studies of human choice behaviors are paradoxical. On the one hand, scientists identify systematic patterns and regularities of choice behavior [1,2]. On the other hand, if choice behavior is determined by these patterns and regularities, a choice will no longer be a choice because people “respond to” but do not “choose” it. This paradox stems from a more fundamental debate between determinism versus free will: whether human behavior is determined and automatic [3–5], or whether people are the sole agents who exercise control on at least some of their behaviors [6–9]. As an attempt to address this controversy, the present report describes two experiments that provide some empirical evidence that choice behavior may not be completely predictable, suggesting the possible existence of free will.

Foundation of Testing Free Will
Scientists from multiple disciplines have shown interest in designing methods for testing whether or not people possess their own freedom to make choices [3,10–12]. Despite considerable debates and controversies, a foundation emerges that involves the following set of propositions. First, free will is generally defined as something that “we could often have done otherwise than we in fact did” [13] or “could have done otherwise” [14]. This definition implies that at least certain human behaviors are not predetermined, and that behavior is “more than the unavoidable consequences of genetic and environmental history of individual and possible stochastic laws of nature” [14], p. 4500). Specifically, after a person has made a choice, if he or she is allowed to return to the moment right before making the decision, and if everything else is exactly identical to the previous decisional context, free will is evident when the person is able to make a different choice.

Second, based on the above understanding, to allow freedom, some physical and behavioral components cannot be summarized nor predicted by rules and laws. In the physical world, quantum physics offers a possible way for delineating the unpredictability of physical nature [15]. Similarly, the prerequisite of free will is that certain behaviors should contain some degree of unpredictable variability [6,8].

It is important to note that our goal of this research is not to confirm the existence of free will. Our goal is to provide some evidence for the necessary, but not sufficient, room for the existence of free will. Demonstrating the unpredictability of behavioral variability does not necessarily reveal the existence of free will because such unpredictability may be due to a number of factors, such as randomness, variability in information sampling but not responding (e.g., as what the signal detection theory tells us), and/or other hidden factors [4]. Nonetheless, showing the unpredictability of behaviors is the necessary (though insufficient) condition for the existence of free will [4]. Unpredictability is the necessary evidence because it is the only part that distinguishes determinism from non-determinisms. Unpredictability is not the sufficient evidence because there could be unobserved factors contributing to the unpredictability.

Free Will in Invertebrates
Brembs [8] reviewed a body of literature on invertebrates that supports the notion that invertebrate behavior is sufficiently unpredictable, fulfilling the prerequisite of freedom to choose their behavior. Studies on the variations of Drosophila behaviors [16–18] are of particular relevance to the present research. In the description of his well-known phototaxis experiments, Benzer observed that...
The Present Study

Following the rationale of the aforementioned studies on *Drosophila*, we examine the extent to which human choice behavior involves variability as the prerequisite of free will. In the two experiments, we instructed participants to make the “same” type of decisions repeatedly. The decisions are adapted from Tversky and Kahneman’s vignettes [2] in which the participant is asked to choose either a decision with a certainly less attractive outcome or an uncertainly more attractive outcome. When making this kind of decisions, robust findings revealed that people are generally risk averse when the vignettes are described in terms of gain (i.e., favoring “a 50% chance of gaining $50” to “a 50% chance of losing $50”).

If human choice behavior is largely determined, a person who chooses a “risky” option in one trial is likely to choose the “risky” option again in the other trial. On the other hand, if the person could have done otherwise, the person’s choice made in a particular trial may not be predicted by his or her choice in another trial.

Ethics. We declare that individual participants in the current study (Experiments 1 and 2) gave their written informed consent. The Institutional Review Boards at the University of Hong Kong approved the study.

Experiment 1

Methods and Materials

In Experiment 1, participants (N=105) were asked to make a series of choices as if they were making it for real. They made two monetary decisions that were separated by a medical decision (see below), with the order of the two monetary decisions counterbalanced across participants. As the participants were residing in Hong Kong, we changed the currency to Hong Kong dollars in the monetary decisions so that participants were more familiar with the context of these decisions. The percentage of participants who made each choice is presented in square brackets, and the results are consistent with those of previous studies in showing that participants generally prefer the “risk averse” to the “risky” choices.

(1) Positive monetary decision 1 (+Mon1), adapted from Tversky and Kahneman’s [2] Problem 3i.

Choose between:
A. A sure gain of HK$240 (66.04%)
B. 25% chance to gain HK$1,000, and 75% chance to gain nothing (33.96%)

(2) Positive monetary decision 2 (+Mon2), adapted from Tversky and Kahneman’s [2] Problem 5.

Choose between:

Table 1. Results from Positively Framed Vignettes (crossing +Mon1 and +Mon2) in Experiment 1.

|          | +Mon1 “Risk Averse” Choice | +Mon1 “Risky” Choice | +Mon2 “Risk Averse” Choice | +Mon2 “Risky” Choice |
|----------|----------------------------|----------------------|---------------------------|---------------------|
| Number of participants | 39                         | 30                   | 19                        | 17                  |

Table 2. Results from Positively Framed Vignettes (crossing +Mon1 and +Med1) in Experiment 1.

|          | +Mon1 “Risk Averse” Choice | +Mon1 “Risky” Choice | +Med1 “Risk Averse” Choice | +Med1 “Risky” Choice |
|----------|----------------------------|----------------------|---------------------------|---------------------|
| Number of participants | 44                         | 25                   | 19                        | 17                  |

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A. 100% to be including at least a cell with expected frequency of 5
B. A Chi square test that corrected the expected frequency of

Alternatively, the findings could be analyzed from a perspective in

We checked this possibility with the following logic. Assume that
one problem is more risk promoting than the other one, if
participants' risk preference is determined and hence showing consistency in their risk preference, then a couple of observations are expected. First, those who choose the risky option in the less risk promoting problem should be determined to choose the risky option in the more risk promoting problem, regardless of their risk attitude. Second, those who choose the risky option in the more risk promoting problem should be determined to choose the risk aversion option in the less risk promoting problem, again regardless of their risk attitude. We conducted the following analyses to examine these possibilities.

Assume that, due to whatever reasons, +Mon1 was more risk promoting than +Mon2. Those who were risk averse in +Mon1 were those who were very conservative. These participants should also be risk averse in +Mon2. There were 65.71% of participants (69 out of 105) who took the risk averse option in +Mon1. Among these 69 participants, 56.52% of participants (39 out of 69) took the risk averse option for +Mon2. The 56.52% of consistency was not significantly different from the 65.71% of the response distribution in +Mon1, \( \chi^2(1) = 2.59, p > .05 \), but was significantly different from 100%, corrected \( \chi^2(1) = 134.77, p < .0001 \). In addition, those who were risk taking in +Mon2 should also be risk taking in +Mon1. There were 44.76% (47 out of 105) who took the risk option in +Mon2. Among them 36.17% (17 out of 47) took the risk option in +Mon1, which was not different from 44.76%, \( \chi^2(1) = 1.40, p > .05 \), but was significantly different from 100%, corrected \( \chi^2(1) = 32.23, p < .0001 \).

Conversely, assume that, due to whatever reasons, +Mon2 was more risk promoting than +Mon1. Those who were risk averse in +Mon2 were those who were very conservative. These participants should also be risk averse in +Mon1. There were 55.24% of participants (58 out of 105) who took the risk averse option for

| Mon2 “Risk Averse” Choice | Mon1 “Risk Averse” | Mon1 “Risky” | Mon2 “Risky” |
|---------------------------|-------------------|-------------|-------------|
| Number of participants    | 37                | 21          | 26          | 21          |

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Table 3. Results from Positively Framed Vignettes (crossing +Mon2 and +Med1) in Experiment 1.

| Mon2 “Risk Averse” Choice | Mon1 “Risk Averse” | Mon1 “Risky” | Mon2 “Risky” |
|---------------------------|-------------------|-------------|-------------|
| Number of participants    | 11                | 6           | 28          | 51          |

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Table 4. Results from Positively Framed Vignettes (crossing -Mon1 and -Mon2) in Experiment 2.
+Mon2. Among these 38 participants, 67% (39 out of 58) took the risk averse option for +Mon1, which was not significantly different from 55.24%, \( \chi^2(1) = 2.97, p > .05 \), but was significantly different from 100%, corrected \( \chi^2(1) = 42.90, p < .0001 \). In addition, those who were risk taking in +Mon1 should also be risk taking in +Mon2. There were 34.29% (36 out of 105) took the risk option in +Mon1. Among them 47% (17 out of 36) took the risk option in +Mon2, which was not significantly different from 34.29%, \( \chi^2(1) = 2.67, p > .05 \), but was significantly different from 100%, corrected Chi = 33.45, \( p < .0001 \).

Finally, we also analyzed the predictability between +Mon1 and +Med1 (see Table 2) and between +Mon2 and +Med1 (Table 3). For +Mon1 predicting +Med1, logistic regression showed a non-significant Nagelkerke \( R^2 = .02 \), \( \chi^2 = 1.18, p = .28 \). For +Mon2 predicting +Med1, logistic regression also showed a non-significant Nagelkerke \( R^2 = .01 \), \( \chi^2 = .78, p = .38 \).

In summary, results from Experiment 1 indicate that when information is positively framed, people’s risk preference in a decision does not predict their preference in another highly similar decision. These findings resemble the Drosophila’s behaviors demonstrated by previous studies [16,17], suggesting that although the positively framed information and people’s genetic component jointly determine the probability of their choice behavior, people seem to freely determine their choices.

**Experiment 2**

**Methods and Materials**

The design of Experiment 2 \((N = 96)\) was identical to that of Experiment 1, except that all the vignettes were negatively framed (i.e., described in terms of loss). The percentage of participants who chose each option is presented in square brackets; the results indicate that people generally prefer “risk” to “risk averse” options.

(1) Negative monetary decision 1 (-Mon1), adapted from Tversky and Kahneman’s [2] Problem 3ii.

Choose between:
- A. A sure loss of HK$750 (17.71%)
- B. 25% chance to lose HK$1,000, and 75% chance to lose nothing (82.29%)

(2) Negative monetary decision 2 (-Mon2), modified from Tversky and Kahneman’s [2] Problem 5.

Choose between:
- A. A sure loss of HK$30 (40.63%)
- B. 80% chance to lose HK$45 (59.38%)

(3) Negative medical decision (-Med 1), adapted from Tversky and Kahneman’s [2] Problem 2.

Choose between:
- A. 400 people will die (21.88%)
- B. 1/3 probability that nobody will die, and 2/3 probability that 600 people will die. (78.13%)

**Results and Discussion**

As done previously, we first analyzed the responses of the two monetary decisions (see Table 4). Among 18% (17 out of 96) of participants who chose the “risk averse” option in -Mon1, 65% (11 out of 17) chose the “risk averse” option again in -Mon2. Among 82% (79 out of 96) who chose the “risky” option in -Mon1, 35% (28 out of 79) chose the “risk averse” option in -Mon2. The percentages of choosing the “risk averse” option from the two groups of participants (i.e., 35% and 63%) were not that close to the 59% (57 out of 96) of the overall percentage of the entire sample. Such results indicate that a person’s choice of risk cannot predict his or her risk preference in another decision. Logistic regression showed that responses in -Mon1 significantly accounted for 7% variance of responses in -Mon2, \( \text{Nagelkerke } R^2 = .07, \chi^2 = 4.89, p = .03 \). Furthermore, there were 60.42% of participants (58 out of 96) showed consistent preference between -Mon1 and -Mon2, which is significantly fewer than 100%, corrected \( \chi^2(1) = 381.77, p < .0001 \).

Next, we checked the issue of individual differences. Assume that, due to whatever reasons, -Mon1 was more risk promoting than -Mon2. Those who are risk averse in -Mon1 were those who were very conservative. That means, these participants should also be risk averse in -Mon2. There were 17.71% of participants (17 out of 96) took the risk averse option for -Mon1. Among these 17 participants 35.29% (6 out of 17) took the risk averse option for -Mon2, which was not significantly different from 17.71%.

| Table 5. Results from Positively Framed Vignettes (crossing -Mon1 and –Med1) in Experiment 2. |

| -Mon1 “Risk Averse” Choice | -Mon1 “Risky” Choice |
|----------------------------|---------------------|
| -Med1 “Risk Averse” Choice | -Med1 “Risky” Choice |
| Number of participants | |
| 6 | 11 |
| 15 | 64 |

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| Table 6. Results from Positively Framed Vignettes (crossing –Mon2 and –Med1) in Experiment 2. |

| -Mon2 “Risk Averse” Choice | -Mon2 “Risky” Choice |
|----------------------------|---------------------|
| -Med1 “Risk Averse” Choice | -Med1 “Risky” Choice |
| Number of participants | |
| 11 | 28 |
| 10 | 47 |

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In this research, we pose a question that explores the extent to which a person’s choice could be a (free) choice. Replicating the findings of Tversky and Kahneman, people’s choice behavior is largely determined by how information is framed: the tendency to be risk averse in positively framed situations, and the tendency to be risk seeking in negatively framed situations. This research extended the body of classic studies by testing how likely people exhibit the same risk preference across different situations with similar risk implications. Consistent with previous research on Drosophila, the present study reveals that all personal and situational factors determine only the probability of choice behaviors, and a large room of variations exists in which a person may freely choose.

As stated in the Introduction, demonstrating the presence of variations does not indicate the existence of free will because randomness can also produce the same variations [8]. Some scholars doubt that separating randomness effects from free will effects is a scientific research topic [4]. Nonetheless, this variation indicates the existence of a considerable room of variations that may allow a person to have free will in their choice behaviors.

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Author Contributions
Conceived and designed the experiments: KFEW CC. Performed the experiments: KFEW CC. Analyzed the data: KFEW CC. Contributed reagents/materials/analysis tools: KFEW CC. Wrote the paper: KFEW CC.

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