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Abstract: The procedures previously used to determine risk preference (risk-averse, risk-neutral or risk-loving) exhibit a number of weaknesses. In part, they are so complex and sophisticated that the subjects frequently give spontaneous, ill-considered answers. In this way, their actual risk preference can often not be correctly determined. In addition, in this process there are situations and circumstances in which it is not possible to clearly assign subjects to one of the three categories of risk preference. In addition, with the previous approaches, loss aversion - which has an important influence on risk preference - is not taken into consideration, or only insufficiently. We propose here a new procedure to determine risk preference which is (1) extremely simple and clear, which (2) enables unambiguous differentiation between risk-averse, risk-neutral and risk-loving subjects, and which (3) takes the influence of loss aversion on risk preference into account in an appropriate way.

Keywords: risk preference, loss aversion, portfolio choice, diversification behavior, behavioral finance, experimental research

JEL classification codes: B49, C91, G11, G40

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1 Introduction

Markowitz (1952) shows that for risk-averse subjects it usually makes sense to hold diversified securities portfolios. However, there are many empirical findings which reveal that under-diversified portfolios are very frequently held.[1] Experimental economic research examines this contradiction and finds many reasons why suboptimal decisions are frequently made with regard to diversification.[2]

Meaningful experimental results on diversification behavior can normally only be obtained if clarity about the risk preference of the subjects can be achieved: because that which is meaningful for a risk-averse subject can be complete nonsense for a risk-loving subject, and vice-versa. In the meantime there are a whole range of procedures available to determine risk preference.[3]

In our view, a good procedure for determining risk preference must above all comply with three criteria:

1. It must be a simple and clear procedure.
2. It must be possible to clearly and unambiguously differentiate between risk-averse, risk-neutral and risk-loving subjects.
3. The influence of loss aversion on risk preference should not be neglected.

We consider these three criteria to be key. (1) The procedure has to be simple and clear so that we can really record the risk preferences of the subjects. In the case of complex and confusing decision-making situations, subjects frequently lose patience and then give spontaneous, ill-considered answers. This can sometimes lead to a blurring of their risk preference rather than it being revealed. (2) In the previous approaches used, there are certain combinations of circumstances in which risk-neutral, risk-averse and risk-loving subjects make - with good reason - the same decisions. In that case, it is not possible to differentiate between the three forms of risk preference. (3) As we will show later on, risk preference is significantly determined by the possibility of suffering losses. Procedures to measure risk preference which do not contain the possibility of losses systematically underestimate the proportion of risk-averse subjects.

Our study is divided up into four sections. First of all, we evaluate the previous approaches against the background of the three criteria we have postulated. In the following chapter we present our new procedure to measure risk preference. Using an experimental investigation we subsequently show that loss aversion should not be neglected when measuring risk preference. In the final chapter we summarize the most important results of the investigation.

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[1] See, for example Dimmock et al. (2016), Anderson (2013), Hibbert, Lawrence and Prakash (2012), Goetzmann and Kumar (2008), Meulbroek (2005), Polkovnichenko (2005), Huberman and Sengmueller (2004), Agnew, Balduzzi and Sundén (2003), Guiso, Haliassos and Japelli (2002), Benartzi (2001), Benartzi and Thaler (2001), Barber and Odean (2000), Bode, van Echelpoel and Sievi (1994), Blume and Friend (1975), and Lease, Lewellen and Schlarbaum (1974).

[2] See, for example Filiz et al. (2018), Gubaydullina and Spiwoks (2015), Fernandes (2013), Morrin et al. (2012), Rieger (2012), Eyster and Weizsäcker (2011), Baltussen and Post (2011), Kallir and Sonsino (2009), Hedesstrom, Svedsater and Garling (2006), Fellner, Güth und Maciejovsky (2004), Choi, Laibson and Madrian (2009), Weber, Siebenmorgen and Weber (2005).

[3] See, for example, Lönnqvist et al. (2015), Charness, Gneezy and Imas (2013), Crosetto and Filippin (2013), Eckel and Grossmann (2002, 2008), Lejuez et al. (2002), Holt and Laury (2002), and Gneezy and Potters (1997).

2 The previous approaches and their weaknesses

In the following section we discuss the approaches of Holt and Laury (2002), Eckel and Grossman (2008), and Crosetto und Filippin (2013). In addition, we briefly consider the approaches used by Lejuez et al. (2002), Gneezy and Potters (1997), the DOSPERT questionnaire created by Weber, Blais and Betz (2002), and the socio-economic panel (Schupp and Wagner, 2002; Wagner, Burkhauser and Behringer, 1993).

2.1 The multiple price list method of Holt and Laury (2002)

In the multiple price list method of Holt and Laury (2002), subjects are asked to make ten decisions choosing between two lotteries in each case (Table 1). As the first decision, lottery A ($2.00 with a probability of 10% or $1.60 with a probability of 90%) is set against lottery B ($3.85 with a probability of 10% and $0.10 with a probability of 90%). The subject has to decide whether they would play lottery A or lottery B. This is followed by the other nine comparisons between lottery A and lottery B. From the sequence of the ten decisions, conclusions about the risk preferences of the subject are then drawn.

Table 1: The lottery alternatives of Holt and Laury (2002)

	Lottery A				Lottery B			
No.	Prob.	Event	Prob.	Event	Prob.	Event	Prob.	Event
1	10%	$ 2.00	90%	$ 1.60	10%	$ 3.85	90%	$ 0.10
2	20%	$ 2.00	80%	$ 1.60	20%	$ 3.85	80%	$ 0.10
3	30%	$ 2.00	70%	$ 1.60	30%	$ 3.85	70%	$ 0.10
4	40%	$ 2.00	60%	$ 1.60	40%	$ 3.85	60%	$ 0.10
5	50%	$ 2.00	50%	$ 1.60	50%	$ 3.85	50%	$ 0.10
6	60%	$ 2.00	40%	$ 1.60	60%	$ 3.85	40%	$ 0.10
7	70%	$ 2.00	30%	$ 1.60	70%	$ 3.85	30%	$ 0.10
8	80%	$ 2.00	20%	$ 1.60	80%	$ 3.85	20%	$ 0.10
9	90%	$ 2.00	10%	$ 1.60	90%	$ 3.85	10%	$ 0.10
10	100%	$ 2.00	0%	$ 1.60	100%	$ 3.85	0%	$ 0.10

Prob. = probability of occurrence; event = random event

The main problem of this approach is the complexity of the decision-making situation. Neither the expected returns nor the extent of the risk exposure of the alternatives A and B are clearly recognizable for the subjects. Accordingly, many subjects decide randomly or based on a gut feeling. In this situation, it frequently occurs that ten decisions are made where the decision-making process cannot be clearly interpreted. Jacobson and Petrie (2009) as well as Charnes and Viceisza (2011) show that between 55% and 75% of the decision-making processes cannot be clearly interpreted. Charness et al. (2018) and Dave et al. (2010) also point out additional uncertainties in the interpretation of results.

The approach used by Holt and Laury (2002) becomes somewhat clearer if one considers the expected returns and the risk (standard deviation) of the ten lottery alternatives (Table 2). In the first lottery alternative, lottery A has an expected return of \$1.64 and a standard deviation of 0.12. Lottery B has an expected return of \$0.48 and a standard deviation of 1.13. Risk-neutral subjects orientate themselves solely towards expected returns and therefore decide in favor of alternative A. A risk-averse subject will also decide in favor of alternative A, because here the expected returns is higher and at the same time the risk is lower than that of alternative B. But how would a risk-loving subject decide? Expected returns would speak for alternative A, but the risk speaks for alternative B. How a risk-loving subject decides therefore depends on the extent of their appetite for risk. Subjects with a great appetite for risk will choose alternative B because the higher risk more than compensates for the lower expected return. Subjects with a mild appetite for risk will choose alternative A because the higher expected return more than compensates for the lower risk.

Table 2: The expected returns and risk (standard deviation) of the lottery alternatives used by Holt and Laury (2002) and the preferences of risk-neutral, risk-averse and risk-loving subjects

	Lottery A		**Lottery B**		Preference	Preference	Preference
No.	E(A)	SD	E(B)	SD	Risk-neutral	Risk-averse	Risk-loving
1	1.64	0.12	0.48	1.13	A	A	A or B
2	1.68	0.16	0.85	1.50	A	A	A or B
3	1.72	0.18	1.23	1.72	A	A	A or B
4	1.76	0.20	1.60	1.84	A	A	A or B
5	1.80	0.20	1.98	1.88	B	A or B	B
6	1.84	0.20	2.35	1.84	B	A or B	B
7	1.88	0.18	2.73	1.72	B	A or B	B
8	1.92	0.16	3.10	1.50	B	A or B	B
9	1.96	0.12	3.48	1.13	B	A or B	B
10	2,00	0,00	3,85	0,00	B	B	B

E(A) = expected returns of lottery A, E(B) = expected returns of lottery B, SD = standard deviation

In the fifth decision, risk-neutral subjects choose alternative B, because the expected value of \$1.98 is higher than that of alternative A (\$1.80). Risk-loving subjects also choose alternative B because here both expected return and risk are higher than in alternative A. But how will risk-averse subjects react? The expected return would speak for alternative B, but the risk speaks for alternative A. How the subject decides now depends on the extent of their risk aversion. If they are highly risk-averse, they will choose alternative A because the lower risk offsets the lower expected return. If, however, they are only slightly risk-averse, they will decide in favor of alternative B, because the higher expected return more than compensates for the higher risk.

Now the following question arises: How should subjects be classified who always prefer alternative A in the first four decisions and then prefer alternative B in the last six decisions? These can be either risk-neutral, risk-averse or risk-loving subjects (see Table 2). It cannot therefore be guaranteed that they will be unambiguously assigned to one of the three possible categories of risk preference (risk-averse, risk-neutral or risk-loving).

The approach used by Holt and Laury (2002) therefore does not satisfy any of the three requirements which we formulated at the beginning for reliable determining of risk preference: (1) It is complex and unclear. (2) It does not lead to a clear differentiation between risk-neutral, risk-averse and risk-loving subjects. (3) It does not take the possibility of losses into account.

2.2 The approach used by Eckel and Grossman (2008)

The approach used by Eckel and Grossman (2008) has the advantage that the decision-making situation is significantly clearer than in the case of Holt and Laury (2002). The subjects decide in favor of one of five possible lotteries. In each lottery there are two possible events which each have a probability of occurrence of 50%. From lottery 1 to lottery 5, the expected values rise, as do the risks (Table 3, Figure 2).

In the loss treatment the participants receive \$6 for filling in a questionnaire[4] in the run-up to the lottery. They can lose part of this \$6 in lottery 4 and all of it in lottery 5. In order to remunerate all subjects uniformly, the expected values are \$6 higher in the no-loss treatment. The approach used by Eckel and Grossman (2008) thus also takes the possibility of losses into consideration.

Table 3: Lottery alternatives in Eckel and Grossman (2008)

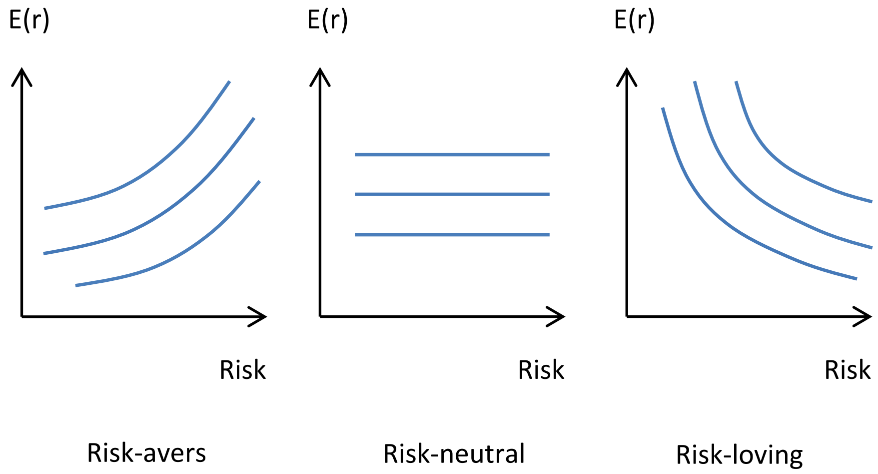
No.	Event	Prob	Return Loss	Return No-loss	E(r) Loss	E(r) No-Loss	Risk SD
1	A	50%	\$ 10	\$ 16	\$ 10	\$ 16	0
	B	50%	\$ 10	\$ 16			
2	A	50%	\$ 18	\$ 24	\$ 12	\$ 18	6
	B	50%	\$ 6	\$ 12			
3	A	50%	\$ 26	\$ 32	\$ 14	\$ 20	12
	B	50%	\$ 2	\$ 8			
4	A	50%	\$ 34	\$ 40	\$ 16	\$ 22	18
	B	50%	\$ -2	\$ 4			
5	A	50%	\$ 42	\$ 48	\$ 18	\$ 24	24
	B	50%	\$ -6	\$ 0			

Event = possible random event, Prob = probability of occurrence, Return Loss = payoff of the coincidental events in the loss treatment, Return No-loss = payoff of the coincidental events in the no-loss treatment, E(r) loss = expected value of the payoff in the loss treatment, E(r) no loss = expected value of the payoff in the no-loss treatment, SD = standard deviation

The approach deployed by Eckel and Grossman (2008) is problematic in that the assignment of the subjects to the three categories of risk preference (risk-averse, risk-neutral and risk-loving) is by no means clear. This becomes apparent when one considers that risk-averse, risk-neutral and risk-loving subjects exhibit fundamentally diverging indifference curves. Risk-averse subjects have rising indifference curves, whereas risk-neutral subjects have absolutely horizontal indifference curves and risk-loving subjects have falling indifference curves (Fig. 1).

[4] Zuckerman's sensation-seeking scale. See Zuckerman (1979, 1994).

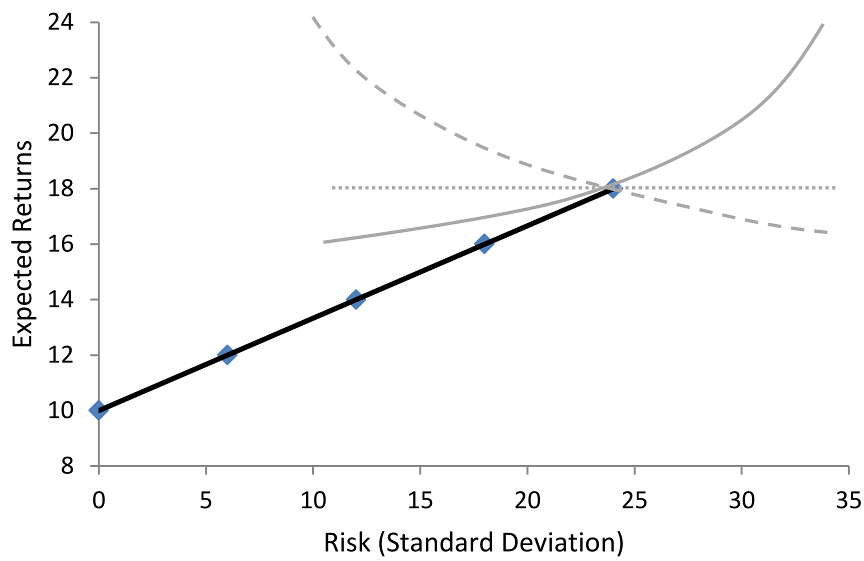
Fig. 1: The form of the indifference curves for risk-averse, risk-neutral and risk-loving subjects



E(r) = expected value of return, risk (standard deviation)

If the space of possibilities which results from the five lotteries is considered, the following becomes recognizable: all of the subjects who choose lottery 5 can be risk-averse as well as risk-neutral or risk-loving (Fig. 2).

Fig. 2: Space of possibilities in Eckel and Grossman (2008) as well as the indifference curves of a risk-averse (unbroken grey line), a risk-neutral (dotted grey line) and a risk-loving subject (dashed grey line)

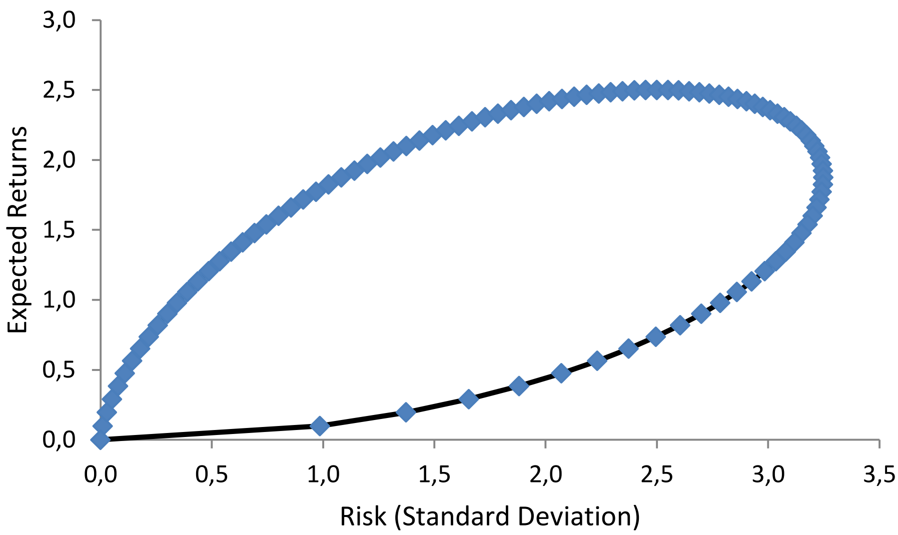


The approach used by Eckel and Grossman (2008) thus manages to fulfill two of the three criteria we have put forward: it is a simple and clear decision-making situation and the possibility of making losses is also taken into account. However, the unambiguous identification of risk-neutral, risk-averse and risk-loving subjects is not possible.

2.3 The approach used by Crosetto and Filippin (2013)

Crosetto and Filippin (2013) have proposed the most interesting approach yet to determine risk preferences. In this approach, the participants are faced with the following decision-making situation: they have to decide how many of a total of 100 boxes they want to collect. One of the boxes contains a 'bomb'. The participants receive a payoff of €0.10 per box. After they have decided on a number of boxes (static version) or have ended the game by pressing the 'stop button' (dynamic version),[5] a number between 1 and 100 is drawn from an urn. If the number drawn is ≤ the number of collected boxes, the 'bomb' has exploded and the money is gone. If the number drawn is higher than the number of collected boxes, the subject receives a payment based on the multiplication of the number of boxes collected by €0.10. It can be expected that the subjects want to win as much money as possible. The more boxes they collect, the higher the payoff. At the same time, the risk of encountering the 'bomb' (number drawn ≤ the number of collected boxes) rises. The subjects thus have to weigh up how much risk is meaningful to them. The space of possibilities of this decision-making situation is shown in Fig. 3.

Fig. 3: Space of possibilities in Crosetto and Filippin (2013)



From the first to the 50th box, expected returns rises gradually. At the same time the risk also increases steadily. From the 50th to the 75th boxes, the risk continues to rise, whereas expected returns falls. From the 75th to the 100th boxes, the risk as well as expected returns both decrease. The highest expected return is achieved if one collects exactly 50 boxes. Risk-averse subjects will -

[5] Crosetto and Filippin deployed a static basic variation and a dynamic variant. In the static variant the subjects only see a picture of 100 boxes and have to decide how many they want to collect. In the dynamic PC version the 100 boxes are shown on the screen. By pressing a start button the participants trigger the collection of one box per second until they press the stop button.

depending on their risk aversion - choose between one and 50 boxes. Risk-loving subjects will choose between 50 and 75 boxes. Risk-neutral subjects will always collect exactly 50 boxes, because expected return reaches its maximum level there. The efficient frontier of the space of possibility thus extends from one to 75 boxes. The section from 76 to 100 boxes, however, is the non-efficient part of the space of possibility.

The great advantage of this approach is the enormous clarity of the decision-making situation. In addition, loss opportunities can also be implemented easily, which Crosetto and Filippin (2013) in fact do in one of the treatments.

Nevertheless, some criticism can be made: (1) If a subject collects exactly 50 boxes it is not possible to recognize whether they are risk-averse, risk-neutral or risk-loving. While it is true that all risk-neutral subjects will collect exactly 50 boxes, one cannot conclude that *all* subjects who collect 50 boxes are risk-neutral. In view of the maximum expected return, slightly risk-averse or slightly risk-loving subjects could also consider 50 boxes to be the most attractive option.[6] (2) The decision-making situation is indeed very clear, but it is not simple. How many subjects recognize that the maximum expected return can be found at exactly 50 boxes? And how many subjects realize what the risk (standard deviation) is for the 100 different possibilities? A considerable amount of calculating is required to work that out. (3) How should subjects who collect more than 75 boxes be characterized? Those persons who move in the non-efficient part of the space of possibilities are also either risk-averse, risk-neutral or risk-loving. There is no other possibility. However, which of these three alternatives they fit into cannot be said, because each subject who collects more than 75 boxes is obviously not aware of the shape of the space of possibilities.

The three requirements we have put forward for a good process to determine risk preference are not completely fulfilled here. The decision-making situation is clear, but it is not exactly simple. It is not possible in every case to unambiguously assign subjects to one of the three categories of risk preference (risk-averse, risk-neutral and risk-loving). On the positive side, introducing a risk of loss is simple, which Crosetto and Filippin (2013) in fact do in one of the treatments.

2.4. Further approaches

The method used by Lejuez et al. (2002) aims to create a relative comparison of risk preference between two or more subjects. However, his aim is not to assign them to one of the three categories of risk preference (risk-averse, risk-neutral and risk-loving). The decision-making situation is designed as follows: a balloon and a pump are shown on a computer screen. With every click of a mouse, the balloon is pumped up a bit more and the participant receives €0.05. Their credit is shown on a temporary account. The subject can stop pumping at any time. If the balloon bursts, the credit accumulated is lost. A total of 90 rounds of the game are played, in which there are three different colored balloons (blue, yellow and orange). The three colors represent different probabilities of bursting. The subjects are only informed that the three different-colored balloons have a different bursting point, and that the balloon can even burst on the first pump. The average number of pumps

[6] Around 14% of the subjects decide to collect exactly 50 boxes. This means that a notable proportion of the subjects cannot be assigned unambiguously to one of the three categories (risk-averse, risk-neutral and risk-loving).

made is used as an indicator for risk preference. As no advance information is provided about expected returns and risk, this method is not suitable for assigning subjects to one of the three categories of risk preference: only a relative comparison between subjects can take place. For example, it can be established that subject A acts more cautiously than subject B. However, whether subject A is risk-averse and subject B is risk-loving remains unclear. Subject A could be strongly risk-averse and subject B could be slightly risk-averse. Or subject A is slightly risk-loving and subject B is highly risk-loving. This remains unclear.

The method used by Gneezy and Potters (1997) examines which proportion of their portfolio subjects invest in a risky asset. To do so, they are asked which proportion of 200 cents they want to bet on a lottery in which there is a probability of two thirds that they will lose the amount and a probability of one third that they will win two and a half times the amount. So if they win they retain the amount they wager plus two and a half times the amount as winnings. The lottery thus has a positive expected value. A total of nine rounds are played. In treatment H, the participants decide separately for each round which proportion of the 200 cents they want to bet. In treatment L, decisions are made in advance for each of three rounds of the game. The amount which is wagered thus remains constant for three rounds. Depending on the treatment, the participants are informed about the (aggregated) results after one or three lotteries and then they bet again. It is shown that the average amount placed as a bet in treatment L (decision in advance) is greater than in treatment H (separate decision for each round). The results reveal that an investment period spread over several periods leads to a larger proportion of the investor's assets being invested in a risky asset. In an adapted form, Charness and Gneezy (2010) established that the participants of the experiment would pay in order to have more frequent opportunities to change the composition of their portfolio. However, the structure of the experiment is not suited to assigning the subjects to one of the three categories of risk preference (risk-averse, risk-neutral and risk-loving). Once again, the approach can only be used to establish that subject A acts more cautiously than subject B. The same issue arises as in the case of Lejuez et al. (2002).

Another way of determining individual risk preference is to interview the subjects. A good example of this is the domain-specific risk taking questionnaire (DOSPERT) developed by Weber, Blais and Betz (2002). The questionnaire relates to a large number of high-risk activities or behaviors from five fields: (1) sports and leisure, (2) health, (3) social issues, (4) ethics, and (5) finances. The questionnaire records the probability of the respondents taking risks, their perception of these risks and of the benefit which might result from the risks taken. A total of 40 topics are evenly distributed over five fields, whereby only the field of finance is subdivided into (a) gambling and (b) investment risks. The participants estimate their own risk preference on a scale from 1 (low risk) to 5 (high risk). Assignation to one of the three categories of risk preference (risk-averse, risk-neutral and risk-loving) is not possible on the basis of this questionnaire. Once again, this approach can only be used to establish that subject A acts more cautiously than subject B. The same issues arise as in the case of Lejuez et al. (2002).

Another example of surveying risk preference within the framework of a questionnaire is the socio-economic panel (SOEP). Schupp and Wagner (2002) as well as Wagner, Burkhauser and Behringer (1993) describe the approach used in the questionnaire. The idea is that the interviewees provide information about their general risk preferences. Assignation to one of the three categories of risk preference (risk-averse, risk-neutral and risk-loving) is not possible on the basis of this questionnaire. The same applies to the differentiated versions of the SOEP approach (Schupp and Wagner, 2002;

Wagner, Burkhauser and Behringer, 1993). These approaches can only be used to establish that subject A acts more cautiously than subject B. The same issues arise as in the case of Lejuez et al. (2002).

Lönnqvist et al. (2015) examine the time stability of various procedures for the measurement of risk preferences, while Charness, Gneezy and Imas (2013) compare different procedures for the measurement of risk preferences. However, they do not provide a different approach for the identification of risk-neutral, risk-averse and risk-loving subjects.

3 The new approach

We propose a procedure for differentiating between risk-averse, risk-neutral and risk-loving subjects which is very clear and simple and which makes it possible to assign subjects unambiguously to the three categories of risk preference.

It deals with a decision to choose between two lotteries.[7] The subjects take a card - they can choose between taking a card from pile A or one from pile B. Both piles consist of four playing cards each. In pile A there are two cards which lead to a profit of €+4, and two cards which lead to a profit of €+6 (Fig. 4). In pile B there are two cards which lead to no profit €±0, and two cards which lead to a profit of €+10 (Fig. 5).

Fig. 4: The four cards in pile A

Fig. 5: The four cards in pile B

[7] We were inspired by Bechara et al. (1994) here.

The subjects are informed that the expected return in both piles is identical at €+5. In addition, the subjects are made aware of the fact that pile A leads to results which fluctuate slightly around the expected value (low risk), while pile B leads to results which fluctuate considerably around the expected value (high risk). The two piles of cards containing four cards each are not only shown on the screen, but can also be seen as real playing cards on the table of the game leader. The subjects are informed that the pile of cards which they decide for (A or B) will be shuffled and that they then have to take a card. The entire survey is programmed in z-tree (Fischbacher, 2007). However, we have decided not to program random events in z-tree, but to carry them out analogously. In this way we want to counteract the possible suspicion that it could be a manipulated random event. The subjects see the playing cards and can be sure that there is a probability of exactly 50% that the favorable event (€+6 in pile A and €+10 in pile B) will occur. In addition, they can also be sure that there is a probability of exactly 50% that the unfavorable event (€+4 in pile A and €±0 in pile B) will occur (Table 4).

Table 4: Lottery alternatives in the new approach

Pile	Prob	Return	E(r)	Risk (SD)
A	50% 50%	€+4 €+6	€+5	1.0
B	50% 50%	€±0 €+10	€+5	5.0

Prob = probability, E(r) = expected value of the return, SD = standard deviation

The shuffling of the cards is left to a machine in order to avoid the suspicion that the game leader has an influence on random events. After the cards have been shuffled, the subjects have to take one of the four cards from the pile they have chosen. They then receive the payment which is noted on this card. Test questions are used to ensure that the subjects understand the circumstances. The instructions for the game, the test questions and selected screenshots can be viewed in the appendix.

The two lotteries lead to a clear space of possibilities (Fig. 6) which also permits an unambiguous assignment of the subjects to the three categories of risk preference (risk-averse, risk-neutral and risk-loving).

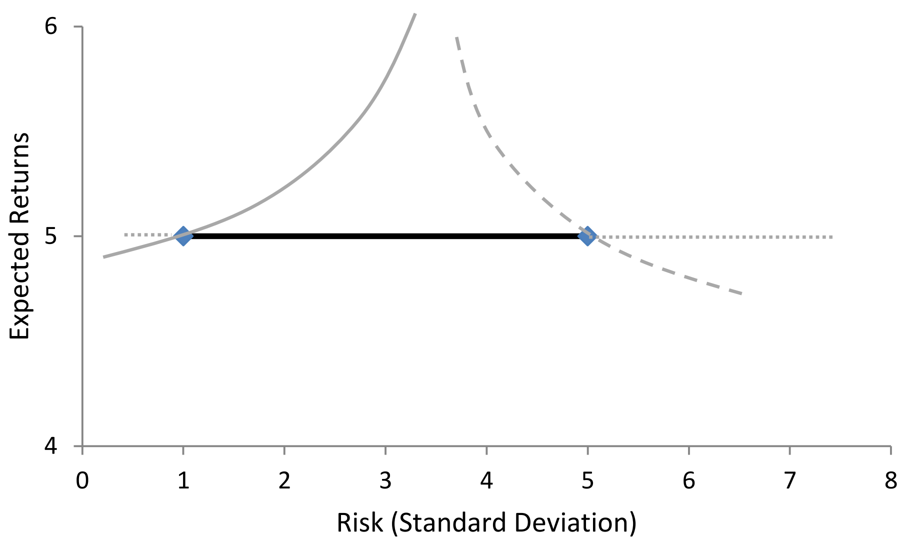
The space of opportunities consists of only two points. The left point shows the expected return and risk profile of pile A (low risk). The right point shows the expected return and risk profile of pile B (high risk).

The decision options for the subjects are:

- I would like to take a card from pile A.
- I would like to take a card from pile B.
- I would like to take a card. I don't mind which pile I take one from.

If one takes into account the form of the indifference curves for risk-averse, risk-neutral and risk-loving subjects (Fig. 1), the decision made by the subjects leads to an unambiguous assignment to one of the three categories of risk preference: Risk-averse subjects prefer pile A. Risk-loving subjects prefer pile B. Risk-neutral subjects are indifferent as to whether they choose pile A or B (Fig. 6).

Fig. 6: Space of possibilities of the new approach as well as the indifference curves of a risk-averse (unbroken grey line), a risk-neutral (dotted grey line) and a risk-loving subject (dashed grey line)



In this way, two out of the three criteria for a suitable procedure to record the risk preference of the test persons are fulfilled: (1) The decision-making situation is very clear and simple. The subjects know precisely which consequences their decision will have. They do not have to decide on the basis of a gut feeling, but can make well thought-out, conscious decisions corresponding to their preferences. (2) The three alternatives (pile A, pile B or indifference as to whether the card is from A or B) permit unambiguous conclusions about the three categories of risk preference (risk-averse, risk-neutral and risk-loving). In the following chapter we will also take the influence of loss aversion on risk preference into account.

4 Taking loss aversion into account in the new approach

There is hardly another phenomenon in behavioral economics which has been the subject of as much research as loss aversion (for a comprehensive overview see, for example, Kahneman 2011, Chapter 29; see also Rabin 2000; Fehr and Goette 2007; Tom et al., 2007). Frequently, subjects are strongly influenced in their actions by the effort to avoid losses. One would expect that risk preference would also be influenced by the possibility of the threat of losses. However, this presumption has not yet been confirmed. Eckel and Grossman (2008) and Crosetto and Filippin (2013) have both included treatments with the possibility of losses. In spite of this, notable effects on the risk preferences of the subjects could not be observed in either study.

Mukherjee et al. (2017) showed that in the case of small amounts up to $4, a profit had a greater positive influence on the well-being of the participants than an equally high loss had in negative terms. Here, an evaluation scale ranging from 0 (= no effect) to 5 (= very strong effect) was used. In the case of an amount of $25, however, the negative perception of a loss was more intense than the positive feeling of an equally large profit. These results indicate that loss aversion might only have an influence on risk preference when larger amounts are involved. In Eckel and Grossman (2008), losses between $-2 and $-6 can occur. And in Crosetto and Filippin (2013), losses of €-2.50 can occur.

We will now carry out the new approach to establish risk preference in three variations in order to investigate the influence of loss aversion on risk preference in more detail. In treatment 1, there is no possibility of making a loss. In treatment 2, a loss of €-2.50 can be made. In treatment 3, a loss of €-25 can be made (Table 5).

Table 5: Random events, expected values and standard deviations in treatments 1-3

Treatment	Pile	Prob.	Return	E(r)	SD
1	A	50%	€+4	€+5	1.0
		50%	€+6		
	B	50%	€±0	€+5	5.0
		50%	€+10		
2	A	50%	€+4	€+5	1.0
		50%	€+6		
	B	50%	-2.5	€+5	7.5
		50%	€+12.5		
3	A	50%	€+4	€+5	1.0
		50%	€+6		
	B	50%	€-25	€+5	30
		50%	€+35		

Prob. = probability, E(r) = expected value of the return, SD = standard deviation

The results obtained by Mukherjee et al. (2017), Eckel and Grossman (2008) and Crosetto and Filippin (2013) lead us to expect that there will be no significant differences between treatment 1 and treatment 2. The possible losses of €-2.50 are presumably too small to have an influence on the risk preferences of the subjects. The first hypothesis is therefore as follows:

<u>Hypothesis 1:</u> in treatment 2, not more (less) subjects will prove to be risk-averse (risk-loving) than in treatment 1.

The first null hypothesis which will have to be examined is therefore:

<u>Null hypothesis 1:</u> in treatment 2, significantly more (less) subjects will prove to be risk-averse (risk-loving) than in treatment 1.

The results of Mukherjee et al. (2017), however, give reason to presume that the danger of losses of €-25 can have an influence on the risk preferences of the subjects. The second hypothesis is therefore as follows:

Hypothesis 2: in treatment 3, more (less) subjects will prove to be risk-averse (risk-loving) than in treatment 1.

The second null hypothesis to be examined is therefore:

Null hypothesis 2: in treatment 3, not more (less) subjects will prove to be risk-averse (risk-loving) than in treatment 1.

If the presumption is correct that the possibility of a small loss does not really impress subjects, whereas that of a larger loss has a significant influence on risk preferences, it must also be possible to establish a difference between treatment 2 and treatment 3. Our third hypothesis is therefore as follows:

Hypothesis 3: in treatment 3, more (less) subjects will prove to be risk-averse (risk-loving) than in treatment 2.

The third null hypothesis which will have to be examined is therefore:

Null hypothesis 3: in treatment 3, not more (less) subjects will prove to be risk-averse (risk-loving) than in treatment 2.

In our experiment we conduct a between-subjects comparison. A total of 157 students of the Ostfalia University of Applied Sciences in Wolfsburg took part in the experiment. 53 subjects played treatment 1, 52 subjects played treatment 2, and 52 subjects played treatment 3. 53 women (33.76%) and 104 men (66.24%) took part. 72 of the subjects study business management (45.86%), 69 subjects study vehicle construction (43.95%) and 16 students study health care (10.19%). The experiment was carried out from 4-10 April 2018 in the Ostfalia Laboratory for Experimental Economic Research (OLEW) in Wolfsburg in Germany. The experiment is programmed in z-tree. Only the playout of random events is carried out in an analogue way by taking a card from the respective selected pile.[8]

The actual experiment is preceded by a real effort task. We give the subjects a task which is not enjoyable and which requires a considerable amount of time. The subjects are supposed to view the task as work which is paid for with an appropriate amount (€25). The subjects have to encode a total of 175 three-letter words in sequences of numbers. When they have encoded a word correctly, the next word appears. This real effort task is based on Erkal, Gangadharan and Nikiforakis (2011). In order to make it more demanding, Benndorf, Rau and Solch (2014) change the assignment of numbers to letters for every word. We used this approach.

In addition, we consider it to be important that payment for the real effort task made is in cash and is carried out directly afterwards and before the actual experiment (the selection of one of the two lotteries). Willingness to spend is noticeably reduced if payment is made in cash in comparison to credit or debit cards (see, for example, Prelic and Semester, 2001; Runnemark et al., 2015). It has also been shown that impulsive purchase behavior is restricted when a person is handling cash (see, for example, Thomas, Kaushik and Seenivasan, 2011). From this we conclude that immediate cash payment after the real effort task leads to the subjects perceiving the amount as their own hard-

[8] We also chose this path in order to obtain maximum credibility with regard to an uninfluenced random process (see also Chapter 3).

earned money. In this way, the so-called house money effect[9] is probably avoided or at least considerably reduced.

We pay the subjects a show-up fee of €2. For the coding work (real effort task) the subjects earn €25, for which they require between 35 and 60 minutes. In the actual experiment the subjects earn an average of €5.56. Overall the subjects thus earn an average of €32.56. Reading the instructions for the game, answering the test questions, carrying out the coding work, deciding between piles A and B and taking a card take up between 60 and 90 Minutes. The payment they receive is therefore at an appropriate, average level. The subjects gave the impression of being very attentive and motivated.

The results were clear and are largely in line with our expectations (Table 6). In treatment 1 (no possibility of loss), only 21 out of 53 subjects (39.62%) chose the low-risk variation (pile A). 28 subjects (52.83%) chose the risky variant (pile B). Four subjects (7.55%) were indifferent to whether they chose a card from pile A or B. In treatment 2 (possibility of a small loss), 25 out of 52 subjects (48.08%) chose the low-risk variation (pile A). 24 subjects (46.15%) chose the risky variant (pile B). Three subjects (5.77%) were indifferent to whether they chose a card from pile A or B. In treatment 2, the low-risk pile A was chosen more often and the risky pile B was chosen less frequently than in treatment 1. However, Pearson's chi squared test showed this difference to be insignificant, with a p-value of 0.418 (Table 7). The null hypothesis 1 therefore has to be rejected. This confirmed our presumption (hypothesis 1) that a possibility of a small loss of €-2.50 does not have any significant influence on the risk preferences of the subjects. This result is in line with the findings of Crosetto and Filippin (2013) and those of Eckel and Grossman (2008).

Table 6: Results of the selection decision according to treatments

Treat-ment	Pile A	Pile B	Decision for pile A number	Decision for pile B number	Indifferent number	Decision for pile A in %	Decision for pile B in %	Indif-ferent in %
1	€+4/€+6	€±0/€+10	21	28	4	39.62%	52.83%	7.55%
2	€+4/€+6	€-2.5/€+12.5	25	24	3	48.08%	46.15%	5.77%
3	€+4/€+6	€-25/€+35	36	11	5	69.23%	21.15%	9.62%

Table 7: Results of Pearson's chi squared test

Comparison	p-value
Treatment 1 (no possibility of loss) versus treatment 2 (possibility of a small loss)	0.418
Treatment 1 (no possibility of loss) versus Treatment 3 (possibility of significant loss)	0.001
Treatment 2 (low possibility of loss) versus Treatment 3 (possibility of significant loss)	0.009

[9] Thaler and Johnson (1990) showed that subjects take more risks when they have previously made a profit or if start-up capital is made available to them. This applies as long as their earlier profit or start-up capital have not been used up, and they are playing with 'house money', as it were.

In treatment 3, however (possibility of a significant loss) a marked influence on risk preferences can be noted. Here, 36 out of 52 subjects (69.23%) chose the low-risk variation (pile A). Only eleven subjects (21.15%) chose the risky variant (pile B). Five subjects (9.62%) were indifferent to whether they chose a card from pile A or B. This is a marked difference in comparison to treatment 1 (no possibility of loss). Pearson's chi squared test also shows this difference with a p-value of 0.001 (Table 7). Null hypothesis 2 clearly has to be rejected. Our presumption that the possibility of a higher loss (€-25) leads more often to risk-averse behavior (hypothesis 2) is thus confirmed.

The comparison between treatment 2 (risk of a small loss) and treatment 3 (risk of high loss) also reveals considerable differences. Pearson's chi squared test shows this difference with a p-value of 0.009 (Table 7). It is therefore clear that null hypothesis 3 also has to be rejected. Our presumption that a risk of a high loss influences the risk preference of subject considerably more than a risk of a low loss (hypothesis 3) is thus confirmed. Crosetto and Filippin (2013) had already expressed the presumption that a probability of a high loss would have an effect on the measurement of risk preferences. Our results entirely confirm this presumption.

Overall, it can be stated that taking a probability of a substantial loss into account leads to a more realistic recording of the three categories of risk preference (risk-averse, risk-neutral und risk-loving).

5 Summary

Experimental research on diversification behavior requires a clear differentiation between risk-averse, risk-neutral and risk-loving subjects, because decisions which can be absolutely meaningful for a risk-loving subject are completely inconceivable for a risk-averse subject and vice versa. Robust findings in experimental research on diversification can only be obtained if it is known how to categorize the risk preferences of the subject. Differentiating between risk-neutral, risk-averse and risk-loving subjects is, however, a demanding task. The approach used by Holt and Laury (2002) has undoubtedly received the most attention. We have also used this procedure on several occasions (see, for example Filiz et al., 2018; Gubaydullina and Spiwoks 2015). However, we also had the impression that not all subjects dedicate themselves to the task with the necessary concentration, and in view of its complexity ultimately make spontaneous decisions which are not well-thought out (for similar observations see Jacobson and Petrie, 2009; Charmes and Viceisza, 2011).

The approach used by Eckel and Grossman (2008) is significantly simpler and clearer, and that deployed by Crosetto and Filippin (2013) even more so. However, all three procedures exhibit the weakness that in certain situations it is not possible to differentiate in an unambiguous and reliable way between risk-averse, risk-neutral and risk-loving subjects. In addition, in these three approaches the influence of loss aversion on risk preference is not taken into consideration, or not sufficiently.

In the form of our treatment 3 (probability of a substantial loss) we are proposing a new approach to discriminate between risk-averse, risk-neutral and risk-loving subjects which is (1) extremely simple and clear, and which (2) permits the clear assignment of subjects to the three categories of risk preference, and (3) takes the influence of loss aversion on risk preference into account in an appropriate way.

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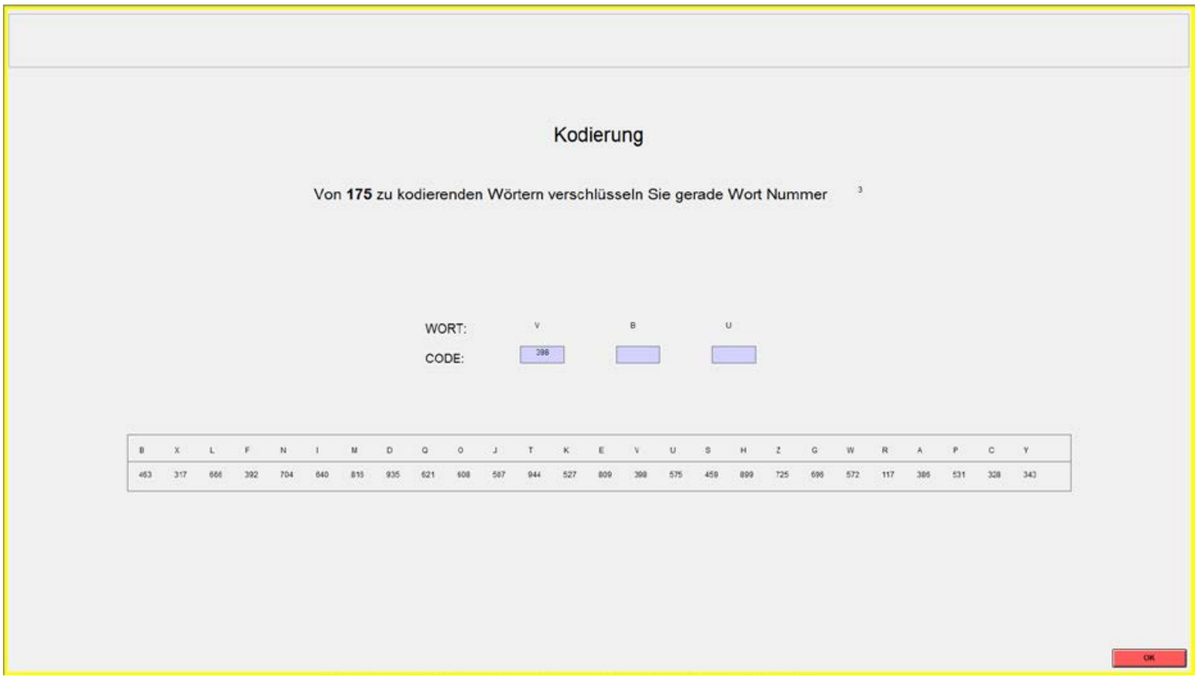
Appendix: Instructions for the game, test questions and selected screenshots

<u>The task</u>

In this game, you can earn money by completing a task. The task consists of **coding 175 words** into numbers. For every correctly coded word you receive credit of **14 cents.** In total you can earn up to **€25**. In the task, **three upper case letters** correspond to one word. Every upper-case letter must be assigned to a number. The coding for this can be found in the table below. Please take a look at the photo on the screen:



In this example, the participant has already coded two words correctly. Now the three upper case letters have to be coded: **V, B and U**. The solution is provided in the table:

- V is 398 (see the number entered above by the participant)
- B is 463
- U is 575.

To enter please click on the blue box below the first upper-case letter.

When all three figures have been entered please click on OK with the mouse.

The computer then checks whether **<u>ALL</u>** upper-case letters have been correctly coded into figures, i.e. whether all three figures were entered correctly. Only then is the word considered to be correct. If the wrong number is entered, the computer points this out (in red letters) after pressing the OK button. The current word remains on the screen until the correct number is entered. However, your previous entries (in the three fields under the upper-case letters) are all deleted. The table remains the same, i.e. the numbers assigned to the letters remain identical. In the same way, the position of the upper-case letters in the table does not change.

When the correct number is entered you receive the next randomly drawn word (again consisting of three upper-case letters). The table continues to be randomly 're-shuffled': new three-digit figures are randomly selected and entered into the table as new mappings for the upper-case letters. The position of the upper-case letters in the table is randomly rearranged. Please note that all 26 upper-case letters of the German alphabet are used.

Following on from this task you will take part in a lottery. You will be given detailed information about the lottery when the time comes.

Payment

- Basic payment of **€2**
- For every correctly coded word you receive credit of **14 cents**. In total you can earn up to **€25** (175 x 14.2857 cents).
- The money you might win in the lottery is added to this.

Important information

- Please remain quiet during the game
- Do not look at your neighbour’s screen
- No aids are permitted (calculators, smartphones etc.) All electronic devices must be switched off.

Test questions (treatment 1)

Test question 1: How much is the minimum and maximum payment when you choose pile A?

a. The minimum payment is €+6 and the maximum payment is €+35
b. The minimum payment is €+4 and the maximum payment is €+6 (correct)
c. The minimum payment is €+4 and the maximum payment is €+35

Test question 2: How much is the minimum and maximum payment when you choose pile B?

a. The minimum payment is €±0 and the maximum payment is €+35
b. The minimum payment is €+4 and the maximum payment is €+10
c. The minimum payment is €±0 and the maximum payment is €+10 (correct)

Test question 3: How many different piles of cards are there?

a. 1
b. 2 (correct)
c. 3

Test question 4: How high is the probability of occurrence of the best and worst possible results in the lottery?

a. 100%
b. 0%
c. 50% (correct)

Screenshot 1: real effort task (reconstructed in order to improve readability)

Coding

Out of **175** words to be coded you are currently encoding word number **1**

Word:	**Y**	**E**	**S**
Code:			

T	C	Y	R	K	Q	V	Z	N	X	D	A	M	U	S	P	W	G	J	B	F	I	Q	H	L	E
735	105	494	343	737	691	825	865	771	587	204	606	362	769	155	345	287	288	165	977	208	200	177	291	791	660

O.K.

Screenshot 2: instructions and test questions on the lottery in treatment 1 (reconstructed in order to improve readability)

<u>Lottery</u>

You can now take a card as part of a lottery. There are two piles of cards to choose from (pile A and pile B). The cards are drawn by hand.

There are four cards in pile A. Two cards lead to a payment of **€+4** and two cards lead to a payment of **€+6**

There are four cards in pile B. Two cards lead to a payment of **€±0** and two cards lead to a payment of **€+10**

Pile A
(consists of four cards)

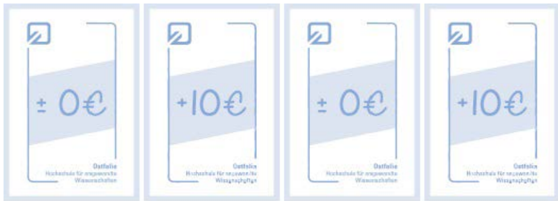
Best possible event: €+6 (Probability: 50%)

Worst possible event: €+4 (Probability: 50%)

Expected value: €+5

Low risk (results fluctuate slightly around the expected value)

Pile B
(consists of four cards)



Best possible event: €+10 (Probability: 50%)

Worst possible event: €±0 (Probability: 50%)

Expected value: €+5

High risk (results fluctuate considerably around the expected value)

Please answer the following test questions about the lottery:

Test question 1: How much is the minimum and maximum payment when you choose pile A?

O The minimum payment is €+6 and the maximum payment is €+35

O The minimum payment is €+4 and the maximum payment is €+6

O The minimum payment is €+4 and the maximum payment is €+35

Test question 2: How much is the minimum and maximum payment when you choose pile B?

ʘ The minimum payment is €+/-0 and the maximum payment is €+35

ʘ The minimum payment is €+4 and the maximum payment is €+10

ʘ The minimum payment is €+/-0 and the maximum payment is €+10

Test question 3: How many different piles of cards are there?

ʘ 1

ʘ 2

ʘ 3

Test question 4: How high is the probability of occurrence of the best and worst possible results in the lottery?

ʘ 100%

ʘ 0%

ʘ 50%

O.K.

Screenshot 3: decision-making options on the lottery in treatment 1 (reconstructed in order to improve readability)

<u>Lottery</u>

You can now take a card as part of a lottery. There are two piles of cards to choose from (pile A and pile B). The cards are drawn by hand.

There are four cards in pile A. Two cards lead to a payment of **€+4** and two cards lead to a payment of **€+6**

There are four cards in pile B. Two cards lead to a payment of **€±0** and two cards lead to a payment of **€+10**.

Pile A

(consists of four cards)

Best possible event: €+6 (Probability: 50%)

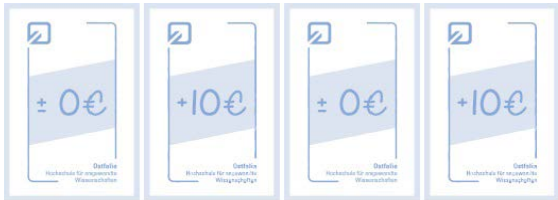
Worst possible event: €+4 (Probability: 50%)

Expected value: €+5

Low risk (results fluctuate slightly around the expected value)

Pile B

(consists of four cards)



Best possible event: €+10 (Probability: 50%)

Worst possible event: €±0 (Probability: 50%)

Expected value: €+5

High risk (results fluctuate considerably around the expected value)

You now have to decide which pile you want to take a card from.

Make your selection now. Click on one of the three alternatives

ʘ I would like to take a card from pile A.

ʘ I would like to take a card from pile B.

ʘ I would like to take a card, but I don't mind which pile I take one from.

O.K.