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No aspiration to win? An experimental test of the aspiration level model

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Abstract A growing body of literature studies the effects of aspiration levels on people's choices. Researchers often assume an aspiration level at zero, which helps to explain several empirical phenomena. In two experiments, we test this assumption. Our experimental design exploits the discontinuity in the utility function at the aspiration level. The lotteries vary in complexity in terms of the number of outcomes and the use of round or non-round probabilities. We do not find support for an aspiration level at zero, neither for simple lotteries nor for complex lotteries. Overall, our aggregate results are consistent with prospect theory, but can also be explained by a population with heterogeneous aspiration levels instead of a homogeneous aspiration level at zero.

Keywords Decision under risk · Aspiration levels

JEL Classification C91 · D81

People often appear to pay attention to the overall probability of reaching a target or aspiration level. In an early contribution, Roy (1952) argued that people seek to minimize the probability of disaster. Indeed, it seems that farmers minimize the probability of falling below the subsistence level (Lopes 1987), cabdrivers aim at a daily target (Camerer et al. 1997), and investment managers try to meet a target return

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(Payne et al. 1980, 1981). Aspiration levels can also account for risk-seeking behavior in the domain of losses, when the risky option minimizes the probability of a loss.[1] Yet, while aspiration levels are plausible, only a few studies explicitly test for their existence. Among the few exceptions is Payne (2005). In his 'value allocation task,' participants can add a fixed amount to one of several possible lottery outcomes, and he finds that participants prefer to maximize the overall probability of winning. He concludes that the overall probability of winning or losing should be part of any descriptive theory of choice. However, the existing evidence is mixed. While Venkatraman et al. (2009, 2014) have replicated and extended Payne's findings, Zeisberger et al. (2012) do not find strong support for an aspiration level in a more dynamic context. Moreover, the existing literature does not precisely locate the aspiration level and cannot exclude Prospect Theory (Tversky and Kahneman 1992) as an alternative explanation for the empirical findings.

The contribution of this paper is to provide a new test of an aspiration level at zero. Our focus is on this particular outcome because many previous experiments have shown that the outcome zero plays an important role in decision making under risk. It is often taken as the reference point in prospect theory (Tversky and Kahneman 1992) and as a natural aspiration level (Lopes and Oden 1999; Pahlke et al. 2013). In psychology, tests of the affect heuristic concentrate around zero (Bateman et al. 2007), and zero-outcomes receive a different weight in configural-weighting theory (Birnbaum et al. 1992; Mellers et al. 1992; Weber et al. 1992).

We report findings from two experiments. Both experimental designs rely on the discontinuity in the utility function at the aspiration level (Diecidue and van de Ven 2008; Levy and Levy 2009). In Experiment I, subjects make a series of choices between 2-outcome lotteries and sure outcomes. In Part 1 of this experiment, we shift the lotteries by adding or subtracting a small amount of money to both outcomes. If one of the outcomes crosses the aspiration level as a consequence of the shift, we predict a substantial change in individuals' certainty equivalents and risk attitudes. In Part 2 of the experiment, we keep the outcomes constant, but vary the probability of the outcomes. We use this method to elicit the certainty equivalents of different lotteries, allowing us to detect discontinuities in the value function that would signal an aspiration level.

The results from Experiment I do not provide support for an aspiration level at zero. Conceivably, aspiration levels are used as a heuristic to simplify a problem, and may become more important as the decision problem becomes more complex. This would unify our findings with existing studies that do report evidence of aspiration levels, as those studies typically use lotteries with more than two outcomes.[2] In Experiment II we test this conjecture. We vary the complexity of the lotteries by changing the number of outcomes (2, 3, or 5) and using non-round probabilities. We again find no support of an aspiration level at zero, neither for easy nor for complex lotteries.

[1] Risk-seeking in the domain of losses is found in many laboratory experiments. See, e.g., Abdellaoui et al. (2008); Baucells and Villasís (2010); Camerer (1989); Etchart-Vincent and L'Haridon (2011); Fehr-Duda et al. (2010); Tversky and Kahneman (1992); Wakker (2010); Weber and Camerer (1998).

[2] E.g., Payne et al. (1980, 1981); Lopes and Oden (1999); Payne (2005); Venkatraman et. al. (2014).

Overall, our results provide no support for an aspiration level at zero. At the aggregate level, the results are consistent with prospect theory, but they can also be explained by a population of individuals with heterogeneous aspiration levels.

The rest of the paper is organized as follows. The next section outlines the theoretical model. This model forms the basis of our experimental design. Section 2 presents the design and results of Experiment I. Section 3 presents the design and results of Experiment II. We discuss our findings in Section 4, and conclude in Section 5.

1 The aspiration level model

Aspiration levels have been formalized by, amongst others, Diecidue and van de Ven (2008) and Levy and Levy (2009).[3] These models make two important assumptions. First, decision makers (DMs) are concerned with aspiration levels and, in particular, with the overall probability of meeting an aspiration level. Second, DMs are also sensitive to the level and likelihood of all other outcomes. In these models, DM preferences are expressed as a combination of expected utility and the aspiration level. We denote by $P(x^+)$ (resp. $P(x^-)$) the overall probability of reaching an outcome strictly above (resp. below) the aspiration level. The valuation of a lottery L with outcomes x_j (j=1, 2, …, n) and probabilities p_j is

$$V^{AL}(L) = \sum_j p_j u(x_j) + \mu^+ P(x^+) - \mu^- P(x^-), \qquad \mu^+, \mu^- \in \mathbb{R}^+. \tag{1}$$

It is straightforward to show that this expression is equivalent to $V^{AL}(L)=\sum_j p_j v(x_j)$ if we define: $v(x_j)=u(x_j)+\mu^+$ for $x>x_0$; $v(x_j)=v(x_j)-\mu^-$ for $x<x_0$; and $v(x_j)=u(x_j)$ where u is a continuous value (or utility) function and x_0 is the aspiration level. The result is a value function v that is discontinuous around the aspiration level. Figure 1 illustrates such a value function v (the solid line), when the aspiration level is set at zero. As the graph shows, the value function v jumps at the aspiration level.

1.1 Model predictions

To derive predictions from the aspiration level model, we assume a value function as in Fig. 1. The value function jumps at the aspiration level. In principle, the theory does not impose any restrictions on the concavity/convexity of the smooth parts of the function. However, a value function as in Fig. 1 is consistent with two major findings from laboratory studies—namely, people exhibit risk-averse behavior in the domain of gains but risk-seeking behavior in the domain of losses. Prospect Theory (PT) (Tversky and Kahneman 1992) accommodates the risk-seeking behavior with a convex value function in the loss domain.[4] However, the aspiration level model offers a different explanation for the risk-seeking behavior. Faced with the choice between a lottery and a sure negative outcome, a DM may prefer the lottery simply because it offers the

[3] See also Castagnoli and LiCalzi (2006), who formulate a theory of target-based decision making and show that this approach satisfies the Savage axioms that underlie the Expected Utility Theorem.

[4] Under PT, risk attitude is described by the value function and probability weighting function. In this paper we address only the value function.

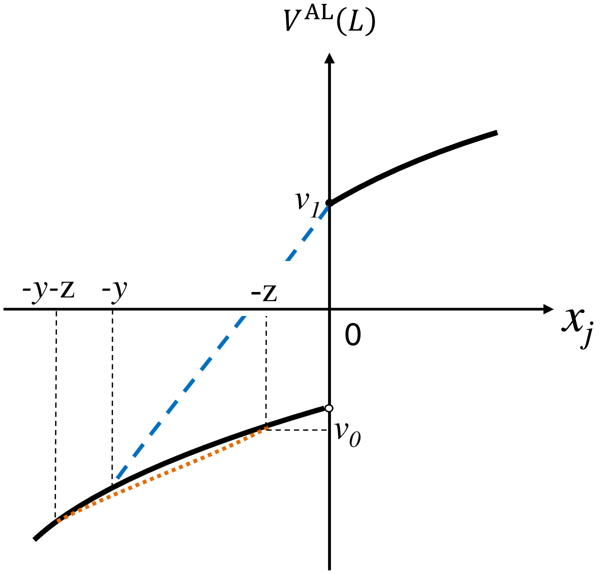


Fig. 1 Example of a value function for the aspiration level (AL) model

only chance of reaching the aspiration level. We can illustrate this in Fig. 1 for a 2-outcome monetary lottery that yields either 0 or $-y$. The expected utility of this lottery (a point on the dashed line) is always at or above the value function, implying that the lottery is preferred to receiving its expected value for sure.

1.2 Testing for an aspiration level

We now derive two predictions from the model that form the basis of our experimental design. Although we derive these predictions using lotteries with only two outcomes, it is straightforward to generalize the predictions to many outcomes.

The first prediction is derived from shifting the lotteries by adding some amount of money to all the outcomes. This design is inspired by Payne et al. (1980, 1981) and Lopes and Oden (1999).[5] Suppose that, as a consequence of the shift, an outcome crosses the aspiration level. In that case, the model predicts (i) a jump in the value function and the valuation of the lottery (the certainty equivalent), (ii) a change in risk attitude. If, for instance, we start with the lottery that gives 0 or $-y$ with equal probabilities, the value function plotted in Fig. 1 predicts risk-seeking behavior. If we then subtract an amount of $z > 0$ from both outcomes, all outcomes are below the aspiration level. The value of the highest outcome drops (in Fig. 1 from v_1 to v_0) and the person becomes risk-averse.

Prediction 1 Suppose that people have an aspiration level. Shifting all the outcomes of a lottery by a constant amount results in a jump in the certainty equivalent and a change in risk attitudes if the shift causes an outcome to cross the aspiration level.

[5] Wang and Johnson (2012) also use this strategy, and they find support for multiple reference points. In the experiments in which they shift lotteries, they prime subjects with reference points by instructing subjects that, e.g., an outcome less than zero is considered as a 'failure.'

For the second prediction, consider a mixed gamble with one outcome above and one outcome below the aspiration level. If we assume that the aspiration model is the correct representation of preferences, then by examining a large number of gambles that differ only in the probability of getting the high outcome, and eliciting the certainty equivalent (CE) of each gamble, one can trace the value function in the entire range between the low outcome and the high outcome (where the value of the low and high outcomes can be set arbitrarily).[6] If an aspiration level exists, this analysis will reveal it as a discontinuity, or "jump", in the value function.

Prediction 2 Suppose that people have an aspiration level and consider a lottery with two given outcomes. We can trace the value function by varying the probability of the high outcome. The aspiration level is revealed by a discontinuity in the value function at the aspiration level.

2 Experiment I: Aspiration levels for 2-outcome lotteries

2.1 Experimental method and task

The experiment consisted of two different parts in which subjects made choices between a sure amount of money and a 2-outcome monetary lottery. We will denote a lottery i by $L_i=(p_i,x_i;y_i)$, where x and $y<x$ are the outcomes and p is the probability of the highest outcome x. Table 1 gives details on all the lotteries.[7]

Lotteries in Part 1 were of the form $L_i=\left(\frac{1}{2},\ x_i;y_i\right)$. In the base lottery we set $x=20$ and $y=0$. The other lotteries in this part are constructed from the base lottery by a *shift*—that is, by adding a constant c to all outcomes. The shifts that we implemented were $c\in\{-28,-24,-20,-0.5,0,+0.5,+4,+8\}$. Since all lotteries in this part had two equally likely outcomes, and to avoid notational clutter, we simply denote these lotteries as L_{y_i,x_i}. Thus, the baseline lottery is denoted by $L_{0,20}$. In Part 2 of the experiment, lottery outcomes were fixed at $x=20$ and $y=-10$. We presented 19 mixed lotteries $(p,20;-10)$ with the probability p of the high outcome varying from 0.05 to 0.95 in steps of 0.05. We will denote these lotteries as $L_{M,p}$, where $p\in\{0.05,\ldots,0.95\}$.

All choices were presented in the form of a "price list" (Andersen et al. 2006; Binswanger 1980, 1981). Each price list consisted of binary choices between the lottery and increasing amounts of sure money (ranging from the lowest to the highest outcome of the lottery). The incremental steps by which the sure amount varied were relatively small compared to the difference in possible outcomes of the lotteries, allowing us to infer a relatively precise certainty equivalent (step sizes were €1 in Part 1 and €0.5 in Part 2). Price lists are built such that a subject should always prefer the lottery in the first decision (where

[6] Because of the utility function's discontinuity, certainty equivalence in the aspiration level model is not well defined everywhere. The CE in our context is defined as the minimum certain amount of money that is (weakly) preferred to the lottery.

[7] The actual experiment had four parts. Each of the two parts presented in this section had a counterpart with large but hypothetical outcomes. For the sake of focus, we only discuss the parts with small outcomes. The results of the other parts are very similar and are reported in Appendix 2 of the Online Supplementary Materials.

Table 1 Summary of lotteries in Experiment I

Lotteries					Results			
Part	Lottery	Outcomes		Probability H (p)	Certainty Equivalent (CE)			
		Low (L)	High (H)		Mean	Median	Interquartile range	
							25%	75%
1	$L_{0,20}$	0	+20	0.5	8.5	8.5	6.5	10
1	$L_{-28,-8}$	−28	−8	0.5	−15.6	−15.5	−18.5	−13.5
1	$L_{-24,-4}$	−24	−4	0.5	−12.9	−13.5	−14.5	−10.5
1	$L_{-20,0}$	−20	0	0.5	−10.1	−10.5	−11	−9
1	$L_{-0.5,19.5}$	−0.5	+19.5	0.5	8.7	8.5	6.5	10.5
1	$L_{0.5,20.5}$	+0.5	+20.5	0.5	8.6	9.5	6.5	10
1	$L_{4,24}$	+4	+24	0.5	11.6	11.5	9.5	13.5
1	$L_{8,28}$	+8	+28	0.5	15.0	14.5	13.5	16.5
2	$L_{M,p}$	−10	+20	{0.05,…,0.95}				

the sure amount is the minimal outcome of the lottery) and always prefer the sure amount of money in the last decision (where the sure amount is the maximal outcome of the lottery). The CE of a lottery is determined by the average of the two points at which the subject switches from the lottery to the sure amount (for example, if the subject prefers the lottery over €4, but prefers €5 over the lottery, then a CE of €4.5 results).

2.2 Experimental procedures

The experimental sessions took place in Amsterdam at the CREED laboratory in April 2009. Forty-eight students from the University of Amsterdam participated in the study. Of these, 52% were female; the mean age was 22. Subjects were recruited from the CREED database. After the general procedures were explained, subjects were assigned to a computer. They first received some general instructions that explained the experimental setup. Subjects were told that they would each receive an endowment of €28 and that it would be possible to earn a considerable additional amount of money, but that it was also possible to incur some losses. Losses would be subtracted from their endowment. Subjects were also informed that they could never lose more than their endowment. At this stage, everyone had the option to opt out of the experiment, but no one did.

Next, we handed out the endowments in (unsealed) envelopes and provided the subjects with detailed written instructions (see Appendix 1 of the Online Supplementary Materials). The motive for giving the endowments up front was to create a feeling among subjects that they owned the money, so that any subtraction would feel as a genuine loss. Subjects answered two practice questions before starting with the main part of the experiment. Thirty-four out of 48 subjects correctly answered both practice questions, and 45 out of 48 subjects correctly answered the second practice question. They then proceeded with the questions of the different parts. They always completed Part 1 before Part 2. Within each part, however, the order of questions was randomized.[8] At the end of the experiment, one question was randomly selected for each subject, and the subject received his preferred choice in real money (if she preferred the lottery, it was played out). Average earnings (including the initial endowment) were €34, and ranged from €0 to €56. Each session lasted for about 45 minutes.

The experiment was computerized using a web-based design. To help visualize the lottery, we showed a probability pie chart that was divided into two parts and colored to reflect the likelihood of each possible outcome. Because the price list for each question was lengthy, subjects had the option of using computer auto-complete assistance (for discussion of a similar procedure, see Andersen et al. 2006). The assistance made it possible for a subject to fill in all entries of a given list with just two mouse clicks. When computer assistance was enabled, the software would autocomplete choices for entries by assuming monotonicity of preferences. For instance, if a subject prefers a certain amount of money to some lottery, then it is reasonable to assume that the subject will also prefer any larger sure amount to that lottery. However, subjects always had the option to change any entry in their list of responses before proceeding, and they could disable computer assistance at any time.

2.3 Classification of choices

With the price lists, subjects always choose between a lottery and a sure amount of money, and therefore cannot express risk neutrality. We classify risk attitudes as follows. Suppose that a subject prefers the lottery for all sure amounts equal to or less than z_L, and prefers the sure amount for all sure amounts equal to or more than z_H . We classify the subject as *risk averse* (resp., *risk seeking*) if the expected value EV of the lottery is larger (resp., smaller) than the upper (resp., lower) bound—that is, if $\text{EV}(L) > z_H$ (resp., $\text{EV}(L) < z_L$). If the expected value of the lottery falls within the interval $[z_L, z_H]$ then we classify the choice as *risk neutral*.[9] This is a conservative way to classify subjects as risk-seeking or risk-averse, because some (mildly) risk-averse or risk-seeking subjects may also have their switchpoint in this interval, but such choices cannot be distinguished from risk-neutral attitudes.[10] We take the midpoint of this interval, $(z_L+z_H)/2$, as the *certainty equivalent*.

2.4 Hypotheses

We formulate three hypotheses. Hypotheses 1 and 2 are based on Prediction 1 and tested using Part 1 of the experiment. Hypothesis 3 is based on Prediction 2 and is tested using Part 2.

[8] We did not expect any order effects between the parts, which is the reason why we did not change the order between sessions. Within each part we randomized the questions because we did not want to make it salient to subjects that we shifted the lotteries. This also encouraged subjects to pay attention to every question.

[9] Very few subjects made multiple switches. For these choices, we take the midpoint between the first and the last switch to determine the certainty equivalent and risk attitude. The results are robust to excluding these choices.

[10] For instance, if the expected value of a lottery is 14, and the subject indicates to prefer the sure amount of 14 to the lottery, but prefers the lottery to a sure amount of 13, this person could be risk-neutral (and therefore indifferent between 14 for sure or the lottery) or risk-averse (and strictly prefer 14 for sure to the lottery). We classify this person as risk-neutral. Note that this may result in an overestimation of the fraction of risk-neutral people, but in any case, people classified as risk-neutral are at most very mildly risk-seeking or risk-averse.

Hypothesis 1 (H1): Risk-seeking behavior in the loss domain is explained by the existence of an aspiration level at zero. Thus, the proportion of risk-seeking choices will be lower for the lotteries $L_{-4,-24}$ and $L_{-8,28}$, where all outcomes are below 0, than for the lottery $L_{-20,0}$, where the highest outcome is equal to 0.
Hypothesis 2 (H2): Adding or subtracting a small amount from the outcome at the aspiration level leads to a significantly different valuation of the lottery. Thus, the CE of lottery $L_{0.5,20.5}$ will be significantly higher than the valuation of $L_{0,20}$, and the CE of lottery $L_{-0.5,19.5}$ significantly lower than the valuation of $L_{0,20}$.
Hypothesis 3 (H3): The CE of lottery $L_{M,p}$ as a function of the probability of the high outcome is constant around the aspiration level of zero, indicating a "jump" in the value function.

2.5 Results

The vast majority of subjects (94%) switched exactly once in each question. Nearly all subjects used computer assistance to autocomplete their choices. Moreover, virtually no one preferred the lottery when it was strictly dominated by the sure amount, or vice versa.[11]

We first focus on Part 1 of the experiment, presenting aggregate results. Table 1 reports the mean and median certainty equivalents, as well as the interquartile range. The means and medians are also plotted in Fig. 2. Except for a single instance, the CEs satisfy (weak) monotonicity. The CEs show risk aversion for gains and risk seeking for losses: CEs tend to exceed the lottery's expected value when losses are involved, and they are typically below the expected value when gains are involved.

Figure 3 shows the percentages of risk-seeking and risk-averse choices. For the baseline lottery, with outcomes 0 and 20, 52% of the subjects are risk-averse, and only 6% are risk seeking. For the lottery $L_{-20,0}$, 25% of subjects are risk-averse and 25% are risk seeking.[12] Our finding that choices tend to be risk-averse for gains and risk-seeking for losses is consistent with the existing literature (see Section 1).

We are mainly interested in how attitudes toward risk change after the shifts in payoffs. If the risk-seeking behavior in $L_{-20,0}$ is driven by a desire to achieve at least zero, then we should observe *less* risk-seeking behavior when a constant is *subtracted* from all outcomes, thereby making it impossible to achieve zero (H1). We find no support for this hypothesis. To the contrary, compared to lottery $L_{-20,0}$, the percentage of risk-seeking choices is significantly higher for the lotteries $L_{-24,-4}$ (χ^2=7.69, p=0.006) and $L_{-28,-8}$ (χ^2=15.06, p<0.001).[13] The percentages of risk-averse choices do not significantly differ for these lotteries.

In the domain of gains, we find that the percentage of risk-averse choices increases after a shift and, compared to $L_{0,20}$, is significantly higher in lotteries $L_{4,24}$ (χ^2=4.92, p=0.027) and $L_{8,28}$ (χ^2=9.09, p=0.003). As is apparent from Fig. 3, the proportion of risk-seeking choices is both small and constant in the gains domain.

The strictest tests of an aspiration level at zero are the comparisons of lotteries $L_{-0.5,19.5}$ and $L_{0.5,20.5}$ to the baseline lottery. These lotteries shift the outcomes of the

[11] We excluded these very few choices from the analysis.
[12] Note that the high fraction of risk-neutral subjects is possibly due to the way in which we classify risk attitudes. See also footnote 10.
[13] Nonparametric McNemar tests for related samples (two-tailed tests with a correction for continuity).

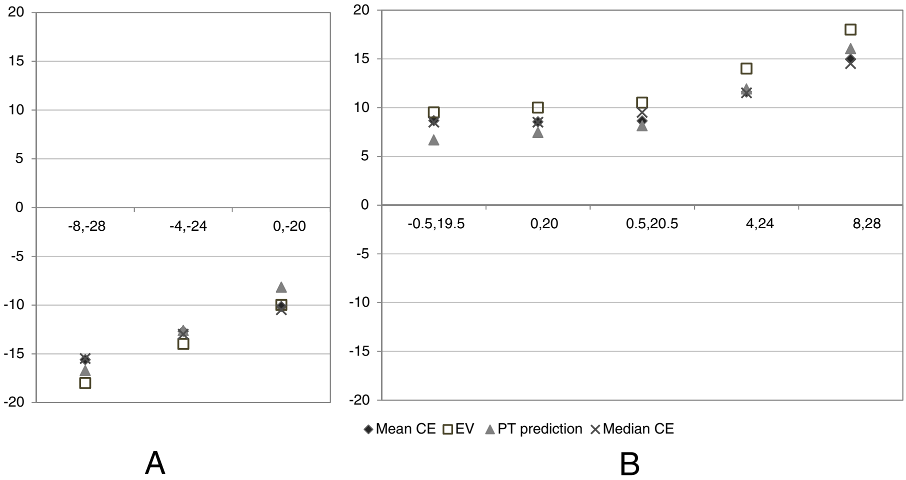


Fig. 2 CEs for lotteries in Part 1. **Panel A**: lotteries with negative expected value; **Panel B**: lotteries with positive expected value. The PT predictions are CEs as predicted by prospect theory for parameter values α= 0.88, β=0.88, γ=0.61, δ=0.69, and λ=1.75

baseline lottery by only a very small amount (€0.50). Observe that $L_{0,20}$ has one positive outcome and one zero outcome, $L_{-0.5,19.5}$ has one negative and one positive outcome, and $L_{0.5,20.5}$ has only strictly positive outcomes. We find no support of an aspiration level: The mean CEs of the two shifted lotteries are very similar (see Table 1) and do not significantly differ from the baseline lottery (for $L_{-0.5,19.5}$, Z=0.081 and p=0.936; for $L_{0.5,20.5}$, Z=1.343 and p=0.180, Wilcoxon signed-rank tests, two-tailed).[14,15,16]

So far we found no support for Hypotheses 1 and 2. We next turn to Hypothesis 3, which states that there is a jump in the value function if people have an aspiration level. In Fig. 4 we plot the probability p against the mean and median certainty equivalent. We plot the probability on the vertical axis, so that the figure can be interpreted as the aggregate value function. We transform CEs as in Tversky and Kahneman (1992), so that any point on the diagonal represents a risk-neutral choice. The figure shows no sign of a vertical part of the value function. The CEs are significantly different for almost all

[14] We cannot compare the risk attitudes between the lotteries with small shifts and the other lotteries. We gave subjects a list of sure *integer* amounts of money. This means that the expected value of the lotteries with small shifts (9.5 and 10.5) fell between two sure amounts. When this is the case, a risk-neutral subject has a unique switching point. For instance, when the expected value is 9.5, a risk-neutral person prefers the lottery to a sure amount of 9, and prefers a sure amount of 10 to the lottery. By contrast, for lotteries with an expected value that is equal to an integer, a risk-neutral person may switch at any one of two points. For instance, when the expected value is 9, a risk-neutral person may switch to the sure amount when the sure amount is either 9 or 10, because the person is indifferent between a sure amount of 9 and the lottery. We therefore look at the CEs instead.

[15] At the individual level we find some violations of monotonicity. Compared with the baseline lottery, 18 of the 48 subjects report a higher CE for $L_{-0.5,19.5}$; for 5 of them, this difference is strictly greater than €2. Also, 13 subjects report a lower CE for $L_{0.5,19.5}$; for 4 of these subjects, the difference is strictly greater than €2. Such violations of dominance for small changes in outcomes have been found elsewhere; see, for example, Bateman et al. (2007) and Mellers et al. (1992).

[16] The fact that the CEs for these three lotteries are so similar is consistent with prospect theory, but also with other theories. For instance, one feature of the Priority Heuristic (Brandstätter et al. 2006) is that people stop examining differences between lotteries if the lotteries are perceived as very similar.

adjacent probabilities and, for all pairs of lotteries whose probabilities differ by at least 0.1, the CEs are all highly significantly different (Wilcoxon signed-rank tests, two-tailed). We conclude that there is no support for H3 at the aggregate level.

In short, we find no support for any of the three hypotheses.

3 Experiment II: Aspiration levels for complex lotteries

The simplicity of lotteries in Experiment I could be the reason why we failed to find support for an aspiration level at zero. Possibly, using an aspiration level is a heuristic that becomes more important in more complex situations (cf. Payne 2005; Hoffmann et al. 2013). Indeed, Venkatraman et al. (2014), for instance, look specifically at complex decision problems to test if people use this as a heuristic. In an attempt to unify our findings with the existing literature, we designed Experiment II. In this experiment, we vary the complexity of lotteries. If we find evidence that aspiration levels become more important when the complexity of lotteries increases, this would reconcile our findings with that of the existing literature, since existing studies that document aspiration levels typically use more complex lotteries than those of Experiment I (see, for example, Payne et al. 1980, 1981; Payne 2005; Zeisberger 2014a, b; Levy and Levy 2009; Lopes and Oden 1999; Venkatraman et al. 2009, 2014).

3.1 Experimental methods and tasks

In Experiment II subjects made choices between lotteries and sure amounts. Table 2 summarizes all lotteries. Our baseline lottery has only two outcomes with equal probabilities: $\left(\frac{1}{2}, 0; 15\right)$. As in Part 1 of Experiment I, our strategy to detect an aspiration level is to shift all outcomes by some small amount. The amounts we used for the shifts were −1, −0.5, 0.5 and 1. We refer to the baseline lottery and the shifted lotteries as a *block*. Each lottery had a counterpart in which we changed the sign of all the outcomes. Hence, there is a block of 5 lotteries that all have a positive expected value, and a block of 5 lotteries that all have a negative expected value.

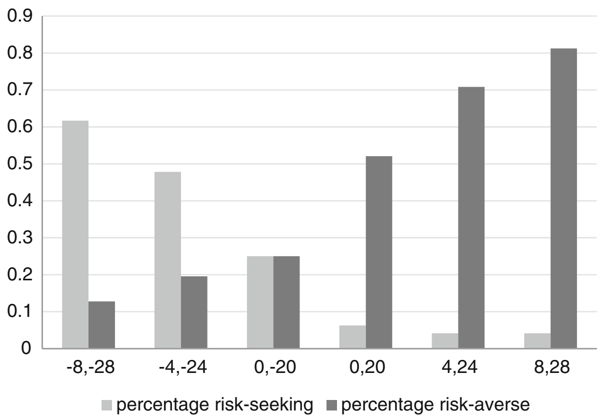


Fig. 3 Proportions of risk-seeking and risk-averse choices for lotteries in Part 1 of the experiment. Numbers on the horizontal axis are the two outcomes for each lottery

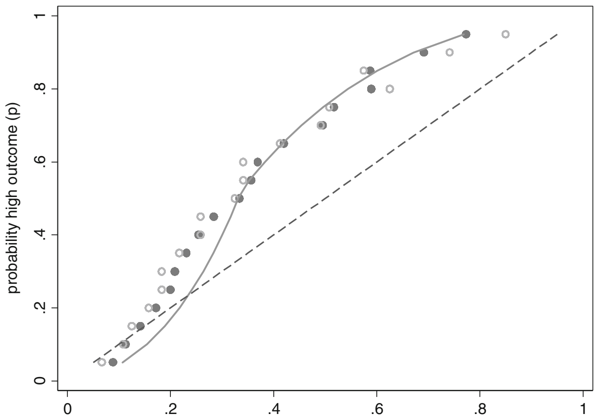


Fig. 4 On the horizontal axis are the mean CEs (*solid dots*) and median CEs (*open dots*) for Part 2. All CE values are rescaled as (x+10)/30. Numbers on the vertical axis are the high outcome's probability. The CE values predicted by prospect theory for parameter values α=0.88, β=0.88, γ=0.61, δ=0.69, and λ=1.75 are shown by the *solid line*

We varied the complexity of lotteries in two dimensions. First, we increased the number of outcomes to 3 or 5 while keeping the new lotteries similar to the 2-outcome lotteries. We did this by transforming the most extreme outcome into multiple outcomes, keeping the expected value constant and the standard deviation similar. We transformed the outcomes such that they remained relatively close to each other, so that the structure of the lottery is not much affected, but not so close that subjects would regard the outcomes as similar enough to treat them as one single outcome. Figure 5 shows an example. On the left is one of the 2-

Table 2 Summary of lotteries in Experiment II

	2-outcomes		3-outcomes			5-outcomes				
Easy probabilities	0.5	0.5	0.5	0.25	0.25	0.25	0.125	0.125	0.125	0.125
Hard probabilities	0.46	0.54	0.46	0.32	0.22	0.46	0.08	0.17	0.16	0.13
Lotteries with positive expected value:	−1	14	−1	11	17	−1	9	13	15	19
	−0.5	14.5	−0.5	11.5	17.5	−0.5	9.5	13.5	15.5	19.5
	0	15	0	12	18	0	10	14	16	20
	0.5	15.5	0.5	12.5	18.5	0.5	10.5	14.5	16.5	20.5
	1	16	1	13	19	1	11	15	17	21
Lotteries with negative expected value:	1	−14	1	−11	−17	1	−9	−13	−15	−19
	0.5	−14.5	0.5	−11.5	−17.5	0.5	−9.5	−13.5	−15.5	−19.5
	0	−15	0	−12	−18	0	−10	−14	−16	−20
	−0.5	−15.5	−0.5	−12.5	−18.5	−0.5	−10.5	−14.5	−16.5	−20.5
	−1	−16	−1	−13	−19	−1	−11	−15	−17	−21

Notes: All outcomes are in €. Each block of lotteries was presented with both the easy probabilities and hard probabilities outcome lotteries (see Fig. 5.A). Lotteries with 3 outcomes were constructed from the 2-outcome lotteries by transforming the most extreme outcome into two separate, equally likely outcomes, by subtracting and adding 3 to the original outcome (Fig. 5.B). Lotteries with 5 outcomes were constructed from the 3-outcome lotteries by splitting each of the two most extreme outcomes into two separate, equally likely outcomes, by subtracting and adding 2 to the original outcomes (Fig. 5.C).

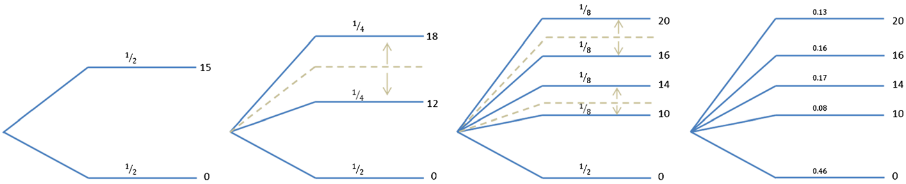
The second way in which we increased complexity was by modifying the probabilities of the lotteries. The first set of lotteries had “easy” probabilities: the probability of one outcome was 0.5 and each of the other outcomes was equally likely. A second set of lotteries had “hard” probabilities. They were similar in magnitude to the easy probabilities, but were slightly perturbed so that all the probabilities differed from each other and were not round. For instance, the 5-outcome lotteries with easy probabilities had one outcome with probability 0.5, and four outcomes with probability 0.125. The counterpart with hard probabilities had one outcome with probability 0.46, and the probabilities for the other outcomes were 0.08, 0.17, 0.16, and 0.13 (Fig. 5D).

Overall, this gives 12 blocks of lotteries (positive and negative outcomes X 3 possible number of outcomes X easy and hard probabilities). Each of those blocks is composed of 5 different lotteries constructed from each other by shifting all the outcomes. There was always one outcome close to 0, varying between −1 and +1 depending on the shift. The shifts did not change the sign of the other outcomes. Thus, the overall probability of a positive or negative outcome depends on whether the outcome that is close to zero is positive, negative, or exactly zero. The outcome close to zero always had a probability of 0.5 (easy probabilities) or 0.46 (hard probabilities).

3.2 Experimental procedures

The procedures were very similar to those of Experiment I. The experiment took place in Amsterdam at the CREED laboratory in September 2014. Subjects were recruited from the CREED database. A total of 97 subjects participated in 7 different sessions (47% female, mean age 22). After some general instructions, subjects received €21 in an envelope as their endowment (this amount was equal to the maximum possible loss). We used the same software and interface as in Experiment I.

Each subject completed 6 blocks of lotteries; either the blocks with easy probabilities or the blocks with hard probabilities. This was randomly determined for each subject. The certainty equivalent of each lottery was elicited using a price list, where the sure outcome ranged from the lowest to the highest outcome of the lottery in steps of €0.5. The order of the blocks was randomized between subjects, and the order of the 5 lotteries within each block was also randomized.



5.A: 2-outcomes, easy probabilities

5.B: 3-outcomes, easy probabilities

5.C: 5-outcomes, easy probabilities

5.D: 5-outcomes, hard probabilities

Fig. 5 Construction of complex lotteries from simple lotteries

Subjects answered two practice questions before starting with the main part of the experiment. Eighty-seven out of 97 subjects correctly answered both practice questions, and 93 out of 97 subjects correctly answered the second practice question. Each session took about 75 minutes. As in Experiment I, one question per subject was randomly selected for payment, and the subject's earnings were determined by his or her choice for that question. Average earnings (including the initial €21 endowment) were €23, ranging from €2.5 to €41.5. Thus, the setup of Experiment II is very similar to that of Experiment I.

3.3 Hypotheses and results

Within each block of 5 lotteries, the lotteries are the same in all respects except that the outcomes are shifted by a small amount (€0.5). Each lottery has one outcome that is close to zero, the presumed aspiration level. Within each block, this outcome is either −1, −0.5, 0, 0.5, or 1 (see Table 2). For each subject, we compute the change in the certainty equivalent when €0.5 is added to all the outcomes. We denote these four certainty equivalent changes by δ_1, δ_2, δ_3, and δ_4, respectively. Thus, δ_1 is the difference in certainty equivalents between the lottery with outcome −1 and the lottery with outcome −0.5, etc. In case subjects have an aspiration level at zero, we should observe that the values of δ_j are larger when outcomes cross the aspiration level. The increase between the lotteries with shifts −1 and −0.5 (δ_1) should be relatively small because both these outcomes are below the aspiration level. Similarly, the difference in certainty equivalents between the lotteries with shifts 0.5 and 1 (δ_4) should be relatively small because both these outcomes are above the aspiration level. In contrast, δ_2 and δ_3 are expected to be large, as in these cases one outcome crosses the aspiration level. Thus, we devise a measure of the importance of an aspiration level at zero for subject i as the difference between the average δ's involving a shift across 0, and the average of all δ's:

$$\Delta_i = \frac{1}{2}(\delta_2 + \delta_3) - \frac{1}{4}(\delta_1 + \delta_2 + \delta_3 + \delta_4).$$

Δ refers to the average Δ_i across all individuals. A high value of Δ indicates an aspiration level at zero. By contrast, if Δ is approximately zero, then the jump in CE is not higher around zero than at other points, indicating no significant aspiration level at zero.

The 2-outcome lotteries with easy probabilities are very similar to some of the lotteries used in Part 1 of Experiment I. For those lotteries, we do not expect to find evidence of an aspiration level, thereby replicating the results of Experiment I. By contrast, we hypothesize that the aspiration level becomes more important as the lotteries become more complex, either in terms of number of outcomes or difficulty of the probabilities. We therefore formulate the following hypothesis:

> **Hypothesis 4 (H4)**: (i) Δ is zero for the lottery with two outcomes and easy probabilities, (ii) Δ is larger for lotteries with 3 or 5 outcomes than for 2-outcome lotteries, (iii) Δ is larger for lotteries with hard probabilities than for lotteries with easy probabilities.

Our analysis starts by showing the mean certainty equivalents of the lotteries, aggregated over all subjects.[17] Figure 6 groups the lotteries by blocks of positive or negative expected value, and by blocks of easy and hard probabilities. On the horizontal axis we plot the outcomes that are close to zero, varying between −1 and 1. The lines connect the certainty equivalents for all lotteries within a block. For comparison, we also plot the expected value of each lottery (dashed line). If, at the aggregate level, subjects have an aspiration level at zero, we should observe that the lines are steeper around zero than at the extremes. Eyeballing the figures, it does not appear that this is the case for any of the blocks of lotteries, including the more complicated lotteries.[18]

Table 3 reports the values of Δ. These confirm our impressions from Fig. 6. For the 2-outcome lotteries with a positive expected value, Δ is close to zero, not giving any indication of an aspiration level at zero. This is consistent with the results of Experiment I and with part (i) of Hypothesis 4. For the 3-outcome lotteries the value of Δ is somewhat higher, but then it decreases again for the 5-outcome lotteries. For lotteries with a negative expected value, the values of Δ are relatively low for all lotteries with easy probabilities. For lotteries with hard probabilities, we do see a value of Δ that is somewhat higher for the 3-outcome lotteries, but it is again a bit lower for 5-outcome lotteries. A statistical analysis also does not lend support for parts (ii) and (iii) of Hypothesis 4. None of the values of Δ for lotteries with 3 or 5 outcomes are significantly different from the lotteries with 2 outcomes at the 10% level, and Δ is never significantly higher for lotteries with hard probabilities than for easy probabilities (all one-sided t-tests, using subjects as the unit of observation).

4 Discussion

Overall, we do not detect evidence of an aspiration level at zero, even for more complex lotteries.[19] Several factors may explain why our results differ from the existing literature. In this section, we discuss some of these possible explanations.

a. *Large versus small shifts.* Possibly, we reach a different conclusion because we zoom in more precisely on zero compared to other studies. For instance, Payne et al. (1980) also shift lotteries, but the shifts are much more sizable than ours.[20]

[17] Using the medians instead of means gives very similar results.

[18] Note that monotonicity is not violated for the 2-outcome lotteries, but sometimes it is violated for 3- and 5-outcome lotteries. This is not too surprising, given that the increments of the shifts are small (€0.5) and questions were randomized within each block of lotteries.

[19] Independently of us, Zeisberger (2014a, b) has also manipulated complexity. He finds that aspiration levels become more important as the complexity of lotteries increases.

[20] The classical study by Payne et al. (1980) shows that a uniform translation of all outcomes can lead to a dramatic reversal of choices. When subjects are asked to choose between GI′=(55, 0.6; 25, 0.1; −35, 0.3) and GII′=(33, 0.5; 25, 0.3; 5, 0.2), 86 % of them choose GII′. However, when all outcomes are shifted by −50 and subjects are asked to choose between GI″=(5, 0.6; −25, 0.1; −85, 0.3) and GII″=(−17, 0.5; −25, 0.3; −45, 0.2), the results are reversed and 86 % choose GI″ (see their Table 4, p. 1048). This is typically interpreted as evidence for an aspiration level at zero. Indeed this is one possible explanation for the observed reversal of choices. However, notice that an aspiration level anywhere in the range [−17,5] explains the results just as well. Moreover, aspiration levels may be heterogeneous across subjects within this range. A relatively large range for the aspiration level is also obtained in experiments in which subjects are allowed to add a certain amount (e.g. $10) to one of the outcomes. Venkatraman et al. (2014) find that subjects tend to choose to add the amount to the middle outcome of 0, which indicates a possible aspiration level in the range [0, 10].

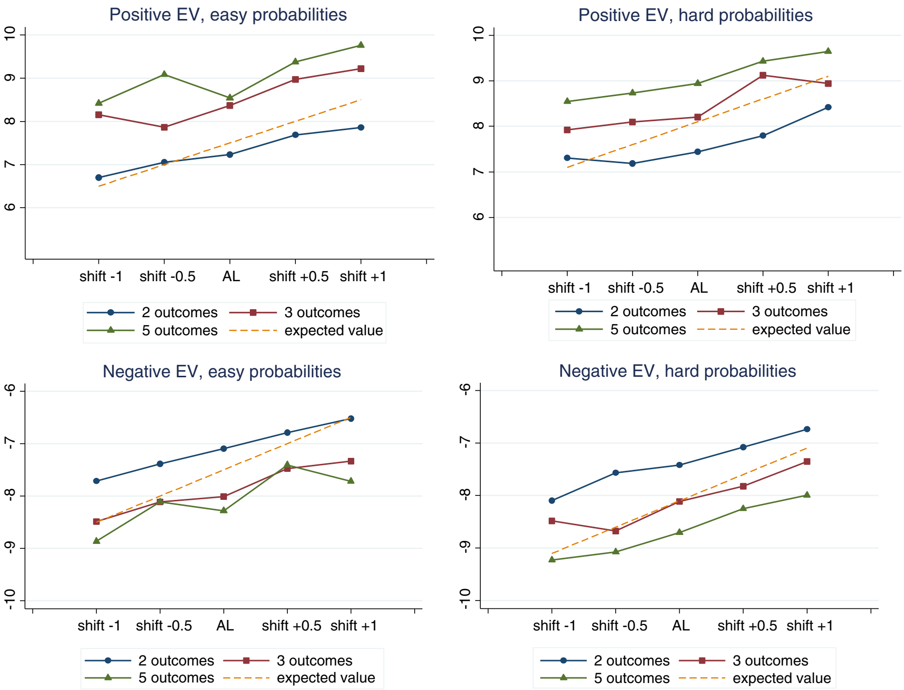


Fig. 6 Mean certainty equivalents and expected values

Perhaps people are heterogeneous in the location of their aspiration level, and it may be at zero for only some people. Indeed, the individual level results reported in the Appendix lend support to the idea of heterogeneous aspiration levels. With a larger shift, it is more likely that lottery outcomes cross the aspiration level.

b. *Risk attitudes and complexity of lotteries.* Another noteworthy aspect of our data is that the number of outcomes of the lotteries appears to affect the risk attitudes of subjects. For the lotteries with a positive expected value, the mean certainty equivalent points to risk aversion (and in some cases risk neutrality) for 2-outcome lotteries, but risk seeking for 3- and 5-outcome lotteries. The pattern for lotteries with a negative expected value is the opposite: risk seeking for 2-outcome lotteries and risk aversion for 3- and 5-outcome lotteries (see Fig. 6). This can potentially explain the difference in findings between our study and that by Zeisberger (2014a, b). Like us, Zeisberger also focuses on outcomes close to zero. He uses lotteries with four outcomes. He finds that subjects tend to prefer a lottery with a higher overall probability of a gain to a lottery that has a higher expected value but a lower overall probability of a gain. He interprets this as evidence of an aspiration level. Alternatively, his use of relatively complex lotteries may have resulted in more risk-seeking behavior, which would also favor the lottery with a lower overall probability of a gain, as that lottery has a higher variance.

c. *Endowments.* We gave subjects an endowment up front. This may have shifted the aspiration level of subjects. However, we also ran a non-incentivized version of Experiment I with large outcomes (see Appendix 2 of the Online Supplementary Materials) without any endowment, and found similar results.

Table 3 Values of Δ

	2-outcome lotteries	3-outcome lotteries	5-outcome lotteries
Positive expected value			
Easy probabilities	0.027	0.285	−0.190
	(0.141)	(0.241)	(0.159)
Hard probabilities	0.028	0.259	0.073
	(0.101)	(0.147)	(0.190)
Negative expected value			
Easy probabilities	−0.001	0.029	0.068
	(0.090)	(0.144)	(0.167)
Hard probabilities	−0.094	0.144	0.103
	(0.119)	(0.120)	(0.122)

Standard errors in parentheses.

d. *Choice set.* In our experiments, subjects answered a series of questions without knowing the full distribution of outcomes over all questions. The range of outcomes may affect the aspiration level. Studies reporting evidence of aspiration levels in financial decision making have first collected the individual value of a target return (aspiration level) and then analyzed data based on this information (Fellner et al. 2009; Hoffmann et al. 2013). It may be that an aspiration level does not emerge until the entire context of outcomes is known by the decision maker.
e. *Time pressure.* Pahlke et al. (2013) put people under time pressure and find evidence consistent with aspiration levels. This may be another form of heuristical decision making that stimulates people to look at aspiration levels.
f. *Reference points.* The evidence from existing studies may be driven by a reference point and loss aversion instead of by the overall probabilities resulting from an aspiration level (Ert and Erev 2011), and disentangling the two effects is complex. Payne (2005), for instance, provides the cleanest evidence in favor of an aspiration level at zero; but although his results are incompatible with the standard parameterization of PT (Tversky and Kahneman 1992), they are consistent with alternative parameterizations of that theory.
g. *Incentives.* Finally, the use of incentives may have induced different results. While participants in our study faced real and substantial incentives, many other studies do not use real incentives, or only use small incentives.

4.1 Unifying Prospect Theory and aspiration levels

We close the discussion section by making a link between Prospect Theory and the Aspiration Level Model. As can be seen from Figs. 2 and 4, the elicited mean and median CEs are close to the PT predictions of Tversky and Kahneman (1992).[21] How

[21] The values of the CEs are based on the parameters and functional forms described in Tversky and Kahneman (1992). We do use a slightly lower value for the loss aversion parameter (λ is set at 1.75 instead of 2.25) to yield a better fit with the data.

can these results be reconciled with the previous findings in the literature supporting the importance of aspiration levels? One possible explanation is that individuals do have aspiration levels, but these levels are not necessarily at zero, and are heterogeneous across subjects. Zeisberger et al. (2012) indeed find considerable heterogeneity in individual behavior. The individual level value function plots are shown in the Appendix. While the individual level data is rather noisy, it does lend some support to this explanation. Eyeballing the individual level data of Part 2 of Experiment I reveals that the choices of about 20% of subjects do exhibit a vertical segment when plotted in this domain; this evidence suggests there is heterogeneity in aspiration levels. It is therefore possible that nonzero aspiration levels play an important role at the individual level. We classified subjects based on the value of the CEs as follows. A subject is considered risk neutral if the CE (normalized to be between 0 and 1) was at most 0.1 away from the expected value in at least 14 out of the 19 questions of Part 2 of Experiment I; a subject is risk averse if at least 14 of the choices had a CE below the expected value. A subject has an aspiration level if there are four or more consecutive choices for which the CE is within a bandwidth of 0.5. In addition, there are subjects with a large number of violations of monotonicity (five or more CE increased by at least 0.15 when the probability decreased) or that are not captured by any of the above classifications. We labeled these subjects as mixed (a more detailed description of the classification procedures can be found in the Appendix). Our classification is, of course, to some extent arbitrary. Eyeballing the individual value functions within each class suggests, however, that the procedure gives reasonable results (see Fig. 8 in the Appendix).

Based on this classification we find that the large majority of subjects is risk neutral (21%) or risk averse (42%). About 20% of the subjects reveal preferences consistent with the aspiration level model, with a jump in their value function. However, the location of the aspiration level differs across subjects. The remaining 17% of subjects are mixed, with no clear pattern emerging from their choices.

It is surprising that such a diversity at the individual level leads to CEs that at the aggregate level are very close to the predictions of PT. We suspect that the aggregate results are generated by individuals with heterogeneous aspiration levels. Figure 7 provides an idea of how this may come about. Consider a population of individuals with a simplified piecewise linear aspiration level value function as in panel A. All individuals have the same type of value function, but each with a different aspiration level. Panel B shows an example of the aggregate value function when the aspiration level is normally distributed in the population with a mean of −0.1 and a standard deviation of 0.1. The aggregate value function conforms to the prospect theory S-shape value function, even though none of the individuals is represented by such an S-shape. This is, of course, a very simplified picture made to convey the basic idea. It is clear that in practice preferences are not all of the same type, which further complicates matters.

5 Conclusion

Aspiration levels are receiving increased attention in the theoretical literature on decision making under risk. The role of aspiration levels in decision making is a natural

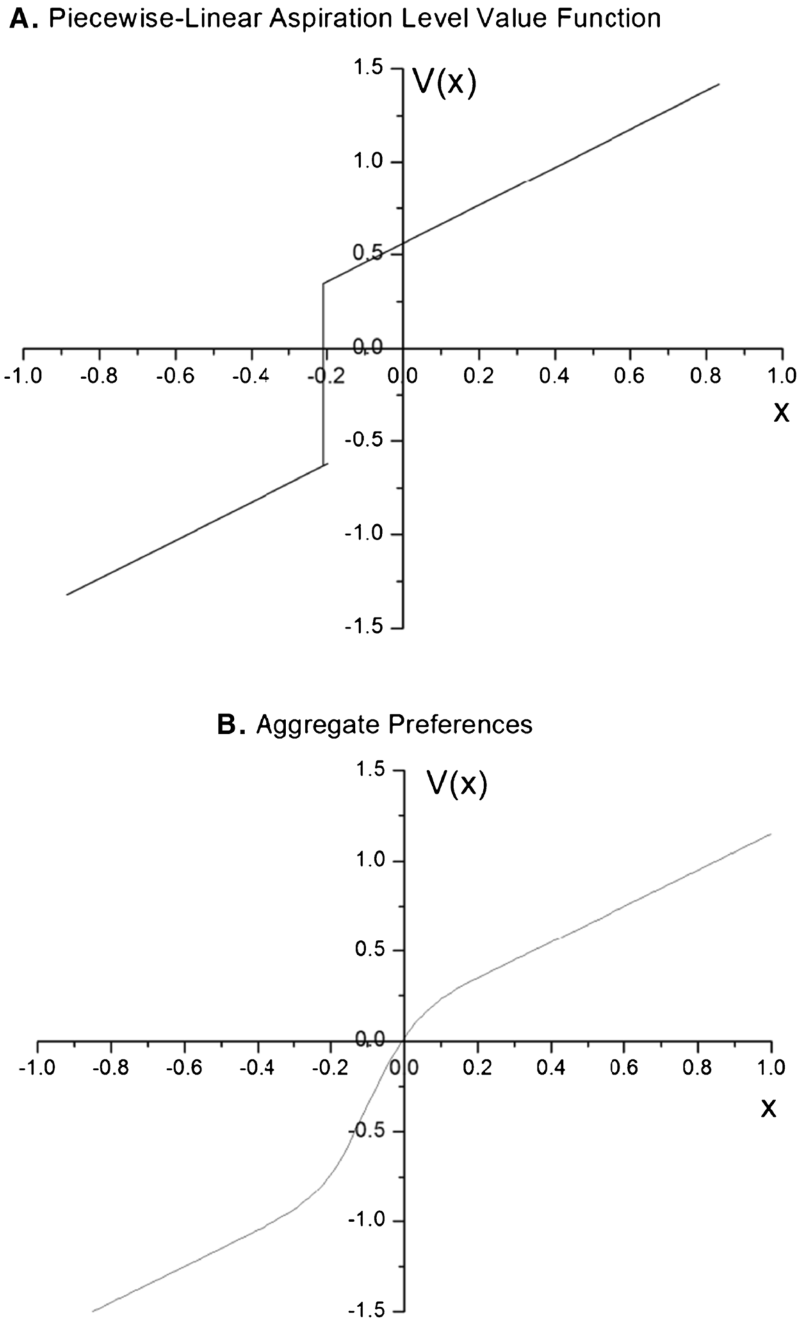


Fig. 7 Aggregate S-shape preferences can arise from heterogeneous aspiration levels. Panel **A**: A piecewise-linear aspiration level value function with an aspiration level at $x=-0.2$. Panel **B**: The aggregate preferences of a heterogeneous population of individuals with value functions as in A, but with the aspiration level distributed normally with mean −0.1 and standard deviation 0.1

and psychologically intuitive one. Models incorporating aspiration levels have been proposed, as an alternative to expected utility and prospect theory, to explain some frequently observed behavior—in particular, risk seeking in the loss domain—with a minimum number of assumptions.

In order to test the main implications of models that assume an aspiration level at zero, we designed two experiments based on the elicitation of CEs for simple 2-outcome lotteries and more complex lotteries. We do not find any support for an aspiration level near zero. It is remarkable that our study, which aimed to assess the effects of an aspiration level at zero, finds no evidence for such an intuitive idea. It is certainly conceivable that nonzero aspiration levels play an important role in decision making, and our evidence suggests that about 20% of the subjects do have an aspiration level, but not necessarily at zero. We suggested that heterogeneous aspiration levels can be consistent with aggregate results conforming to PT.

The evidence presented here challenges the notion of simply assuming an aspiration level at zero, and it opens the way for additional research dedicated to examining other aspiration levels. Several caveats are in place, however. Our findings may be specific to our context. We gave subjects an upfront endowment, which may have shifted their aspiration level away from zero. In our experiment, subjects were not informed about the full distribution of outcomes. Possibly, participants form their aspiration level after knowing what they can win or lose. We also gave participants ample time to make their decisions. Perhaps people use aspiration levels as a heuristic when they do not have the time or cognitive ability to study the situation that they are facing in much detail. We listed several other factors in the previous section which may have led to our results. Moreover, even if there is no *aspiration level* at zero, other processes may make the outcome of zero special, such as a reference point in the form of a kink in the utility function rather than a discontinuity of the utility function.

There is more to be discovered about the circumstances under which aspiration levels play a role. These explorations require that we modify theoretical models of aspiration levels and will thereby advance our understanding of the decision making process.

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Appendix: Classification of subjects

This appendix describes our procedure for classifying subjects. The individual certainty equivalent (CE) for a question is determined as described in the main text. We normalized the certainty equivalent of a subject to (CE-y)/(x-y) and interpret the probabilities of the high outcome as utilities. The first step is to eliminate subjects that show strong violations of monotonicity. A subject is classified as violating monotonicity if on five or more occasions the associated probability decreased by 0.15 or more as the CE increased, or if on three or more occasions the associated probability decreased by 0.30 or more as the CE increased. The second step identified the remaining subjects as risk-neutral if in at least 14 out of the 19 questions the probability was at most 0.10 away from the expected value. The third step identified the remaining subjects as having an aspiration level if there were four (or more) consecutive choices for which the CEs were within a bandwidth of 0.50. The fourth step identified the remaining subjects as risk-averse if in at least 14 out of the 19 questions the CE was below the expected value. All subjects that could not be classified are, together with those that showed violations of monotonicity, grouped as mixed. The resulting classification is shown in the figures below.

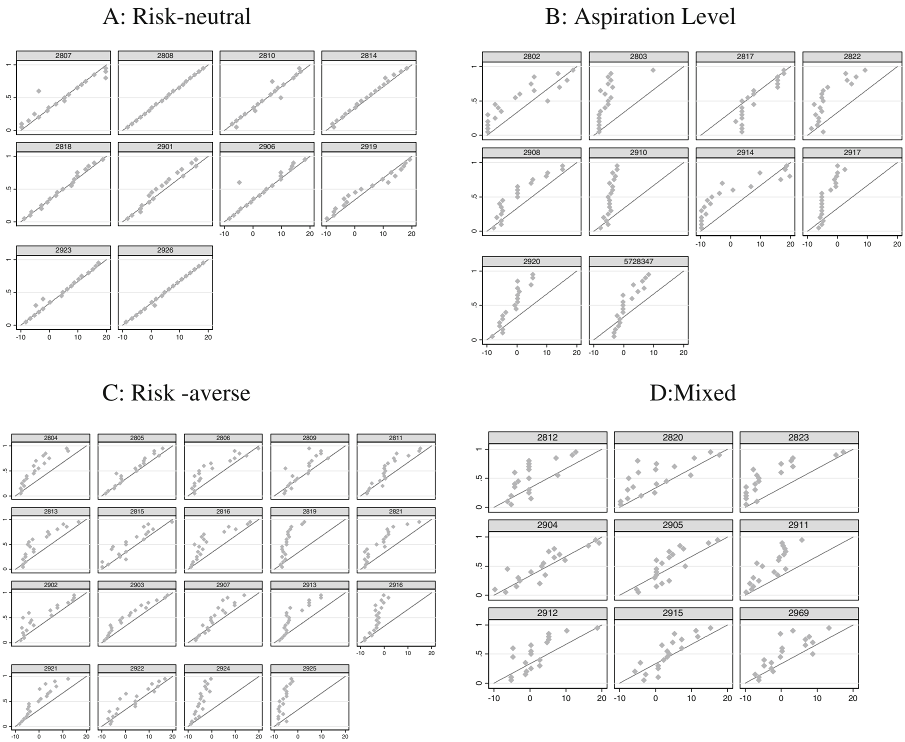

Fig. 8 Classification of risk attitudes and value functions. Certainty equivalents of lotteries in Part 2 of Experiment I are on the horizontal axis and the probability of the high outcome on the vertical axis. The number at the top of each figure indicates the subject number

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