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How incidental values from our environment affect decisions about money, risk, and delay

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Abstract

How different are £0.50 and £1.50, or "a small chance" and "a good chance", or "three months" and "nine months"? Our experiments show that people behave as if these differences alter after incidental everyday experiences. Preference for a £1.50 lottery rather than a £0.50 lottery was stronger after exposure to intermediate supermarket prices. Preference for "a good chance" of winning rather than "a small chance" was stronger after predicting intermediate probabilities of rain. Preference for consumption in "three month" rather than "nine months" was stronger after planning for an intermediate birthday. These fluctuations offer a direct challenge to economic accounts which translate monies, risks, and delays into subjective equivalents by stable functions. The decision by sampling model, in which subjective values are rank positions constructed from comparisons with samples of monies, probabilities, or delays, predicts these effects and indicates a primary role for sampling in decision making.

How incidental values from our environment affect

decisions about money, risk, and delay

Representations of amounts of money, the sizes of risks, and the lengths of delays are central to economic decision making. The traditional approach to describing decisions involving risk or delay is to translate objective amounts of money, risk, and time into their subjective equivalents using psychoeconomic functions. For example, in prospect theory, monetary gains and losses are translated into their subjective equivalents by a value function and probabilities are translated into their subjective equivalents by a weighting function (e.g., Kahneman & Tversky, 1979; see Starmer, 2000, for a review). In delay discounting, delays are translated into subjective weightings (see Scholten & Read, 2006, and Zauberman, Kim, Malkoc & Bettman, 2009 for discussion). Once monies, risks, and delays are translated into their subjective equivalents, they are combined to give overall subjective values for each of the options on offer, with the option with the highest overall subjective value being selected. As psychoeconomic functions are assumed to be stable within individuals, the subjective values of any given monies, risks, or times – ignoring wealth effects and reference point shifts – should also be stable and unaffected by context.

Another possibility is that, instead of preferences being derived from stable, underlying psychoeconomic functions, preferences are constructed (cf. Payne, Bettman, & Johnson, 1992, 1993; Slovic, 1995; Weber & Johnson, 2006). The effects of choice set context in multiattribute choice are well established (e.g., Birnbaum, 1992; Huber, Payne & Puto, 1982; Simonson, 1989; Stewart, Chater, Stott, & Reimers, 2003; Tversky, 1972). Here we explore the hypothesis that subjective values are constructed according to the principles of relative judgment taken from perception and psychophysics (e.g., Laming, 1997; Parducci, 1965, 1995; Stewart, Brown, & Chater, 2005). These principles lead to the hypothesis that it is the ordinal relationship among attribute values which is critical. Independent motivation comes from fuzzy-trace theory, in which participants reason using the qualitative gist of the choice and this gist can be relative (Reyna & Brainerd, 1995). The decision-by-sampling model (Stewart, Chater, & Brown, 2006; Stewart & Simpson, 2008) gives a mechanism for the evaluation of attributes. The subjective value of a particular target attribute value is given by its rank position within a sample of attribute values held in memory. The sample is assumed to comprise both attribute values from the immediate external context and attribute values retrieved from memories of previous experiences. The subjective value is simply the proportion of pair-wise comparisons to the sample in which the target attribute appears favorable. For example, the subjective value of $12 might be compared against other amounts on offer, say $5 and $20, and recent payments recalled from memory, say $8 and $35. In this example, $12 has a subjective value of 1/2, because half of the comparisons make $12 look good (i.e., those to $5 and $8) and half make $12 look bad (i.e., those to $20 and $35). One consequence of this, which we exploit in the studies below, is that the difference between two values depends on the proportion of intermediate values in the context. For example, $10 and $20 will seem more different if the context is $13, $15, $18, and $19, and will seem more similar if the context is $3, $6, $25, and $30.

At the population level, Stewart et al. (2006) showed that the shapes of the psychoeconomic functions for money, risk, and delay – a concave utility function for gains and a convex function for losses, an inverse-S-shaped probability weighting function, and a hyperbolic delay discounting function – can be derived from this simple idea if it is assumed that attribute values in the decision sample are representative of the real-world distributions of gains, losses, risks and delays. Brown, Gardner, Oswald and Qian (2008) showed that the rank position of one's wage within the real-world distributions of wages from the same employer is a better predictor of wage satisfaction than the absolute size of the wage. Olivola and Sagara (2009) found that real-world distributions of death tolls from disasters in different countries predict cross-national differences in risk preferences for decisions involving human fatalities. In these three examples subjective values emerge from comparisons with samples from real-world attribute distributions.

Here, we test whether the variation of distributions of attribute values between individuals in everyday life can be used to account for differences in choice behavior. This would provide strong evidence that sampling from everyday experience plays a major role in our routine valuation of money, risk, and delay. To this end, we present four studies in which the subjective values of monies are affected by prices sampled from a recent supermarket visit (Study 1a and 1b), the subjective values of probabilities are affected by sampling likelihood expressions from recent conversational exchanges (Study 2), and the subjective values of delays are affected by sampling recently considered future events (Study 3). All the studies follow the same basic design. In an initial stage, people experience a sample of attribute values. In a second stage, people choose between two options designed to reveal changes in the subjective values of attributes caused by their initial sample.

Study 1a: The Supermarket

The receipts customers receive when leaving a supermarket provide an approximation of the samples of monetary amounts they have encountered recently and which are quite likely still to be available in memory. We offered customers leaving the supermarket the opportunity to swap their receipt for the chance to choose one of two lotteries, one risky lottery with a small probability of a large prize and one safe lottery with a large probability of a small prize. We hypothesized that the prizes from the two lotteries would be evaluated in the context of the sample of items on the receipt. Specifically, we expected more choices for the risky lottery when the small and large prizes differ more in their rank position within the receipt sample.

Method

Stimuli. We collected bin bags of discarded receipts from the campus supermarket on different weekdays at different times to obtain a representative sample. At total of 400 receipts was sampled from these bags, providing 1,082 item prices. The interquartile range containing the center 50% of the distribution of prices lay between the boundaries of approximately £0.50 and £1.50. These boundaries were used to create two critical lotteries for the main experiment. The smaller amount was combined with a high probability to create a safe lottery (55% chance of winning £0.50) and the larger amount was combined with a small probability to create a risky lottery (15% chance of winning £1.50).

The lotteries were presented in the form of urns, each containing 100 poker chips of two different colors. The safe-lottery urn contained 55 green poker chips worth £0.50. The risky-lottery urn contained 15 green poker chips worth £1.50. Other poker chips had a value of £0.

Participants and procedure. 180 customers leaving the supermarket (about 75% of all customers asked participated, median age of 20 years, 58% male), comprising both university students (91%) and staff (9%) agreed to provide us with their supermarket receipt in exchange for an opportunity to draw a poker chip from one of the two urns. First, participants received a verbal description of the two lotteries and were allowed a look inside the urns. The urns were then shaken to reshuffle the poker chips again before participants drew a chip from the preferred lottery urn. The result of the draw was recorded and the poker chip was returned to the urn. Before being paid their earnings participants were required to give some demographic information including age, gender, monthly income and familiarity with the British pound as a currency (in years). Both the position of the urns (left or right) and the order of presentation (first, second) were alternated randomly throughout.

Results and Discussion

Using the prices on the receipts we calculated, for each participant, the difference in the relative rank of the two lottery outcomes (£0.50 and £1.50) within the sample of prices on the receipt. For example, if the receipt contained the prices {£0.35, £0.79, £0.99, £1.19} the relative rank of £0.50 within this sample would be 1/4 and the relative rank of £1.50 would be 4/4, and thus the difference in relative rank would be 3/4. A high difference in relative rank indicated that there were a large number of prices falling between the values of the two lottery outcomes. A small difference, on the other hand, indicated that most of the experienced prices lay outside (above or below) the range of the two lottery outcomes.

Across all participants there was a slight preference for the risky lottery (59%). The mean rank difference between the two lottery outcomes was .5 (SD=.36). To test our hypothesis regarding the relationship between the difference in relative rank and the likelihood of choosing the risky lottery we conducted a logistic regression with preference (risky vs. safe lottery) as the dependent variable and difference in relative rank, monthly income, total amount spent, average price, highest price, number of items, age, gender and familiarity with the British pound as independent variables. As predicted, we found a positive association between the difference in relative rank and the probability of choosing the risky lottery, Wald $z = 2.90$, $p = .004$. This relationship is illustrated in Figure 1. Moreover, the difference in relative rank was the only significant predictor found: none of the variables related to income and wealth provided a significant increase in model fit (see Table 1).

The absence of any effects of income or receipt total indicated that the differences in choice behavior cannot be explained as a wealth effect. Further, wealth effects would not discriminate between, for example, the cases of purchasing 3 items at £1.00 vs. one item at £3.00. Although they give the same reduction in wealth they have different effects on the rank:

In the case of the three £1.00 items £0.50 and £1.50 are less similar in rank whereas in the case of one £3.00 item £0.50 and £1.00 are more similar in rank.

Study 1b: Price Experiment

To test whether there was a causal relationship between the distribution of experienced prices and the choice made we conducted an online experiment.

Method

200 university staff members were randomly allocated to experience either prices below and above the lottery prizes (£0.19 and £3.80) or within the range of the lottery prizes (£0.74 and £1.07). To minimize effects of specific products, each price was presented with one of four plausible products. To mimic the shopping experience, participants judged the value of the price-product pairs on a five point scale (with verbal labels from ‘extremely poor value’ to ‘extremely good value’) and indicated whether they would buy the products. Finally, participants made the same lottery choice used in Study 1a, with the knowledge that all earnings were to be donated to charity.

Results and Discussion

Participants randomly assigned to prices outside the range of the lottery prizes were more likely to choose the safe option (70%) than participants evaluating prices within the range (53%), $\div^2$ (1, N = 200) = 6.1, p = .014. This replicates the finding from Study 1a and demonstrates a causal link between the distribution of prices experienced and the risky choice. The subjective values of objective quantities of money seem to be constructed using the relative rank of the target values within the distribution.

Study 2: The Weather

In this study we used probability phrases from everyday life as the analogue for supermarket prices. Verbal probability expressions appear more naturally and more frequently in everyday life communications than numerical ones (Zimmer, 1983). Despite considerable variability in interpretations of verbal probability expressions between individuals (e.g. Budescu & Wallsten, 1990; Budescu, Weinberg & Wallsten, 1988), probability phrases provide relatively stable rank orderings within individuals (e.g., Clarke, Ruffin, Hill & Beamen, 1992; Hakel, 1968), and risky behavior does not depend on the mode used to communicate the probabilities (e.g., Budescu & Wallsten, 1995; Erev & Cohen, 1990). To obtain self-generated probabilities we asked people to predict the likelihood of rain tomorrow. We then offered a choice between two verbally-described prize draws. Congruent with the findings of Studies 1a and 1b it was predicted that people with self-generated probabilities below or above the two probabilities in the prize draws should be more likely to prefer the prize draw with the larger prize and the smaller probability, because the difference in gamble probabilities will seem small. In contrast, people with self-generated probabilities falling between the two prize draw probabilities should be more likely to prefer the prize draw with the higher probability and the smaller prize, because the difference in gamble probabilities will seem large.

Method

Participants. A total of 401 participants (median age of 42, 59% female) completed the five-minute task for the chance to win an Amazon gift certificate. Participants were recruited through a local BBC radio station and web site, and via Warwick's Twitter stream and web pages. Data were collected over September and October of 2009.

Design and Procedure. The experiment was run online in the participant's web browser. Participants were asked to answer the question "How likely do you think it is to rain tomorrow?" by writing a short sentence using their own words. On a second page, participants were offered the choice between two lotteries for Amazon gift certificates: "a good chance of winning a prize of £5" and "a small chance of winning a prize of £50". They were informed that, for a small number of randomly selected participants, their chosen lottery would be played for real and their winnings sent to them by email. After participants selected their preferred option their email address was collected for the prize draw.

Results and Discussion

Running over a two month period of varied weather with participants across the UK meant a large range of phrases was collected. For each participant, we extracted the probability phrase used to describe the likelihood of rain from their sentence and converted it to a numerical probability using tables of phrases and their corresponding mean probabilities from the literature (Budescu et al, 1988; Clark et al., 1992; Lichtenstein & Newman, 1967; Reagan & Mosteller, 1989; Stewart et al. 2006). We could complete this translation for 294 of the 401 participants, discarding idiosyncratic responses and responses with no preexisting numeric equivalent. Figure 2 shows the frequency of the different phrases, plotted by the numerical equivalents. Because each probability phrase maps onto a distribution of numerical equivalents that is quite broad for most phrases, we cannot with certainty categorize phrases as less likely than "a small chance", more likely than "a good chance" or as of intermediate likelihood. Instead we used the numerical equivalent as a continuous predictor of the lottery choice.

Out of the 294 participants 60% preferred "a good chance of £5" and 40% preferred "a small chance of £50". Of most interest was the relationship between the weather phrase and the preferred gamble. Consistent with our prediction, a logistic regression model with preferred gamble as the dependent variable and the numerical equivalent and its square as the independent variables revealed a significant quadratic component ($\div^{2}(1) = 10.04$, $p = .0015$), indicating a non-linear relationship between the weather phrase numerical equivalent and the log odds of the probability of choosing the riskier gamble. As a significant curvature could be consistent with patterns other than the U-shape we predicted (e.g., an L-shape), we split the data at the median numerical equivalent (50%) and performed two separate logistic regressions, each with gamble choice as the dependent variable and the numerical equivalent as the independent variable. The line segments in Figure 3 illustrate the results. For numerical equivalents less than 50%, there was a negative relationship (coefficient = -.026, z = -1.35, p = .17), with higher numerical equivalents associated with a lower probability of choosing "a small chance of £50". For numerical equivalents greater than 50% there was a positive relationship (coefficient = 0.040, z = 2.35, p = .0190), with higher numerical equivalents associated with a higher probability of choosing "a small chance of £50". These two coefficients were significantly different, z = 2.57, p = .0102. That is, when the weather phrase was most likely to be less than "a small chance" or greater than "a good chance", people were most likely to select "a small chance of £50". When the weather phrase was most likely to be in between "a small chance" and "a good chance" people were least likely to select "a small chance of £50". The weather study therefore replicated the effect of the supermarket experiment showing that self-generated probabilities, instead of outcomes, can also alter preferences in risky choice.

Study 3: Birthday Plans

In Study 3 we investigated whether rank-dependent choice phenomena could also be observed in the domain of intertemporal choice. We tested whether thinking about an event occurring sometime in the future (one's birthday) affected preferences in a subsequent choice between a smaller-sooner amount and a later-larger amount. It was predicted that participants with birthdays falling between the sooner and later delays would perceive the delays as more different and therefore show a shift in preference towards the smaller-sooner option. Conversely, birthdays falling before the sooner delay or after the later delay should make the delays appear less different resulting in smaller levels of discounting.

Method

Participants. A total of 75 unpaid participants, almost all university applicants aged 17 or 18 (80% female), completed the 5-minute task.

Design and Procedure. The experiment was run in a web browser while participants sat at individual computers in a large room. An instructions page informed participants that they would have to make a series of choices between smaller-sooner and larger-later sums of money. Participants were then asked to think about their next birthday, and what they planned to do. They had to rank six options for celebrating their birthday – from having a big party to ignoring it – in order of likelihood using radio buttons displayed to the right of each option.

Immediately following this, participants completed a delay discounting task. They were initially presented with two buttons. The button on the left was labeled "£75 in three months"; the button on the right was labeled "£100 in nine months". A standard adjusting-immediate-amounts procedure was then used to determine the approximate smaller-sooner sum of money that was valued the same as the larger-later sum. For example, if on the first trial, a participant chose “£75 in 3 months”, the smaller-sooner sum for the next trial would be set at half way between the smallest possible value that the indifference point could take (£0) and the highest value (£75), in this case, £38 (rounded to the nearest integer). If, on the next trial the participant then chose the larger-later sum, the smaller-sooner sum would be set at half way between £38 and £75 (£57). This continued for four trials, and a participant's indifference point was recorded as the midpoint between the lowest and highest possible values that the point could take after the fourth trial. At the end of the discounting task, participants were asked to provide their date of birth.

Results and Discussion

Participants whose birthday came within the next 3 months (n = 17) had a mean indifference point of £77.38 (*SD* = £19.24). In other words, £100 in 9 months was rated the approximately the same as £77.38 in 3 months, on average. Participants whose birthday was in more than 9 months' time (*n* = 19) had a mean indifference point of £70.13 (*SD* = £21.70). Crucially, participants whose birthday lay between 3 months and 9 months (*n* = 39) showed higher levels of discounting over the period, with a mean indifference point of £57.70 (*SD* = £21.04). To examine this effect statistically, we compared the smaller-sooner indifference points between two groups: Those whose birthday lay between 3 and 9 months, versus those whose birthday did not lie between 3 and 9 months. There was a significant difference between the two groups, $t(73) = 3.29$, $p = .002$. This effect was not moderated by participants' preferences for birthday plans.

These results indicate that rank-dependent evaluations of alternatives using information from the immediate context is not a phenomenon restricted to decisions under risk. Instead, they seem to apply to delays as well and affect preferences in intertemporal choice.

General Discussion

Recently experienced prices, likelihoods, and future events altered people's risk and inter-temporal preferences. Traditional models, which assume stable psychoeconomic functions and discard contextual information, cannot explain these results. Minimally, one must assume unstable functions which vary from context to context. Incorporating this instability will undermine the descriptive power of these otherwise simple models, because one must also specify a mechanism determining the shape of the psychoeconomic function contingent on the context. As sampled attribute values were peripheral to the task and not part of the choice set even models of context effects caused by altering the choice set (e.g., Roe, Busemeyer & Townsend, 2001; Usher & McClelland, 2004) do not predict the results without modification.

We distinguish these effects from anchoring (see Wegener, Petty, Blankenship, &

Detweiler-Bedell, 2010, for a recent review), which predicts opposite effects. For example, if representations of the target values are anchored on intermediate amounts this should make the targets more similar and not more different. Instead, we take these results as evidence that the subjective values of objective quantities of monies, risks, and delays are not stable but are instead derived online by counting favorable comparisons to a sample of attribute values from the immediate context and more generally from memory.

We have found consistent effects for a variety of different attributes like money, risk, and delay. Given the ubiquity of these effects in perception (Laming, 1997) and of range-frequency effects in judgment, we predict that all magnitudes (e.g., iPod capacity, CO_2 emissions, and fat content) will be processed in the same way and thus subject to these contextual effects. Formal economic framing or other calculation may override this processing • \ but we propose rank-based processing is a natural default. Models built on the sampling hypothesis (like Stewart et al. • fs, 2006, decision-by-sampling model) provide new opportunities to model individual differences in choice behavior and its instability over time, which have often been neglected as noise.

Of course, because people's supermarket experience, birthday, or belief about the weather was not randomly assigned in Studies 1a, 2, and 3, the relationship between the sample and the choice in one of these studies could be caused by a common underlying variable. However, it may be hard to think of one common explanation for all three studies simultaneously, moreover one that explains the nonlinear relationship. Further, participants were randomly assigned to experience in Study 1b, providing evidence for a causal link (see also Stewart, 2009; Stewart et al., 2003; Stewart, Reimers, & Harris, 2010).

Conclusion

Prices sampled from a supermarket changed subsequent preferences for risky lotteries.

Thinking about the likelihood of rain, a common British activity, changed subsequent preferences for prize draws for Amazon vouchers. Considering birthday plans changed subsequent preferences for delayed rewards. One conclusion would be that, in order to reveal true underlying subjective values of monies, risks, and delays, one should be careful to avoid testing a participant who recently used money, talked about risks, or planned for the future. But these data are consistent with a more radical possibility. Perhaps there are no underlying psychoeconomic functions providing stable translations between attribute values and their subjective equivalents. Instead, perhaps subjective values are entirely constructed from a comparison with the ever-changing sample of attribute values in memory.

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Table 1

Inferential Statistics for the Coefficients in the Logistic Regression.

	z	*p*
Intercept	-.888	.374
Difference in relative rank	2.904	.004**
Income	1.034	.301
Total amount of money spent	-.326	.745
Average price	-.048	.961
Highest price	.483	.629
Number of items on receipt	.163	.870
Age	.760	.447
Years living in the UK	-1.739	.082
Gender	.960	.337

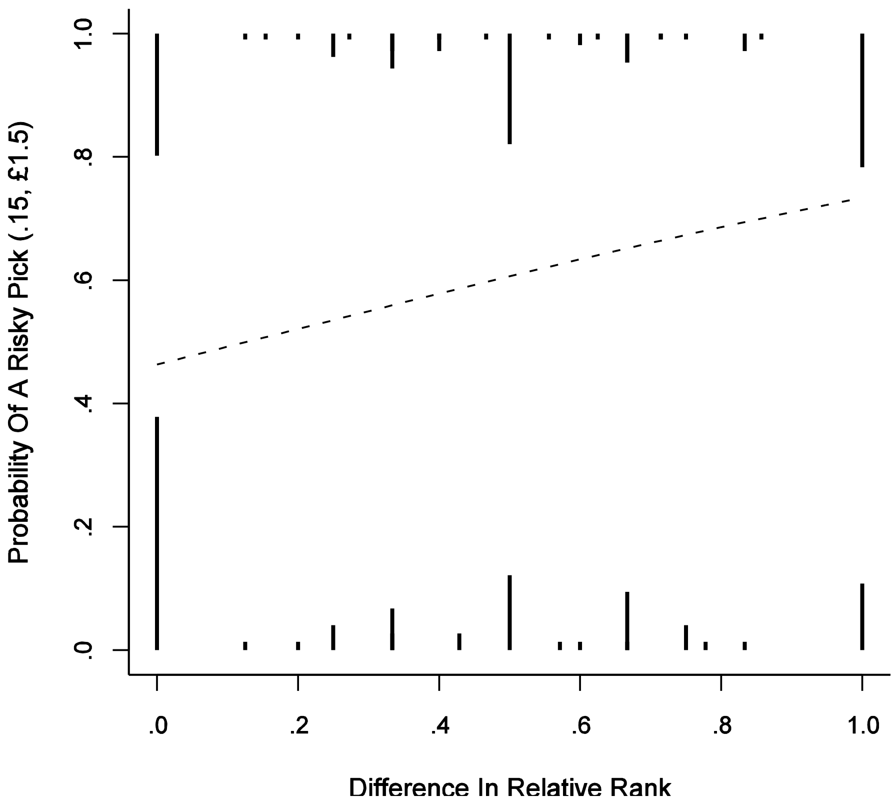
Figure Captions

Figure 1. Summary of the logistic regression analysis with the probability of choosing the risky option predicted by the rank difference between the two lottery outcomes (Study 1). The dashed line plots the predictions of the logistic regression model. The shorter lines on the top and bottom plot the distribution of rank differences for participants choosing the risky lottery (top) or the safe lottery (bottom).

Figure 2. The frequency of the numerical equivalents for the different weather phrases (Study 2).

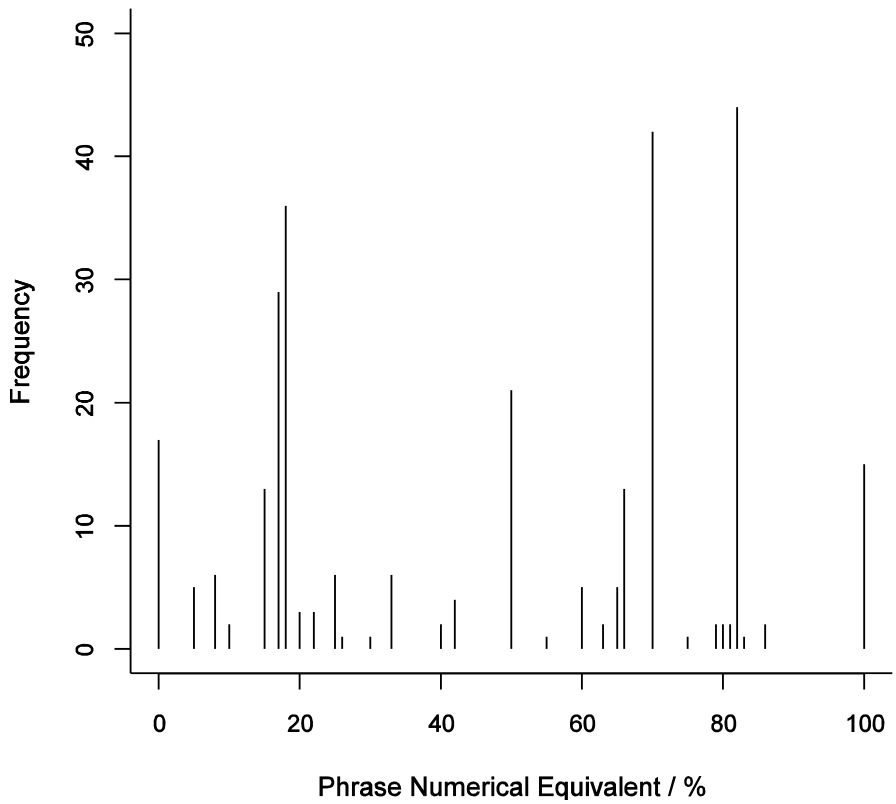
Figure 3. The U-shaped curve plots the predictions for a logistic regression model with numerical equivalent and its square as predictors (Study 2). The two shorter lines plot the predictions of logistic regression models with numerical equivalent as a predictor separately for each half of the data. The shorter lines on the top and bottom indicate the frequencies of the numerical equivalents separately for those choosing "a small chance of £50" (top) and "a good chance of £5" (bottom). The dashed vertical lines indicate the numerical equivalents for the two probability phrases from the lotteries.

Figure 1:



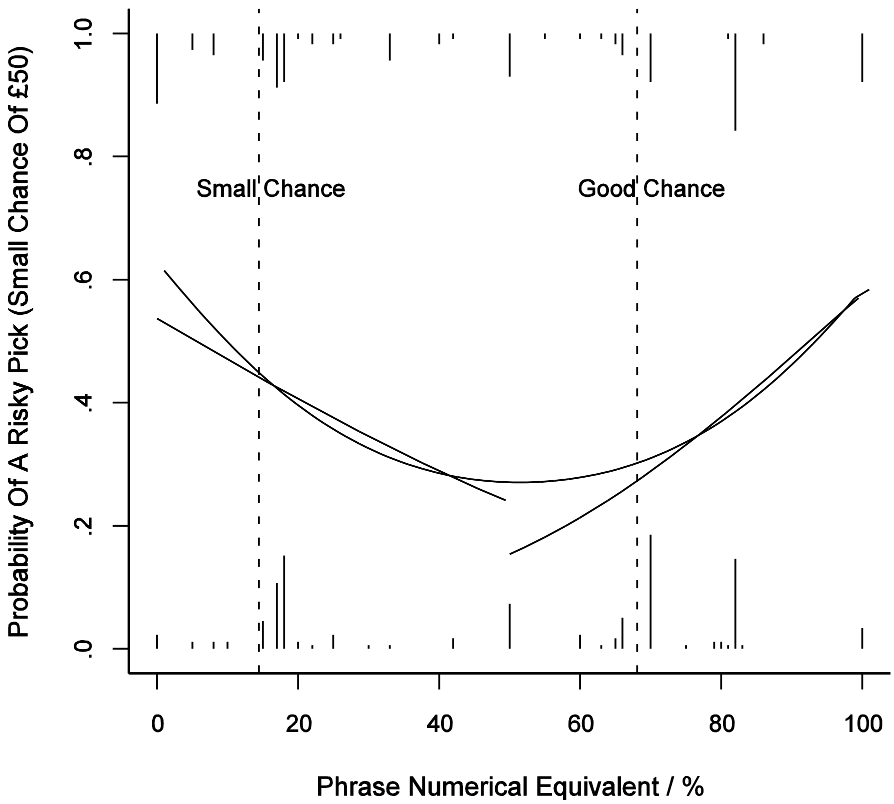
Probability Of A Risky Pick (.15, £1.5)
Difference In Relative Rank
.0
.2
.4
.6
.8
1.0

Figure 2:



Frequency
0
10
20
30
40
50
0
20
40
60
80
100
Phrase Numerical Equivalent / %

Figure 3:


Probability Of A Risky Pick (Small Chance Of £50)
1.0
.8
.6
.4
.2
.0
Small Chance
Good Chance
0
20
40
60
80
100
Phrase Numerical Equivalent / %