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How Incidental Values From the Environment Affect Decisions About Money, Risk, and Delay

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Abstract

How different are £0.50 and £1.50, "a small chance" and "a good chance," or "three months" and "nine months"? Our studies show that people behave as if the differences between these values are altered by incidental everyday experiences. Preference for a £1.50 lottery rather than a £0.50 lottery was stronger among individuals exposed to intermediate supermarket prices than among those exposed to lower or higher prices. Preference for "a good chance" rather than "a small chance" of winning a lottery was stronger among participants who predicted intermediate probabilities of rain than among those who predicted lower or higher chances of rain. Preference for consumption in "three months" rather than "nine months" was stronger among participants who planned for an intermediate birthday than among participants who planned for a sooner or later birthday. These fluctuations directly challenge economic accounts that translate monies, risks, and delays into subjective equivalents with stable functions. The decision-by-sampling model—in which subjective values are rank positions constructed from comparisons with samples—predicts these effects and indicates a primary role for sampling in decision making.

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; Tversky & Kahneman, 1992; 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 discussions). Once monies, risks, and delays are translated into their subjective equivalents, they are combined to give overall subjective values for each of the options available, 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 delays—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; Wedell, 1991). Here, we explore the hypothesis that subjective values are constructed according to 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 that is critical to predicting choice behavior. Independent motivation for this hypothesis comes from fuzzy-trace theory, according to which

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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) provides 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 with 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 against recent payments recalled from memory—say, $8 and $35. In this example, $12 has a subjective value of .5 (2/4), because half of the comparisons make $12 look good (i.e., the comparisons with $5 and $8) and half make $12 look bad (i.e., the comparisons with $20 and $35). One consequence that we exploited in the studies reported in this article is that the subjective difference between two objective attribute 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 than 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 proposed by the decision-by-sampling model 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 is 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 with consequences for human fatalities. In these examples, subjective values emerge from comparisons of attributes with samples from real-world attribute distributions.

We tested whether the variation in distributions of attribute values between individuals in everyday life can be used to account for differences in choice behavior. Such a finding would provide strong evidence that sampling from everyday experience plays a major role in people's routine valuation of money, risk, and delay. We present four studies in which the subjective values of monetary amounts were affected by prices sampled from a recent supermarket visit (Studies 1a and 1b), the subjective values of probabilities were affected by sampling likelihood expressions from a recent conversational exchange (Study 2), and the subjective values of delays were affected by a recently considered future event (Study 3). All the studies followed the same basic design. In an initial stage, people experienced a sample of attribute values. In a second stage, they chose between two options designed to reveal differences in the subjective values of attributes caused by the initial samples.

Study 1a: The Supermarket

The receipt a customer receives when leaving a supermarket provides an approximation of the sample of monetary amounts he or she has encountered recently, and this sample is quite likely still to be available in memory. We offered customers leaving a supermarket the opportunity to swap their receipt for the opportunity 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 in the two lotteries would be evaluated by a customer in the context of the sample of items on that customer's receipt. Specifically, we expected more participants to choose the risky lottery when more of the values listed on the receipt fell between the small and large prizes. The more intermediate items there were, the greater the subjective difference between the prizes would be. Thus, having more intermediate items would increase the attractiveness of the larger-prize lottery relative to the smaller-prize lottery.

Method

Stimuli. Prior to the main study, we collected bags of discarded receipts from the University of Warwick supermarket on different weekdays at different times to obtain a representative sample of receipts. A total of 400 receipts sampled from the thousands of receipts in the bags provided 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 study. 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 played by allowing participants to draw a poker chip from one of two urns, each containing 100 poker chips of two different colors. The safe-lottery urn contained 55 green poker chips worth £0.50 and 45 other poker chips worth £0. The risky-lottery urn contained 15 green poker chips worth £1.50 and 85 other poker chips worth £0.

Participants and procedure. We recruited 180 customers leaving the supermarket, who agreed to provide us with their supermarket receipt in exchange for an opportunity to draw a poker chip from one of the two urns (about 75% of all customers we asked participated; median age = 20 years; 58% male and 42% female; 91% students and 9% staff). First, a

participant received a verbal description of the two lotteries and was allowed to look inside the urns. The urns were then shaken to reshuffle the poker chips before the participant drew a chip from the lottery urn of his or her choice. 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 number of years living in the United Kingdom. Both the position of the urns (left or right) and the order of their presentation (first or second) were alternated randomly across participants.

Results and discussion

For each participant, we calculated the difference in the relative rank of the two lottery outcomes (£0.50 and £1.50) within the sample of prices on his or her receipt. For example, if the receipt contained the prices £0.35, £0.79, £0.99, and £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; thus, the difference in relative rank would be 3/4. A large difference in relative rank indicated that a large number of prices on the receipt fell between the values of the two lottery outcomes. In contrast, a small difference indicated that most of the prices on the receipt 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 prize values for the two lotteries 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 of the items on the receipt, highest price of the items on the receipt, number of items on the receipt, age, gender, and familiarity with the British pound (i.e., years living in the United Kingdom) 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 $z = 2.90$, $p = .004$. Moreover, difference in relative rank was the only significant predictor: None of the other variables provided a significant increase in model fit (see Table 1). When all values were outside the range of £0.50 to £1.50, the probability of choosing the risky lottery was .43. When all the prices on the receipt were between £0.50 and £1.50 the probability of choosing the risky lottery was .73.

Given that there were no effects of income or receipt total, 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 three items at £1.00 and purchasing one item at £3.00. Although these two cases would result in the same reduction in wealth, they would have different effects on the rank difference of the lottery prizes: The prizes of £0.50 and £1.50 would be less similar in

rank in the case of three £1.00 items than in the case of one £3.00 item.

Study 1b: Price Experiment

To test whether there was a causal relationship between the distribution of experienced prices and the choice participants made, we conducted an online experiment using the same lotteries and prize values as in Study 1a.

Method

A total of 200 University of Warwick staff members participated in this study, which was advertised on the University of Warwick Intranet. To mimic the shopping experience, we had participants judge the value of price-product pairs on a 5-point scale (from 1, *extremely poor value*, to 5, *extremely good value*) and indicate whether they would buy the products. Participants were randomly allocated to experience prices either below and above the lottery prizes (£0.19 and £3.80) or within the range of the lottery prizes (£0.74 and £1.07). Finally, participants made the same lottery choice as in Study 1a, with the knowledge that all earnings would be donated to charity. To minimize the effects of specific products, we presented each price with one of four plausible products (randomized across participants).

Results and discussion

Participants who were randomly assigned to experience prices outside the range of the lottery prizes were more likely to choose the safe option (70%) than were participants who experienced prices within the range (53%), $\chi^2(1, N = 200) = 6.1$, $p = .014$. This replicates the finding from Study 1a and demonstrates a causal link between the distribution of prices experienced and preference for 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 experienced distribution.

Table 1. Inferential Statistics for the Coefficients in the Logistic Regression From Study 1a

Coefficient	z	p
Intercept	−0.888	.374
Difference in relative rank	2.904	.004
Income	1.034	.301
Total amount of money spent	−0.326	.745
Average price of items on the receipt	−0.048	.961
Highest price of items on the receipt	0.483	.629
Number of items on the receipt	0.163	.870
Age	0.760	.447
Years living in the United Kingdom	−1.739	.082
Gender	0.960	.337

Study 2: The Weather

In our next study, we used probability phrases from everyday life as the analogue for supermarket prices. We decided to use verbal probability expressions, rather than numerical ones, because they appear more naturally and more frequently in everyday-life communications (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, 1969), and risky behavior does not depend on the mode used to communicate probabilities (e.g., Budescu & Wallsten, 1995; Erev & Cohen, 1990).

To obtain self-generated probabilities, we asked people to predict the likelihood of rain the next day. We then offered a choice between two verbally described lotteries. Congruent with the findings of Studies 1a and 1b, our prediction was that people with self-generated probabilities below or above the two probabilities in the lotteries would be more likely to prefer the risky lottery with the larger prize and the lower probability because the difference between the probabilities of the two lotteries would seem small. In contrast, people with self-generated probabilities falling between the two lottery probabilities would be more likely to prefer the safe lottery with the higher probability and the smaller prize because the difference in the probabilities of the two gambles would seem large.

Method

Participants. A total of 401 participants (median age = 42 years; 59% female and 41% male) completed the 5-min task for the chance to win an Amazon.co.uk gift certificate. Participants were recruited through a local BBC radio station and its Web site and via the University of Warwick's Twitter stream and Web site. Data were collected during September and October of 2009.

Design and procedure. The study was run online via each participant's Web browser. On the first page, 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 the second page, participants were offered the choice between two lotteries for Amazon.co.uk 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 the chosen lottery would be played for real for a small number of randomly selected participants, and their winnings would be sent to them by e-mail. After participants selected their preferred option, their e-mail address was collected for the prize draw.

Results and discussion

Running the study over a 2-month period of varied weather with participants living across the United Kingdom meant that a large range of phrases was collected. We extracted the probability phrase each participant used to describe the likelihood of rain and converted it to a numerical probability using tables from the literature on phrases and their corresponding mean probabilities (Budescu et al., 1988; Clark et al., 1992; Lichtenstein & Newman, 1967; Reagan, Mosteller, & Youtz, 1989; Stewart et al., 2006). We were able to complete this conversion for 294 of the 401 participants; idiosyncratic responses and responses with no preexisting numerical equivalent were discarded. Figure 1 shows the frequency of the different phrases, plotted by their mean numerical equivalents. Because most of the probability phrases mapped onto a distribution of numerical equivalents that was quite broad, we could not with certainty categorize phrases as meaning less than "a small chance," more than "a good chance," or an intermediate likelihood. Instead, we used the numerical equivalent as a continuous predictor of lottery choice.

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 participants' estimate of the probability of rain and the preferred lottery. Consistent with our prediction, a logistic regression model with preferred lottery as the dependent variable and the numerical equivalent of the probability of rain and its square as the independent variables revealed a significant quadratic component, $\chi^2(1, N = 294) = 10.04$, $p = .0015$, indicating a nonlinear relationship between the numerical equivalent of the probability of rain and the log odds of the probability of choosing the riskier lottery.

Because 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
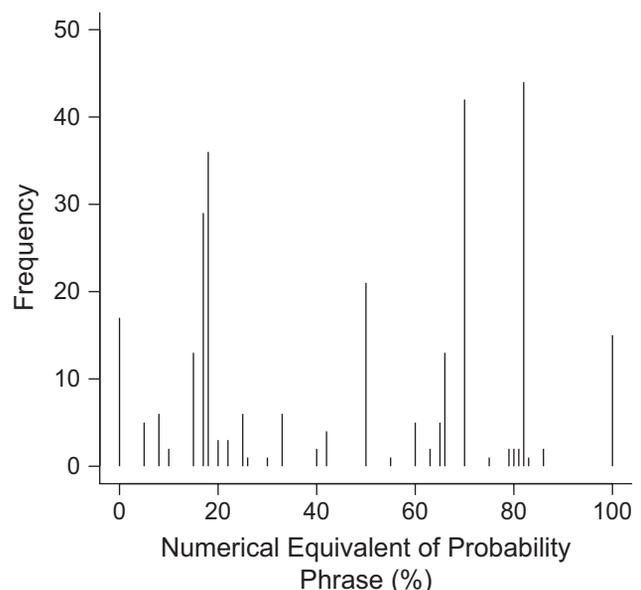
Fig. 1. Frequencies of the different probability phrases used by participants in Study 2, plotted by their mean numerical equivalents.

with lottery choice as the dependent variable and the numerical equivalent of the probability of rain as the independent variable. (Data with a 50% numerical equivalent were discarded, but including the data in either regression did not alter the pattern of results.) The line segments in Figure 2 illustrate the results. For numerical equivalents less than 50%, there was a negative relationship between preference for the risky lottery and numerical equivalent of the probability of rain (coefficient = -0.026, $z = -1.35$, $p = .17$), with higher numerical equivalents associated with a lower probability of choosing the risky lottery. For numerical equivalents greater than 50%, there was a positive relationship between preference for the risky lottery and numerical equivalent of the probability of rain (coefficient = 0.040, $z = 2.35$, $p = .0190$), with higher numerical equivalents associated with a higher probability of choosing the risky lottery. These two coefficients were significantly different, $z = 2.57$, $p = .0102$. That is, when the estimated probability of rain was most likely to be less than "a small chance" or greater than "a good chance," participants were most likely to select "a small chance of £50." When the estimated probability of rain 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." This study therefore replicated the effect observed in the supermarket study, showing that, like outcomes, self-generated probabilities can alter preferences in risky choice.
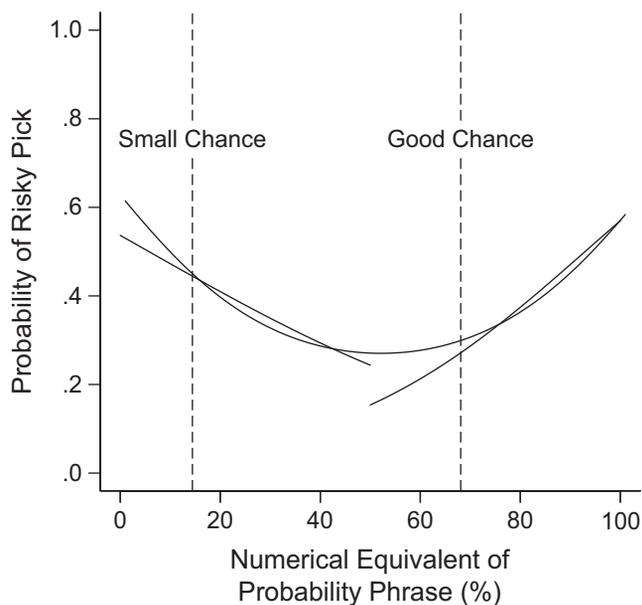
Fig. 2. Results of Study 2: predicted probability of a risky choice as a function of the numerical equivalent of the phrase used to describe the probability of rain. The U-shaped curve plots the predictions for a logistic regression model with numerical equivalent and its square as predictors. The two straight lines plot the predictions of two separate logistic regression models predicting the probability of a risky choice from numerical equivalents less than 50% and from numerical equivalents greater than 50%. The dashed vertical lines indicate the numerical equivalents for the probability phrases corresponding to the chances of winning the lotteries.

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 some time in the future (the participant's birthday) would affect preferences in a subsequent choice between a smaller, sooner amount (shorter delay) and a later, larger amount (longer delay). We predicted that participants with birthdays falling between the shorter and longer delays would perceive the delays as more different and therefore show a shift in preference toward the smaller, sooner option. Conversely, we expected that having a birthday falling before the shorter delay or after the longer delay would make the delays appear less different, resulting in smaller levels of discounting.

Method

Participants. A total of 75 unpaid participants, almost all University College London applicants who were 17 or 18 years old (80% female and 20% male), completed the 5-min task.

Design and procedure. The study 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 to celebrate it. 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 ranking task, participants completed a delay-discounting task, through which we determined the value at which participants were indifferent between the smaller, sooner and larger, later sums (the indifference point). They were initially presented with two buttons: The button on the left was labeled "£75 in three months," and the button on the right was labeled "£100 in nine months." Participants were asked to select which option they preferred. Next, a standard adjusting-immediate-amounts procedure was used to determine the approximate smaller, sooner sum of money that was valued the same as the fixed larger, later sum. The later, larger sum was held constant throughout the task. 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 halfway between the smallest possible value that the indifference point could take (£0) and the highest possible value it could take (£75), in this case, £38 (rounded to the nearest integer). On the next trial, if the participant chose the larger, later sum, the smaller, sooner sum would be set at halfway between £38 and £75 (£57). On the other hand, if on the first trial, the participant chose £100 in 9 months, the smaller, sooner amount was increased to halfway between the current smaller, sooner sum (i.e., £75) and the larger, later sum (i.e., £100), meaning the next trial would be a

choice between £88 in 3 months and £100 in 9 months. This means that indifference points were bounded by £0 and £100. 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 indifference 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 approximately the same as £77.38 in 3 months, on average. Participants whose birthday was more than 9 months away ($n = 19$) had a mean indifference point of £70.13 ($SD = $ £21.70). Crucially, participants whose birthday lay between 3 months and 9 months away ($n = 39$) showed higher levels of discounting over the period, having a mean indifference point of £57.70 ($SD = $ £21.04). To examine this effect statistically, we compared the indifference points between two groups: participants whose birthday was between 3 and 9 months away and those whose birthday was not between 3 and 9 months away. There was a significant difference in the average indifference point 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 evaluation of alternatives using information from the immediate context is not a phenomenon restricted to decisions under risk. Instead, this phenomenon is found in decisions involving delays as well, such that rank-dependent evaluations based on information from the immediate context affect preferences in intertemporal choice.

General Discussion

Recently experienced prices, likelihoods, and plans altered people's risk and intertemporal preferences. Traditional models, which assume stable psychoeconomic functions and discard contextual information, cannot explain these results. At a minimum, one must assume that there are unstable functions that vary from context to context. Incorporating this instability into the models will undermine the descriptive power of these otherwise simple models because one must also specify a context-contingent mechanism to determine the shape of the psychoeconomic function in each context. As sampled attribute values were peripheral to the tasks used in our studies and were 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 (for a recent review, see Wegener, Petty, Blankenship, & Detweiler-Bedell, 2010), which predicts effects opposite to the ones we observed. For example, if representations of the target values are anchored on intermediate amounts, this should make the targets more

similar to each other and not more different. Instead, we take our results as evidence that the subjective values of objective quantities of money, risks, and delays are not stable but are instead derived on-line by counting favorable comparisons with a sample of attribute values from the immediate context and, more generally, from memory.

We found consistent attribute-value-distribution effects for a variety of attributes (i.e., money, risk, and delay). Given the ubiquity of contextual 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 a food's fat content) will be processed in the same way and will therefore be subject to these contextual effects. Formal economic framing or other calculation may override this processing, but we propose that rank-based processing is a natural default. Models built on the sampling hypothesis (e.g., the decision-by-sampling model; Stewart et al., 2006) 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, birthdays, and belief about the weather were not randomly assigned in Studies 1a, 2, and 3, the relationship between the sample and the choice in any of these studies could have been caused by a common underlying variable. However, it is hard to think of a common underlying variable that would explain the results for all three studies simultaneously, and it is especially hard to think of an underlying variable that would explain the nonlinear relationship. Further, participants were randomly assigned to different experiences in Study 1b, which provided evidence for a causal link (see also Stewart, 2009; Stewart et al., 2003; Stewart, Reimers, & Harris, 2010).

Conclusion

Prices sampled from a supermarket affected subsequent preferences for risky lotteries. Thinking about the likelihood of rain, a common British activity, affected subsequent preferences for lotteries for Amazon.co.uk gift certificates. Considering birthday plans affected subsequent preferences for delayed rewards. One possible conclusion from these results would be that in order to determine true underlying subjective values of monetary amounts, risks, and delays, one should be careful to avoid testing participants who have 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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