Deconstructing Prospect Theory

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CITATION:

Modic, D., Pendry, L., & Lea, S. E. G. (2015). *Deconstructing Prospect Theory*. Paper presented at the IAREP - SABE JOINT CONFERENCE. Conference (2015 ; Sibiu), Sibiu, Romania. Retrieved from http://www.epia.ro/

Abstract

In the present report, we explore the connection between prospect theory (PT) and both economic and psychological constructs measuring attitudes towards risky choices. 388 individuals responded to a survey containing modified PT items, the Domain Specific Risk Taking Scale (DOSPERT-R), the Stimulating-Instrumental Risk Inventory (SIRI) and the Holt – Laury (H-L) measure of risk sensitivity. Results show the items used in PT to be resistant to usage as a psychometric instrument. Nevertheless, we show that PT as a single construct is significantly correlated the SIRI measure. We also note that instruments measuring risk preferences across economic and psychological domains have relatively little in common.

Introduction

Prospect theory (PT)[1] is one of the cornerstones of modern behavioural economics[2]. It replaces the essentially normative subjectively-expected utility theory[3] of decision under risk with a positive theory based on surveys and experiments. The key features of that theory are that (a) people's assessments of the relative values of prospects depend on the risks attached to them in ways that cannot be captured by simple expected value or utility calculations (the Certainty Effect); (b) there is an asymmetry between judgements about gains and losses, with people showing an aversion to loss that is greater than their attraction to an equal gain (the Mirror Effect); and (c) decisions under risk are taken relative to a reference point of current wealth, rather in terms of their impacts on total wealth (the Isolation Effect). Although these generalisations have stood the test of time, the psychological constructs that might underlie these tendencies have not been investigated, and the present study sought to do that. Our underlying hypothesis was that if there are distinct psychological tendencies to use reference points, to avoid losses, and to be sensitive to risk, people will almost inevitably vary in the strength of those tendencies, and these individual differences should be reflected in the answers that different people give to the questionnaires from which prospect theory was derived. To investigate this question, we posed the questions on which the original prospect theory was based to a large sample of adults. Kahneman and Tversky subsequently developed a more refined version of prospect theory[4], but the core concepts are the same so we used the simpler original version. We then used factor analysis to investigate whether the responses do, as Kahneman and Tversky originally suggested, reflect three distinct psychological constructs which could be expected to show independent individual variation. In addition we obtained measures of the participants' risk sensitivity using three methodologically well grounded measures of risk attitude. Two of these were psychometrically based. These were the Domain Specific Risk Taking Scale (DOSPERT-R)[5], which has been developed

according to the well-established principles of psychometrics and is empirically established to be both reliable and valid (including, with minor variations, across cultures[6]). From the five DOSPERT-R domains of risk preference, we chose the financial domain and its two subdomains (investing / betting) as those most likely to give meaningful results when compared to the three constructs of PT. The second psychometric scale was the Stimulating-Instrumental Risk Inventory (SIRI)[7].The final measure of risk sensitivity we used was the Holt-Laury lottery-choice measure[8], which has its origins in behavioural economics. It uses real financial incentives in order to meet the methodological standards of experimental economics[9] and is widely used in that field. Among experimental economists it is accepted as valid without question[10 11] though some have criticised it as overly complex[12]. We compared the measure of risk sensitivity obtained from the prospect theory items with the measures on these three established scales.

Materials and Methods

Participants

Participants were recruited in three sittings using Amazon Turk between October and December 2013. They were offered a baseline payment of $0.10US for attempting the survey, plus an incentive payment of $0.10 for completing it, and an additional amount of up to $3.85 that was contingent on their answers on the Holt-Laury risk-preference items. In all 443 responses were received. After the removal of 66 duplicate responses (established through examination of the respondents' IDs on the Amazon Turk system, together with demographics), 388 responses that were complete enough for analysis remained. All participants were based in the USA.

Survey instrument

The survey included, in the following order:

(a) A series of demographic questions, investigating participants' age, internet sophistication, gender, living conditions, marital status, educational level, income, countries of birth and current residence (and, if these were different, the time they had lived in the latter), and occupational status

(b) The 15 items from the original Kahneman and Tversky study, modified slightly to allow for the changes in monetary values since the 1970s and for the fact that the participants were based in the US rather than Israel. In addition we changed the response format to allow a graded response, on a 6-point Likert scale. Of these items, 8 relate to the Certainty effect, 4 to the Mirror effect and 3 to the Isolation effect. The items in the form in which they are used are listed in Table 1.

(c) The 6 items of the investment and betting subdomains of the DOSPERT-R scales. These items required a response on a 7-point Likert scale. Of these items, 3 relate to the investment subscale and 3 to the betting subscale.

(d) The 17 items of the SIRI scale, again requiring responses on a 7-point Likert scale. Of these items, 10 relate to "social" risk and 7 to "instrumental" risk.

(e) The 10 items of the Holt-Laury risk preference inventory. For each option, participants were asked to make a binary choice between two probabilistic items, but we expanded the response scale to a 6-point Likert type scale to additionally capture the strength of their preference. They had been told that one of these items would be chosen at random and they would receive the additional payment they had chosen, with the probability that they had chosen.

(f) A question about the participants' understanding of the purpose of the research, included as a check on any influence of demand characteristics on their responses.

Data analysis

The usable responses were divided into two, an exploratory sample (N=264) and a holdout sample (N=124). In the exploratory sample, each set of items was subjected to exploratory factor analysis, using principal axis factoring followed by oblique rotation. Where previous literature specified an expected number of factors, the solution was constrained to this number, but the appropriateness of this was checked using the scree test and parallel analysis of the observed principal component eigenvalues[13]. Where a set of items was expected to constitute a single scale, the internal consistency of this scale was assessed using Cronbach's α. Where the assignments of items to scales implied by previous literature proved unsatisfactory, conventional item analysis was used to form modified scales. The holdout sample was then used to assess relationships between mean scores on the various scales that had been established, using simple correlations (Pearson's) and Ordinary Least-Squares linear regression. Demographic variables were included in the regression analyses as a second step. All analyses were carried out using SPSS, versions 17-22.

Results

Prospect theory items

Factor analysis of the remaining 15 Prospect Theory items did not identify three constructs corresponding to the Certainty, Mirror and Isolation effects. Both the scree test and parallel analysis supported the extraction of three factors, but the distribution of the items between factors does not correspond to their origins in the three supposed effects. Table 1 shows the loadings of the Prospect Theory items onto these empirically determined factors; note that some items did not have acceptable loadings on any factor. Furthermore, attempting to use the items theoretically assigned to each effect to constitute a set of psychometric scales leads

to unacceptable levels of reliability, with α values of .549, .373 and .512 for the putative Certainty, Mirror and Isolation effect scales; note that one of the Isolation effect items had to be discarded because responses to it were essentially random, and with only two items remaining for the Isolation effect the α coefficient is of uncertain usefulness.

By standard psychometric item analysis, we found that the least unsatisfactory approach to the data from the Prospect Theory items was to discard four of the Certainty effect items, all the Mirror effect items and one of the Isolation Effect items and treat the remaining items as a scale of a single construct. This 6-item scale has borderline acceptable reliability (α=0.648). It corresponds exactly to the first factor extracted in the exploratory factor analysis above. Since the majority of the items in this scale relate to the Certainty Effect, it is appropriate to compare scores on it with those from the economic and psychometric scales of risk sensitivity.

Risk sensitivity scales

The reliability of the six DOSPERT items in the financial domain taken together was adequate in the exploratory sample (N = 388) with Cronbach α of .749. The two subscales, for investment and betting, also showed satisfactory reliability (Cronbach's α of .711 and .863 respectively). The SIRI full scale and subscale reliabilities were also satisfactory (Cronbach α values .819 for the full scale, .802 for the social subscale and .727 for the instrumental subscale). However, we found that we could improve the reliabilities by dropping 3 items from the social set and 1 from the instrumental set; this yielded α values of .862 for the full scale, .865 for the social subscale and .769 for the instrumental subscale, and these reduced scales were used for subsequent analyses. Although the Holt-Laury scale is not

designed as a psychometric instrument, it is still possible to assess its internal consistency; using standard methods it yields a Cronbach α of .854, although given the nature of this instrument, in which the probability of accepting the second outcome is expected to rise monotonically across the series of 10 items, it would probably be preferable to treat it according to the principles of Rasch scaling[14]. As an aside, we note that the reliability of this measure would be improved by eliminating the two end items, which ask participants to make choices under certainty rather than risk, suggesting that these items may engage slightly different psychological processes than the others. The DOSPERT full scale value was well correlated with the SIRI scale value (r = .42, P=.005), but neither was significantly correlated with the Holt-Laury measure (r=-.09, P=.32 for the DOSPERT scale and r=-.11, P=.24 for the SIRI scale).

Relation of Prospect Theory items to risk sensitivity scales

Regressions were run using as dependent variable

(a) the mean of the scores on all 14 Prospect Theory items
(b) the mean of the scores of the items assigned to each of the three concepts Certainty, Mirror and Isolation effects
(c) The means of scores on items assigned to each of three empirically determined factors
(d) The mean of the 6-item reduced Prospect theory scale.

Regressions were run first including just the DOSPERT, SIRI and Holt-Laury scale values (entering the two subscales of the DOSPERT and SIRI instruments as separate regressors), and then including also the demographic variables of age, Internet sophistication, educational level and income.

While the results differed in detail between these analyses, there was a general pattern. Only in the case of the full set of Prospect Theory items did including the demographic variables lead to a significant improvement in variance accounted for, and even in that case none of the individual demographic factors had a significant effect. Accordingly, only results from the regressions against the risk sensitivity scales are reported. In all several of these analyses, the DOSPERT scales had a significant relationship with the Prospect Theory items if considered on their own, but if the SIRI scales were included in the analysis the DOSPERT scales dropped out of significance. Where significant effects were found, they were always for the betting subscale of the DOSPERT test and the Instrumental subscale of the SIRI test. For the full set of Prospect Theory items, the reduced Prospect Theory scale, the Certainty effect and Isolation effect items, and the first of the three empirical scales derived from the Prospect Theory items, the Instrumental SIRI subscale score had a substantial and significant relationship to the Prospect Theory score (β values between -.29 and -.34; P values from .04 to .02). The Holt-Laury measure did not have a significant relationship to any of the combinations of Prospect Theory items that we investigated.

Discussion

We conclude that although three concepts contributed to the design of the original Prospect Theory investigation, they do not correspond to three distinct psychological constructs – or if they do, they are not constructs in which individuals vary within our participant population. Support for our conclusion comes from the finding that, although aggregate PT parameters are stable across time, values of them for individuals are not[15]. However the majority of the items used to establish Prospect Theory turn out to be related, albeit weakly, to psychometric measures of risk sensitivity that are now well established. They are not well related to the widely used Holt-Laury measure of risk sensitivity, however.

It is also worth noting, and of some concern, the economic and psychometric measures of risk attitude have effectively no correlation. The same result has been found in some previous comparisons between the two[16,17], though not all[18]. In addition we note that in our study the SIRI instrument outperformed the better-known DOSPERT scales.

These results do not cast doubt on the validity or value of Prospect Theory as a critique of expected utility theory and the formal economic theories that depend on it. The demonstration that, in probabalistic situations, humans do not behave in accordance with the expectations of normative theory remains sound. What our results do show, however, is that Prospect Theory does not carve human behaviour towards risk at its joints. Individual differences between people in risk sensitivity do not align neatly with conceptually distinct deviations from rational choice, and their structure remains to be determined empirically.

Table 1

The updated Prospect Theory items, their identification with the original Prospect Theory constructs, and their loadings on three empirically determined factors.

Item		Original construct	Empirical factor loadings		
Option A	Option B		Factor 1	Factor 2	Factor 3
Please consider the following two-outcome questions. You are always presented with two options (A and B) and are asked to pick the one you prefer.					
33% chance to win $1360; 66% chance to win $1280; 1% chance to win $0	$1280 for sure	Certainty	.370		
33% chance to win $1360; 67% chance to win $0	34% chance to win $1280; 66% chance to win $0	Certainty		.357	
80% chance to win $2080	$1600 for sure	Certainty	.644		
20% chance to win $2080	25% chance to win $1600	Certainty		.537	
5% chance to win a three-week tour of Florida and the Caribbean	10% chance to win a one-week tour of Florida	Certainty		.353	
50% chance to win a three-week tour of Florida and the Carribean	Win a one-week tour of Florida with certainty	Certainty	.365		
45% chance to win $3200	90% chance to win $1600	Certainty	.516		
0.1% chance to win $3200	0.2% chance to win $1600	Certainty		.747	
80% chance to lose $2080	lose $1600 for sure	Mirror			.475
20% chance to lose $2080	25% chance to lose $1600	Mirror			.418
45% chance to lose $3200	90% chance to lose $1600	Mirror			
0.1% chance to lose $3200	0.2% chance to lose $1600	Mirror			

Item		Original construct	Empirical factor loadings		
Option A	Option B		Factor 1	Factor 2	Factor 3
Imagine that you have been involved in a complex two-stage game. In the first stage there was a probability of 75% to end the game without winning anything, and a probability of 25% to move into the second stage. On this occasion, imagine yourself to be through the first stage already and need to consider the following:					
80% chance to win $2080	$1600 for sure	Isolation	.607		
In addition to whatever you own, you have been given $530. You are now asked to choose between:					
50% chance to win $530	$265 for sure	Isolation	.460		
In addition to whatever you own, you have been given $1060. You are now asked to choose between:					
50% chance to lose $530	lose $265 for sure	Isolation			.528

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