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Need, framing, and time constraints in risky decision making

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Abstract The present study examined how induced needs and time constraints interact with framing effects in risky decision making. Two experiments were conducted in which participants made decisions about gambles framed as either gains or losses with two different time limits manipulated across blocks. Furthermore, three levels of need were induced. Need was defined as a minimum score the participants had to reach. Experiment 1 and 2 different with respect to need levels and amounts to win. The probabilities of the gambles were the same in both experiments. Participants gave also statements on their risk behavior. Cluster analysis based on choice proportions identified two different groups unrelated to self-assessments. In experiment 1, one group was more risk taking than the other group but the overall choice patterns were similar. In experiment 2, no difference in risk taking could be observed but differences in choice patterns. Data were analyzed on groups and subgroups. Overall, the results showed riskier behavior when the choice options were presented as losses. More framing effects could be observed with shorter time limits and for higher induced needs.

1 Introduction

In psychology *need* and *needs* typically refer to an actual state of deprivation or merely a feeling of deficiency, which drives the individual to action satisfying them. In this sense needs are motivational forces to activate behavior for reaching a goal. They range from physiological or basic survival needs such as breathing, food, sex, and sleep, which are common to all animals, to psychological needs such as cultural, intellectual, and social needs. Sometimes physiological needs are called drives; sometimes need and drive are uses as synonyms (e.g., Maslow (1943)).

In economics needs as actual or felt deficiencies are satisfied by necessities or necessaries, entities that the individual needs to survive or to live satisfactorily. These entities are often called needs as well. In distinction from economics necessities and necessaries like goods are no object of research in psychology. In this paper we induce need by setting a specific amount of points a participant has to accomplish and investigate whether a specific need may influence the decision behavior of a person. To that end, we utilize a gambling task with different induced needs.

Expected utility theory, the normative model for decision making under risk (e.g., gambles), involves consistent decisions across different context. Numerous empirical studies, however, have shown that the required invariance is frequently violated. Description-invariance has been challenged most: people react to a particular choice in different ways depending on how it is presented (Kahneman and Tversky, 2000; Tversky and Kahneman, 1985). The presentation or *frame* may refer to the wording of formally identical problems (strict definition, (Kühberger, 1998)) or a frame may refer to an internal event resulting also from other contextual features of a situation and from individual factors (loose definition, (Kühberger, 1998)). The Asian disease problem is the most prominent example for a frame in its strict sense (Tversky and Kahneman, 1985).. In all cases, the problems need to be equivalent with

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respect to expected utility theory. Kahneman and Tversky (1979) call the frame induced deviation from rational decision making "framing effect". For instance, in a game with two options, one of them a sure option and the other a risky gamble, decision makers tend to be risk averse when the situation is framed as a gain (e.g. saving lives) and risk seeking when the situation is framed as a loss (e.g. people dying) (Tversky and Kahneman, 1985). Losses and gains are interpreted with respect to a reference point (reflection effect) (Tversky and Kahneman, 1985). Another frame, in rather in a loose sense, is different time constraints. Presenting identical choice options but constraining the decision time can produce preferences reversal and shifts (Diederich, 2003; Diederich and Busemeyer, 2006) or modify wording induced framing effects Guo et al (2015).

In the following we investigate the effects of induced need and time constraints on choice behavior in a gambling task with two choice option, one being a sure option and the other a risky gamble. Two experiments are reported with slightly different values.

Experiment 1

Similar to De Martino et al (2006) and Guo et al (2015, 2017) the present study involved a game with two choice options. At the start of each trial, participants were given a message indicating an initial amount of money that they would receive on that trial. They then had to choose between a sure option and a gamble, with the sure option presented in either a gain or a loss frame (Figure 1). The gamble's possible outcomes were 0 and the initial amount, displayed in a gray scale pie chart to represent the probability of winning and losing. In both frames, the gamble was identical (i.e., had the same expected value). Furthermore, the expected value of the gamble was identical to the amount received in the sure option. Two response limits were included and three different levels of induced need.

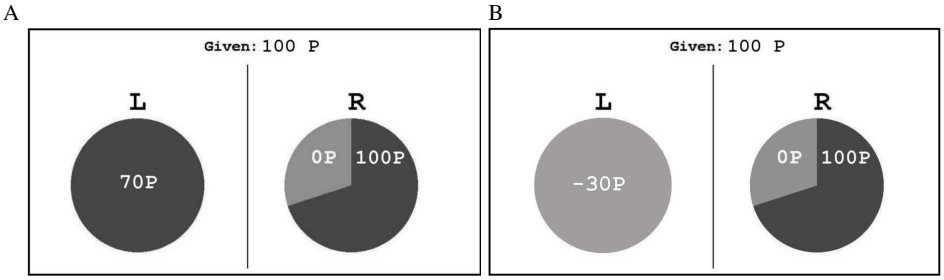

Fig. 1 Sample trial presentations for a gain frame (A) and a loss frame (B).

Material and Methods

Participants

Nineteen individuals from Jacobs University Bremen (13 female; age between 19 and 24 years; median = 21 years) participated in the study. All participants were undergraduate students and English speakers. They received 6.00 € per hour for their participation (regardless of performance) and 0.001 € per point earned in the games. Participants completed three sessions, spread over three days; a session lasted between 35 and 55 minutes. They gave their written informed consent prior to their inclusion in the study, and the experiment has been conducted according to the principles expressed in the Declaration of Helsinki.

Materials

The experiment consisted of three sessions, each session with four blocks of trials. Within each session two different response time limits were included. Across sessions different levels of induced need applied. One block of trials consisted of 64 tests trials: 32 gain frames and 32 loss frames. In addition 16 catch trials were included in each block to assess accuracy and engagement in the task resulting in a total of 80 trials per block. For the test trials, four point amounts were selected: 25, 50, 75, and 100. They were identical to the study of De Martino et al (2006). In addition four probabilities were selected to serve as the probability of winning the gamble: 0.3, 0.4, 0.6, and 0.7. The initial amounts and probabilities of winning the gamble were paired together to form 16 unique gambles. From these pairs the sure option for each trial was created to match the expected value of the gamble, depending on frame. For instance, for an initial amount of 100 points and a winning gamble probability of 0.7, the sure option would either be "Keep 70" (gain frame) or "Lose 30" (loss frame). The catch trials had non-equivalent sure, and gamble options in which one option had a significantly larger expected value. Eight catch trials were constructed: four gain frame trials and four loss frame trials. The initial starting values for these trials were 25, 50, 75 and 100; the winning gamble probabilities were 0.3 and 0.7. In half of these trials, the sure option had a higher expected value (starting value $\times$ 0.7) than the gamble option (starting value $\times$ 0.3). In the other half of the trials, the gamble option had a higher expected value (starting value $\times$ 0.7) than the sure (starting value $\times$ 0.3) option. This results in 40 unique games (16 gain frame test games; 16 loss frame test games; 4 gain frame catch games; 4 loss frame catch games). Within each block each game was presented twice in random order, resulting in 80 trials per experimental block. Furthermore, two time limits were included. Previous experiments with a similar design including deadlines have shown that mean response time under a no-time-constraints condition was about 2 seconds, but response times expressed considerable variability (a standard deviation of about 3 seconds.) (Guo et al, 2015, 2017). Therefore, the response time limit for a block of trials was set to 1 second (1s) or 3 seconds (3s). Need was defined as the minimum points to be obtained during one block of trials, with levels 0, 2500, and 3500 points. Zero points served as baseline control; 2500 points could be reached in about 50 percent of the blocks; 3500 points were unattainable. If the participant met the required minimum score, the points earned during one block of trials were converted into money (0.001 € per point) and paid at the end of the experiment. If the participant did not reach the goal no points were awarded. To summarize: the 2 frames $\times$ 2 time limits $\times$ 3 needs design produced 12 experimental conditions. One session consisted of four experimental blocks, two with a 1s time limit and two with a 3s time limit. 20 unique games for each of the 2 frames and each of the 2 response time limits and each of the 3 needs with 4 replications per condition results in a grand total of 960 observations per participant.

Apparatus

Stimulus presentation and response registration was controlled by a standard computer running a 64bit Linux operating system (v. 17.3.) with a standard 22" LCD wide-screen monitor (screen resolution: 1920$\times$1080 pixels). The control software operated on Matlab® 2014a including the Psychophysics Toolbox version 3. The response device was a USB 2.0 controller with two buttons. The monitor display had a white background; the instruction text there was written in black with font "courier new" and font size 24pt. Choice options were represented by grayscale representations of keeping an amount (represented by dark gray) and losing an amount (represented by light gray), as shown in Figure 1; text there was written in white. The diameter of the pie charts representing the choice options was 250px. The sure or the gamble option was randomly presented on the left or the right side. Available time for making a decision was indicated by eight vertical bars displayed at the bottom of the screen and removed one by one as a function of the preset time limits, i.e., the given time limit divided by eight. (see Figure 2, C).

Procedure and design

The participants performed three sessions on three different days. The three sessions differed with respect to the induced need (0, 2500, 3500), pseudo randomized across days and participants. After reading the instructions, the participants completed three guided practice trials where they were told to select specific options (i.e., the gamble or sure option). After the guided practice, participants completed and additional six trials practice where they could

respond freely. This procedure was repeated at the beginning of each session. Participants were told that they could not reach the points in the experimental trials when choosing the sure option only.

In all of the guided practice trials and in the first two practice trials, a legend appeared below the pie charts for each option explaining the amounts that could be won or lost (see Figure (see Figure 2, A)). This legend faded away step by step during the practice. No time limits and no need points were applied in practice trials. The

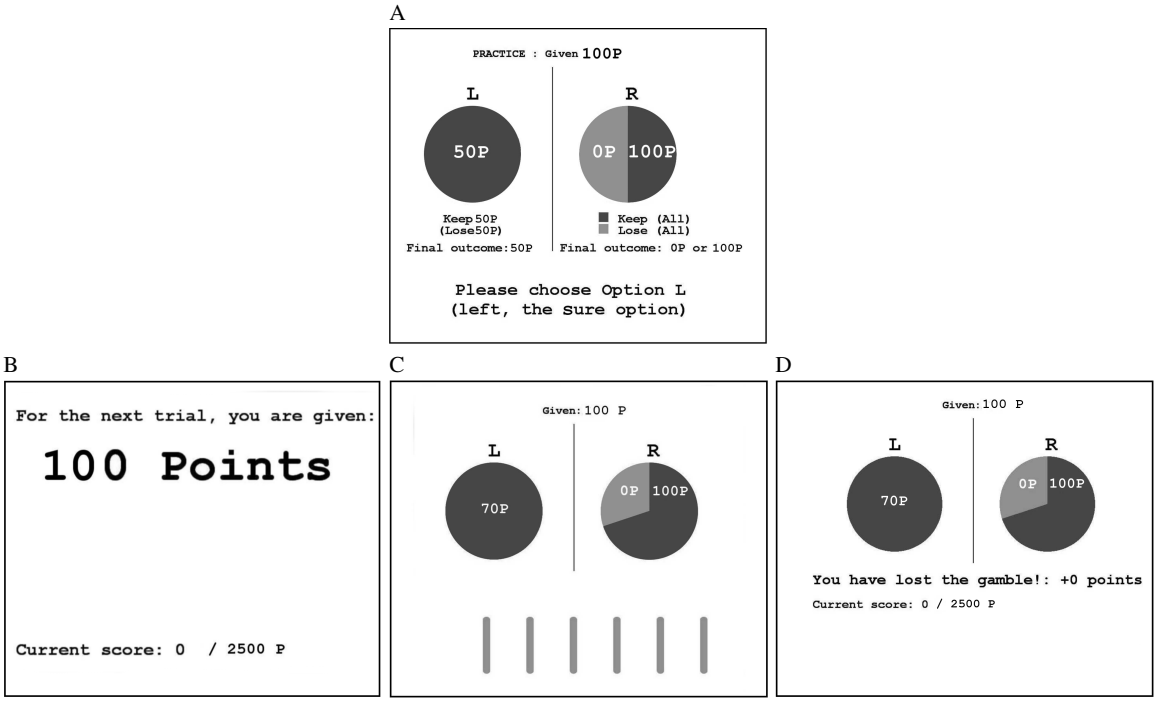

Fig. 2 Example of a guided practice trial (A) and time line for one trial in a gain frame (B–D). The screen displaying the initial amount was presented for 2.5 sec (B). It also displayed the induced need for the block of trials and the points reached so far. The screen displaying the gamble was presented for either 1s or 3s, depending on the experimental condition (C). The bars below the pie-charts indicate the available time for a particular trials (speed by which the bars were removed). The feedback screen (D) was presented for 2.5 sec, in which the result of the current gamble was announced, the accumulated points and the need target.

experimental trials started with showing the amount of points given for that trial and the induced need, which was constant within one block of trials. In addition, the accumulated points up to that trial were also shown. The display lasted for 2.5 sec (Figure 2, B). The subsequent screen showed the gamble and the time limit for that particular trial (Figure 2, C) and lasted for 1 or 3 secs, depending on the experimental condition. A response had to be made within the time limit. The last screen (Figure 2, D) provided a feedback about the outcome of the gamble and the points accumulated so far. It lasted for 2.5 sec. After offset of the screen the next trial started.

In the gain frame, participants selected between keeping a portion of the initial amount for sure (70 P) or playing a gamble where they could either keep all of the initial starting amount (100 P) with some probability (0.7) or lose all of this amount (equivalent to getting 0 for the trial). Note that the expected value of the gamble is $0.7 \times 100 = 70$, which is the same as the sure option. In the equivalent loss fame, the gamble was identical to the gain frame. For example, the gamble outcomes were keeping the initial starting amount of $100P$ with probability 0.7 or losing the entire amount with probability $1 - 0.7 = .3$. The only difference between the gain and loss frames was the framing of the sure option. In the loss frame, the sure option was described as losing a portion of the initial amount. For example a sure loss of 30 P is equivalent to keeping 70 (as described in the gain frame). Thus, the payoffs in the gain and loss frames were identical. In the gain frame, the sure option was presented as an amount retained in a 100% dark gray pie chart (e.g., "Keep 70 P". In the loss frame, the sure option was presented as an amount lost in a 100% light gray pie chart (see figure 1) (e.g., "Lose 30 P"). For both the gain and loss frames, the gamble option was presented as a pie chart representing the probability of keeping the entirety of the initial amount or losing the initial amount.

After participants finished the last block of the experiments participants were given a short questionnaire on their individual risk behavior. The questionnaire is part of the "Sozio-Oekonomischen Panels 2009" (SOEP 2009)(SOEP, 2007), which is "(...) a wide-ranging representative longitudinal study of private households, located at the German Institute for Economic Research, DIW Berlin. Every year, there were nearly 11,000 households, and about 30,000 persons sampled by the fieldwork organization TNS Infratest Sozialforschung. (...) Some of the many topics include household composition, occupational biographies, employment, earnings, health and satisfaction indicators." (`https://www.diw.de/en/diw\_02.c.221178.en/about\_soep.html`). This survey contains three questions on individual risk behavior. The questions are in Appendix 1. All items were measured on a scale from 0 to 5 with 0 for no willingness for taking risk and 5 for willingness to take high risk.

All items were measured on a scale from 0 to 5 with 0 for no willingness for taking risk and 5 for willingness to take high risk.

Results

We analyzed the data of all 19 participants, removing the catch trials. On average, they answered about ten out of 192 catch trials incorrectly, i.e., correct average proportion was 94.6%. Of the remaining 14,592 test trials, 93 (.6%) were time outs and were also removed from further analysis. In all three induced need conditions (0, 2500, and 3500 target points), the mean number of points obtained in the games was about the same (2616, 2678, and 2656 points, respectively). In 62% of all trials participants chose the gamble. For the 3s (1s) time limit condition, the proportion of playing the gamble was 58% (47%) and 71% (74%) for gain and loss frame trials, respectively. Accordingly, mean response times for gain frame trials were 1.16s (0.63s) compared to 1.12s (0.62s) in loss frame trails.

A generalized linear model (GLM) analysis (IBM SPSS Statistics 24, method: generalized linear model, model type: binary logistic regression, clustered subjects) with Frame (gain, loss), Time (1s, 3s), and Need (0, 2500, 3500) as explanatory variables showed statistically significant main effects for Frame and Time (Table 1). The results suggest that participants tend to choose the sure option in the gain frame and the risky game in the loss frame, i.e., a framing effect. Furthermore, they tend to choose the sure option more often under the short time limit than under the longer time limit (Table 1, Model 1, main effects).

To investigate a possible moderator effect of time constraints and induced needs on choice frequencies we performed a GLM with a 2-way and 3-way interaction analysis. We found that Frame by Time interactions were statistically significant, but not Frame by Need and Time by Need interactions (Table 1, Model 2, interactions). Time constraints seems to reinforce the framing effect (Kahneman and Tversky, 1979), i.e., the tendency to choose the gamble in loss frames and the sure option in gain frames. Under shorter time limits participants tend to be even more risk averse when the lottery was framed as a gain and more risk seeking when the lottery was framed as a loss (see also Figure 4). No 3-way interactions could be observed.

	Model 1		Model 2	
	Odds ratio	95% CI	Odds ratio	95% CI
Frame (Gain)	**0.414*** **	0.327 – 0.525	**0.301*** **	0.214 – 0.422
Time (3s)	**1.206*** **	1.086 – 1.340	0.884	0.750 – 1.042
Need (3500)	1.231	0.953 – 1.589	1.261	0.913 – 1.742
Need (2500)	0.974	0.824 – 1.150	0.903	0.659 – 1.238
Frame × Time			**1.763*** **	1.530 – 2.032
Frame × Need (3500)			1.001	0.799 – 1.254
Frame × Need (2500)			1.114	0.893 – 1.388
Time × Need (3500)			0.955	0.742 – 1.229
Time × Need (2500)			1.033	0.879 – 1.213
Intercept	2.258***	1.634 – 3.121	2.692	1.855 – 3.906

Table 1 Experiment 1: Odds ratios obtained by GLM with n = 19 subjects. Number of measurements per participant varied between 745 (min) and 768 (max). Dependent variable: 'Choosing the gamble'. Reference category: 'Sure option'. Model 1 main effects; Model 2 main effects and 2-way interactions; **p $<$ 0.05; ***p $<$ 0.01. 95% Wald Confidence Interval for odds ratios.

A framing effect, that is, participants' choice behavior depending on the presentation frame of the choice options, may manifest itself in a preference reversal or in a preference shift (Kühberger, 1998; Tversky and Kahneman, 1985). Figure 3 shows the choice proportion for the 16 individual games within each condition as a function of time limit conditions for the gain (A) and loss (B) frame and as a function of the frame conditions for time limit 3s (C) and 1s (D) for all three need conditions. Each choice proportion is based on 76 games (4 replications for each of the 19 participants). Choice proportions in the upper left and lower right quadrant indicate preference reversals; off diagonal choice proportions in the upper right and lower left quadrant indicate preference shifts. There are some preference reversals as a function of time limits in the gain frame condition (A); and very few in the loss frame condition (B). The pattern looks different when we consider the choice proportions as a function of frames given a time limit condition (3s and 1s are shown in C and D, respectively). A further analysis of the framing effect across all games, separate for each need and time limit condition, can be found in Appendix 2.

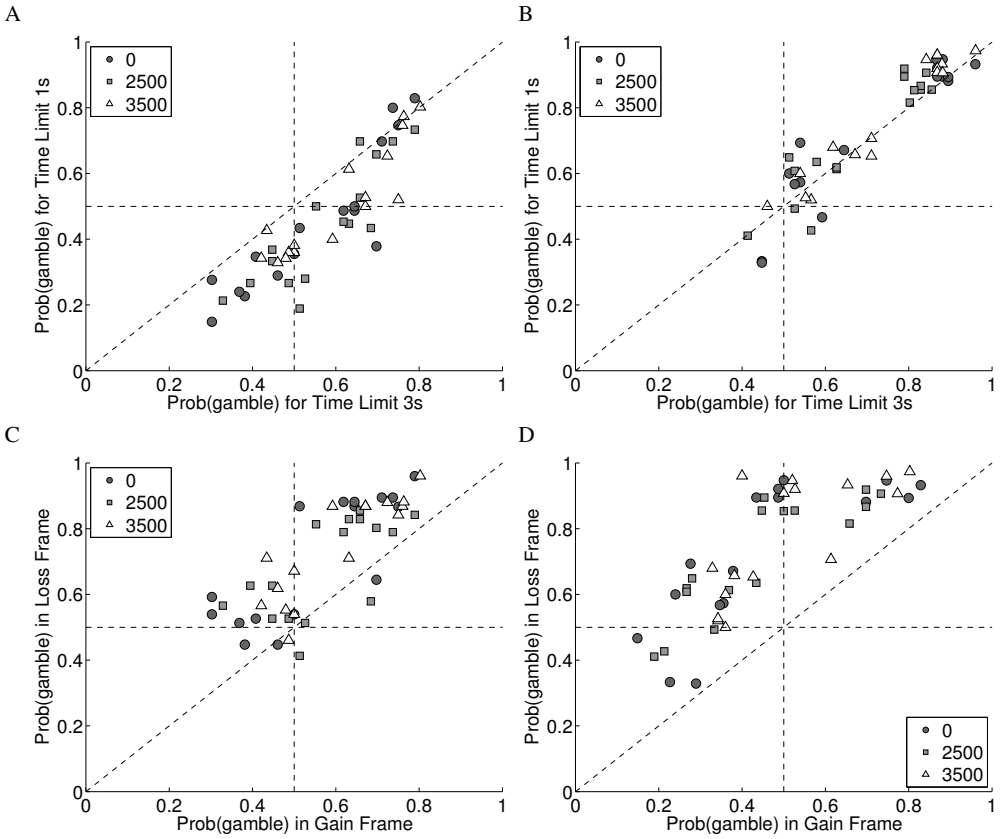

Fig. 3 Experiment 1: Choice proportions for choosing the gambles as a function of time limits for a gain frame (A) and a loss frame (B) and as a function of frames with 3s (C) and 1s (D). The symbols and gray shades correspond to the needs conditions with darker shades to lower points.

The framing effect may also depend on the concrete values defining a gambles. Therefore, we plotted the choice proportions for choosing the gamble as a function of probabilities to keep the initial amounts (Figure 4, panel A and B) as well as a function of the initial amount given across the probabilities to keep it (Figure 4, panel C and D), similar to the presentation in De Martino et al (2006) . The framing effect – gain versus loss frame – is clearly preserved in the need conditions (solid versus filled bars with different gray shades) as well across the time limits. The probability to choose the gamble depends also on the probability of keeping. The smaller the keeping probability is the less often the gamble is chosen. This is in stark contrast to the results of De Martino et al (2006), where the probability to choose the gamble decreases with increasing keeping probabilities. We will return to this in the discussion. The probability to choose the gamble also seems to depend on the initial amount given but not in a systematic way. That is, it is neither decreasing as a function of the amount given, as in the De Martino et al

(2006) study, nor increasing. In particular, the responses to the 75 initial amounts strikes as odd. Therefore, we investigated the results on the individual participant's level as well.

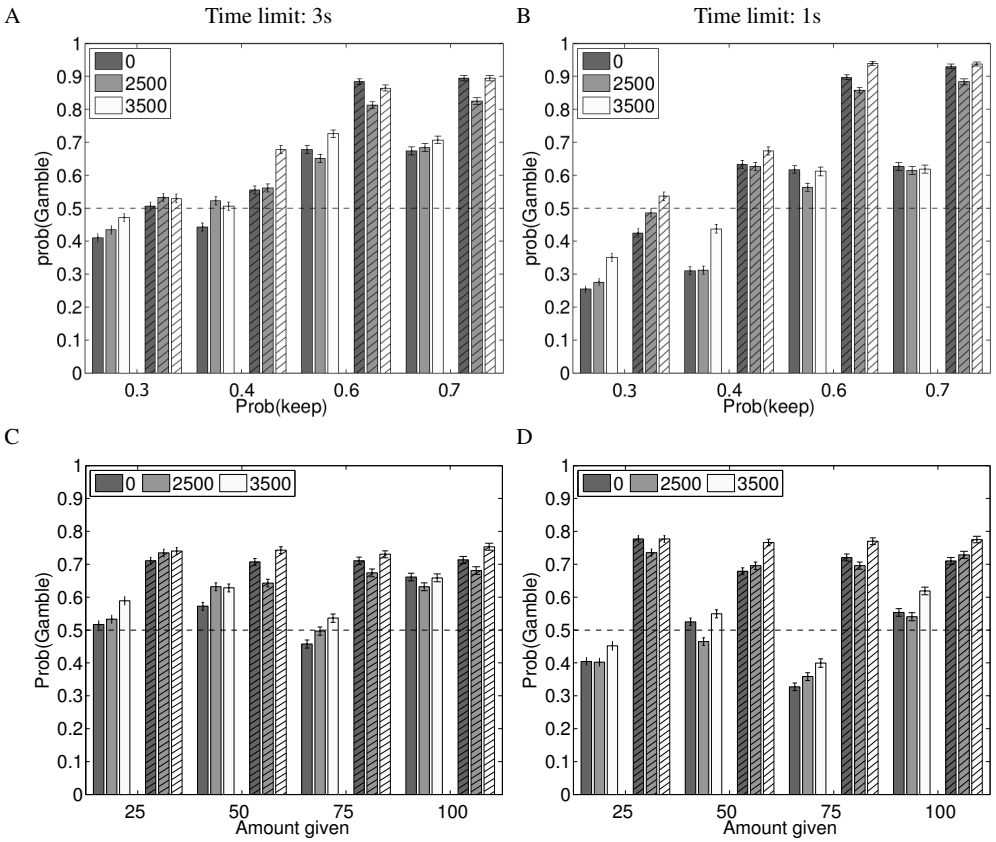

Fig. 4 Experiment 1: Choice proportions for choosing the gambles as a function of the probability of keeping across all four initial amounts within the given probability (panel A and B) and as a function of the initial amount given across the probabilities of keeping it (panel C and D). The 3s time limit condition is presented in panel A and C; the 1s condition in panel B and D. The solid bars refer to the gain frame condition, the filled ones to the loss frame condition. The gray shades correspond to the needs conditions with darker shades to lower points.

Individual differences

The self-assessment of risk attitudes varied between 1 and 4 (mean = 1.95, median = 2, and standard deviation = 0.9). The willingness to take risk measured in terms of the sum of scores of the six items (Question 1 in Appendix 1) yielded between 7 and 20 points, with 0 being the lowest possible points to reach (no willingness to take risk) and 30 the highest possible scores to obtain (willingness for taking high risk)(mean = 11 , median = 10, std = 3.4). For the willingness to bet in a risky gamble scores ranged between 0 and 3 (mean = 1, median = 1, std = 0.85). Detailed results are in Appendix 3. The correlation between the overall scores of the willingness-to-take-risk scales plus the willingness-to-bet scales and the self-assessment scores was 0.59. The overall scores served to divide the participants into two groups, labeled R1 and R2, with the median as criterion. R1 is the more riskier groups. In addition we performed a hierarchical cluster analysis (complete and average) on the choice proportions for the four gamble replications of all participants across all experimental conditions. Two major clusters were identified with seven and ten participants each, in the following labeled as G1 and G2. A third small cluster, G3, contained two participants. Both clustering methods gave the same results. A k-means cluster analysis with $k = 2$ suggested to merge G1 and G3. Results shown are based on the 2-means clustering. Participants in G1 chose the gamble in

71.2% of all cases whereas participants in G2 chose it in 54.3% of all cases. The overlap between the two risk attitude groups and the clusters is moderate with five common members in R1 and G1 and six common members in R2 and G2. Analysis was done with both classification results; however, only the one based on the statistical clustering is reported here.

On average, G1 answered about 15 out of 192 catch trials incorrectly, i.e., correct average proportion was 92.4% whereas G2 answered about 6 out of 192 catch trials incorrectly, i.e., correct average proportion was 96.7%. A t-test showed that the difference between the proportion of incorrect catch trials of both groups was statistically significant ($t = 2.230$; p< 0.05). In all three induced need conditions (0, 2500 and 3500 target points), the mean number of points obtained in the games was 2562.85, 2674.17 and 2632.22 points for G1, respectively and 2664.69, 2681.56 and 2678.06 points for G2, respectively. In 71.2% of all trials participants in G1 chose the gamble compared to 54.3% in G2. Furthermore, participants in G2 were, on average, faster (0.87s) than those in G1 (0.90s) ($t = 4.591, p < 0.01$). Further analysis of the RT is here omitted.

The GLM analysis conducted separately for each group revealed significant main effects for Frame and Time but not for Need in both groups. A subsequent 2-way interaction analysis showed statistically significant results for Frame by Time for both groups (Table 7 in Appendix 4). Again, the interaction of Frame by Time indicates an increased framing effect when time is short. Induced need does not affect choice behavior.

Figure 5 shows a scatter plot of response proportions for choosing the gamble as a function of lime limits (A to D) given a frame and as a function of frames given a time limit separated by groups (G1, left; G2 right.) For G1 each choice proportion is based on 28 trials (4 replications for each of the 7 participants), and for G2 on 40 trials. Obviously G1 is more risk taking than G2 as the choice proportions are mainly in the upper two quadrants. Using the procedure for quantifying the framing effect as described in Appendix 2, Table 2 shows the number of framing effects and preference reversals (in parentheses) for each group and treatment. Note that the framing effects includes preference reversals and preference shifts. Preference reversals occur more often for G1 ($n = 7$) (Figure 5 upper left and lower right quadrants Table 2) than for G2 ($n = 10$). Furthermore most preference reversals for G1 occur in the need 0 condition; in G2 most preference reversals in the need 3500 condition.

Group	1				2			
Need	Gain|Time	Loss|Time	3s|Frame	1s|Frame	Gain|Time	Loss|Time	3s|Frame	1s|Frame
0	13(8)	9(0)	15(1)	15(9)	15(0)	8(1)	14(0)	16(1)
2500	14(6)	9(0)	13(0)	16(8)	13(4)	12(1)	15(1)	16(4)
3500	12(0)	11(0)	13(0)	16(1)	10(4)	11(3)	14(2)	16(5)

Table 2 Number of framing effects (preference reversals) for both groups and each condition. Gain|Time means gain frame condition given both time limit conditions. 3s|Frame means 3s time limit given both frames.

We also investigated the framing effect on the level of gambles separately for each group. That is, we plotted the choice proportions for choosing the gamble as a function of probabilities to keep the initial amounts (Figure 6, A to D) as well as a function of the initial amount given across the probabilities to keep it (Figure 6, E to H). The results of G1 are shown in the left panels and the results of G2 in the right panels. The framing effect is preserved across frames (solid versus filled) and time limits (A vs C for G1; B vs D for G2) for each need condition. Considering the 75 amount given in panels E to H in the gain frame it still sticks out, causing a non-monotonicity in choice proportions as a function of amounts given.

Summary and Discussion

The results corroborate those by De Martino et al (2006), i.e., a gain and loss frame changes the response behavior of the participant. In a gain frame, the participant chooses the sure option more often than in a loss frame. Furthermore, the study replicates the results by Guo et al (2015, 2017), i.e., time limits enhance the effect. Under short time limits the participant tends to choose the sure option much more often in the gain frame as compared to the loss frame. In addition to time limits, induced need was introduced to investigate whether a target amount to reach, the induced need, would modify the framing effect even further. No effect of induced need on choice behavior could be observed.

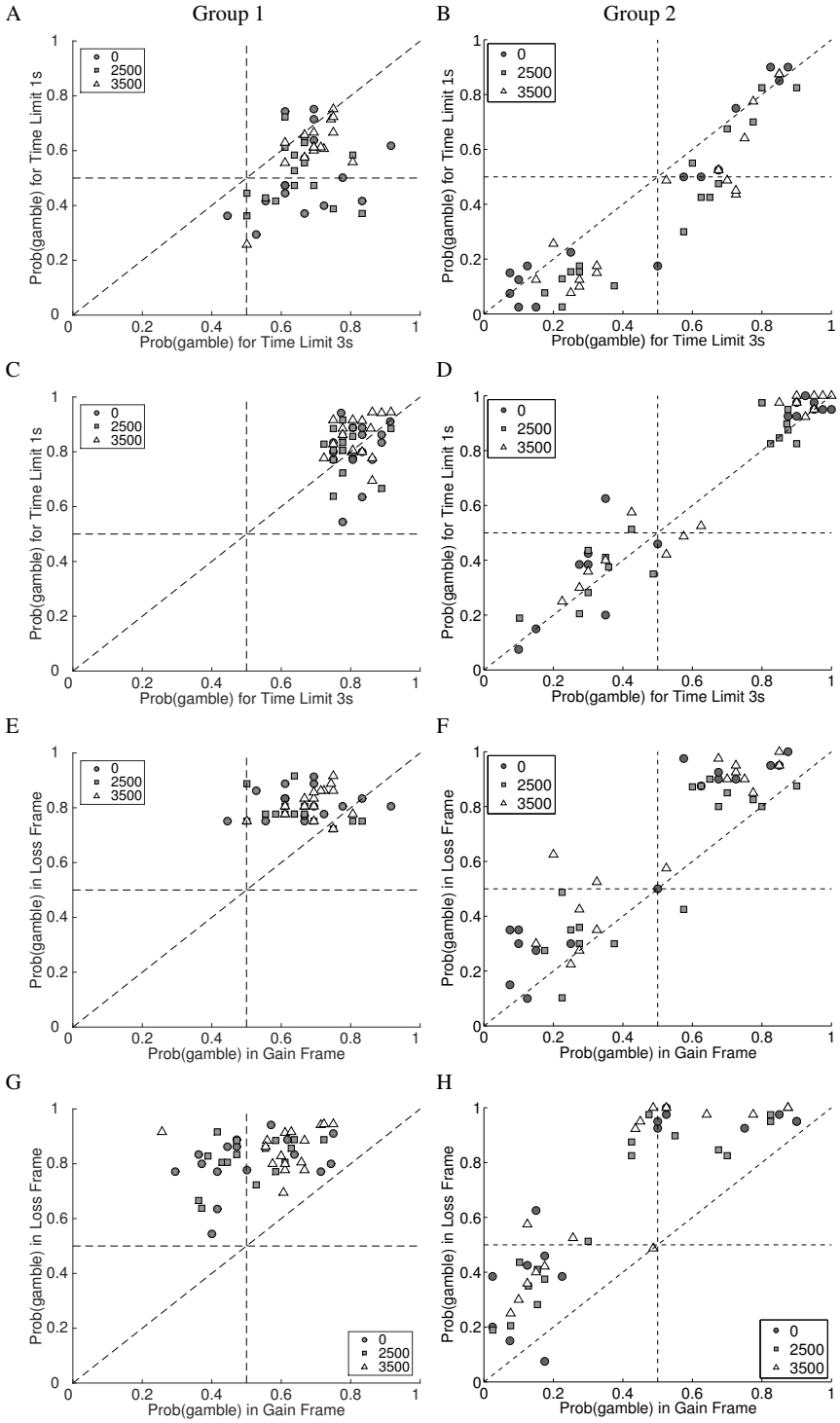

Fig. 5 Experiment 1: Choice proportions for choosing the gambles as a function of time limits for a gain frame (A and B) and a loss frame (C and D) and as a function of frames with 3s (E and F) and 1s (G and H) separated by groups. The left panels refer to G1 and the right panels to G2. The symbols and gray shades correspond to the needs conditions with darker shades to lower points.

Individual differences in risk attitudes may also contribute to the size of the framing effect. Therefore, several measure were taken to access a person's risk attitude. Furthermore, a cluster analysis based on choice behavior was

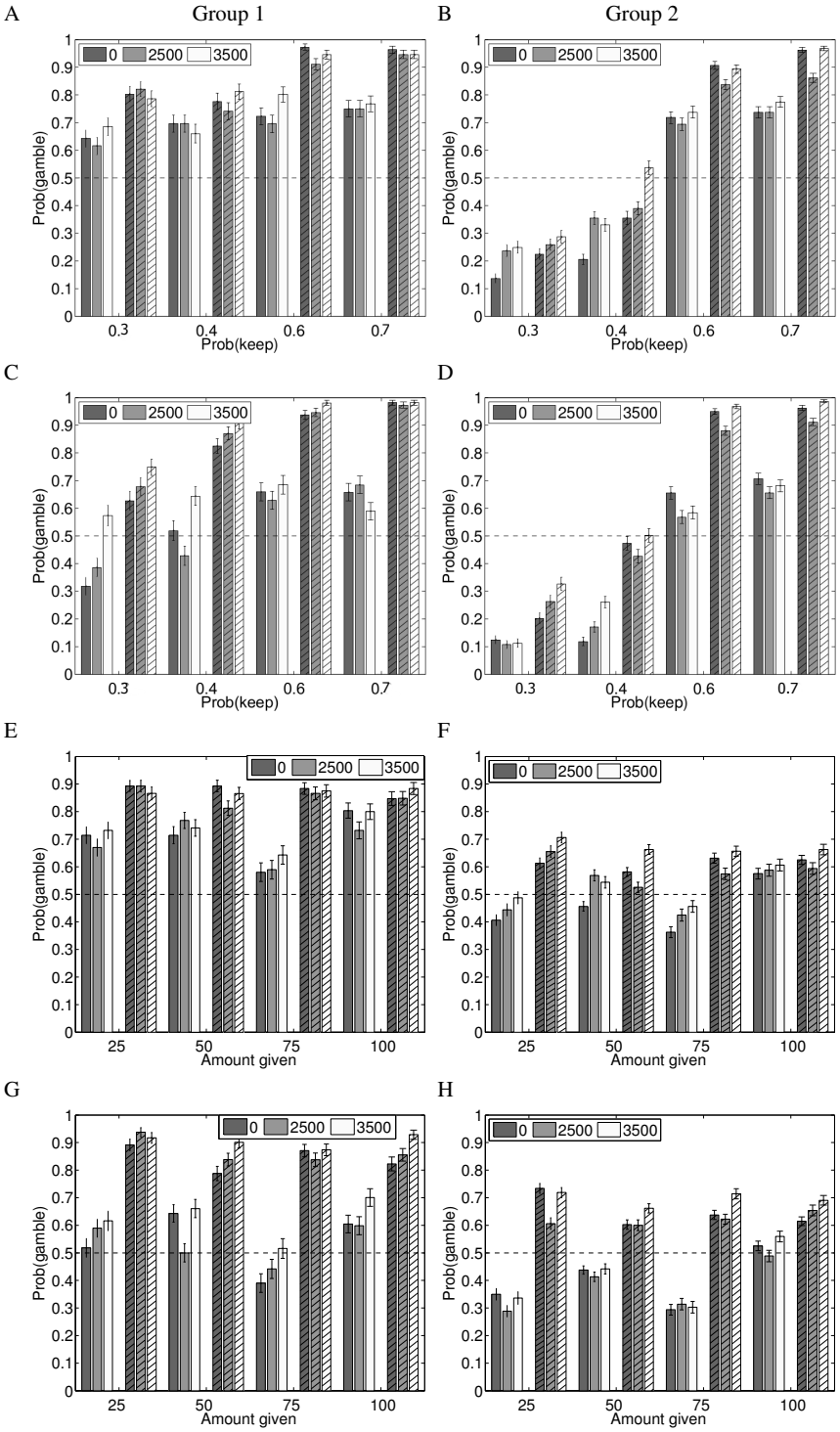

Fig. 6 Experiment 1: Choice proportions for choosing the gambles as a function of the probability of keeping across all four initial amounts within the given probability (A to D) and as a function of the initial amount given across the probabilities of keeping it (E to H). The results of group G1 are shown in the left panels and those of G2 in the right panels. The 3s time limit condition is presented in panel A and B and in E and F; the 1s condition is presented in panel C and D and in G and H. The solid bars refer to the gain frame condition, the filled ones to the loss frame condition. The gray shades correspond to the needs conditions with darker shades to lower points.

conducted, resulting in two groups. The relation between stated risk attitudes (self assessment tests) and revealed risk attitudes (frequency of choosing the gamble) was moderate. For both groups we could observe framing effects; and time constraints reinforced them. However, no effect on induced need could be observed for any of the groups either. Because the need conditions were randomly assigned to experimental blocks it could have happened that the participants did not pay enough attention and/or varied across blocks. Furthermore, the choice proportions in the gain frame for the 75 initial amount condition is smaller than for the 50 initial amount *and* for the 100 initial amount conditions. An error in the experimental setup and in the analysis was excluded by various independent checks and various programs written by different researchers of the team. We speculated that the displayed amount in the sure option may have caused some effect (different from multiples of 5, decimals were rounded to the next integer) (e.g., Albers (2001); Bateman et al (2007)) but this is also true for the 25 initial amount condition. Furthermore, this is also valid for the loss frame where the 75 initial amount condition does not stick out. In any case, the amounts displayed may have had an effect, which cannot explain. Finally, the choice proportions for choosing the gamble are increasing as a function of probabilities for keeping the amount, i.e., in opposite directions of the study by De Martino et al (2006). To shed some light on some of the unexpected results we conducted a second experiment.

Experiment 2

The setup of the second experiment is identical to the first one but with different initial amounts, need levels, and procedure.

Materials and Methods

Participants

Fifty eight individuals from Jacobs University Bremen and University of Bremen (29 female, age between 18 and 49 years, median: 20) participated in the experiment. Fifty seven participants were undergraduate students and one participant was a visitor of the university. All Participants were English speakers. In addition to a show up fee of 9.00 € and they received 0.0025 € per point earned in one of the six experimental blocks. The payment block was selected randomly. Participants completed one session; it lasted approximately 90 minutes. They gave their written informed consent prior to their inclusion in the study, and the experiment has been conducted according to the principles expressed in the Declaration of Helsinki.

Materials

The experiment consisted of one session with six blocks of trials. One block of trials included 96 test trials: 48 gain frames and 48 loss frames. In additions eight catch trials were included in each block of trials, resulting in a total of 104 trials per block. For the test trials, four basic initial point amounts were selected: 20, 40, 60, and 80, flanked by plus/minus one point amounts, resulting in the following set: 19, 20, 21, 39, 40, 41, 59, 60, 61, 79, 80, and 81. This was done to minimize the effect of specific values on the choice behavior. Responses to a triple were collapsed for evaluation. The probabilities of winning the gamble were identical to experiment 1: 0.3, 0.4, 0.6 and 0.7. The initial amounts and probabilities to gambles were paired to form 48 unique gambles. The dead lines were the same as in experiment 1: 1s and 3s. Need levels were 0, 2800, and 3600 points. 52 gambles (48 test and 4 catch trials) for each of the 2 frames and each of the 2 response time limits and each of the 3 needs results in a grand total of 624 observations per participant.

Apparatus

The control software was identical to the one in experiment 1. In addition to the Linux system, five other computer running Microsoft operating system (Windows 7) were used. Two of them had a smaller standard 17“ LCD monitor (screen resolution: 1280×960 pixels). The input devices were standard keyboards with the left and right arrow-key to choose the choice option displayed left or right on the screen, respectively.

Procedure

The participants performed one session. The instructions and training trials were similar to the one in experiment 1. The first two experimental blocks were a 0-need condition with a S-time-limit condition in the first block and a S-time-limit condition in the second block for all participants. They served as a benchmark. The remaining need and time limit conditions were pseudo-randomized provisory with the same need condition in two consecutive blocks. After each block the participants had a break. They could continue when they were ready for the next block.

Results

Data of one participant was lost due to a computer failure. Data of three participants were excluded from the analysis: for two participants the proportion of incorrect catch trials was above 50% and one participant did not response within the deadlines. The correct average proportion of the remaining 54 participants was 76.5%. Of the remaining 33696 test trials 291 trials were time outs or anticipations ($<$ 300ms) and were removed from the analysis. In all three need conditions (0, 2800, 3600) the mean number of points was about the same (2598, 2628, and 2617 points, respectively). In 61% of all trials participants chose the gamble. For the 3s (1s) time limit condition, the proportion of playing the gamble was 54% (50%) and 69% (72%) for gain and loss frame trials, respectively. Accordingly, mean response times for gain frame trials were 1.24s (0.65s) compared to 1.24s (0.64s) in loss frame trails.

A GLM analysis with Frame (gain, loss), Time (1s, 3s), and Need (0, 2800, 3600) as explanatory variables showed statistically significant main effects for Frame but not for Time and Need (Table 8 in Appendix 5). The results suggest that participants tend to choose the sure option in the gain frame and the risky game in the loss frame, i.e., a framing effect.

Surprisingly, for the main effect model only Frame had an effect on choice behavior but not Time as we observed in experiment 1. The 2-way interaction model, however, showed a statistically significant effect for Frame by Time and for Frame by Need. However, experiment 1 has shown that participants differed with respect to their response behavior. In particular, participants in experiment 1 could be classified according to their risk behavior, i.e, choosing the gamble more often than the sure option across all conditions. Possibly, we can identify different groups with different choice strategies, which may have nullified the effect of time limits. Therefore, in the following we concentrate on individual groups. For completeness the analysis of the overall results and of the framing effect across all games, separate for each need and time limit condition, are reported in Appendix 5. Data were analyzed in the same way as in experiment 1.

Individual differences

Of the 54 participants 49 completed the risk-assessment test. The self-assessment of risk attitudes varied between 0 and 4 (mean= 2.6 , median= 3, standard deviation= 1.1). The willingness to take risk measured in terms of the sum of scores of six items yielded between 6 and 25 points (mean= 14.1, median= 13, standard deviation= 4.9). For the willingness to bet in a risky gamble values ranged between 0 and 5 (mean= 1.8, median = 2, standard deviation = 1.6). Frequency distributions and further details are found in Appendix 7. Similar to experiment 1 we performed a hierarchical cluster analysis (complete and average) on the choice proportions for the triple gambles (initial amounts differ by 1 or 2 points) of all 54 participants across all experimental conditions. Two clusters were identified with 32 and 22 participants each, in the following labeled as G1 and G2. Both clustering methods gave the same results. Furthermore, a k-means cluster analysis with $k = 2$ gave the same results. Self-classification scores and clusters did not agree. There were only 26 out of 49 possible matches. Various scores (subtests and overall) were taken to classify the participants. However, none of these measure could differentiate response behavior in an obvious fashion (see also 5). Analysis based on the clustering is reported here.

On average, G1 answered about 10 out of 48 catch trials incorrectly (correct average proportion 79.7%) whereas G2 answered about 14 out of 48 catch trials incorrectly (correct average proportion 71.8%; difference between proportions is statistically significant: $t = -2.621$; p$<$ 0.05).

In all three induced need conditions (0, 2800, and 3600 target points), the mean number of points obtained in the games was about the same across conditions and groups (2586.10, 2651.64 and 2632.77 points for G1, respectively; 2608.79, 2578.25 and 2607.91 points for G2, respectively). In contrast to experiment 1, participant in each clusters did not differ with respect to risk taking. Here, participants in G1 chose the gamble in 61.9% of the cases, similar to participants in G2, who did so in 60.3% of the cases. Furthermore, participants in G1 were, on average, faster (0.88s) than those in G2 (1.03s; $t = -25.040, p < 0.01$). No further analysis on RT is pursued here.

A GLM analysis revealed statically significant main effects for G1 for Frame and Need but not for Time whereas for G2, it revealed statistically significant main effects for Frame and Time but not for Need (see Table 3). Participants of both groups chose the gamble more often in the loss frame than in the gain frame condition, the effect being more pronounced for G1. Furthermore, participants in G1 chose the gamble more often in the high need (3600) condition compared to the no need (0) condition. Participants in G2 chose the gamble more often in the 3s

time limit condition compared to the 1s time limit condition. A subsequent interaction analysis showed significant results for Frame by Time and Frame by Need for G1. Here we find a stronger framing effect with shorter time limits as in experiment 1. No statistically significant interactions could be observed for G2 (Table 3).

	Group 1				Group 2			
	Model 1		Model 2		Model 1		Model 2	
	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
Frame (Gain)	**0.366****	0.294 – 0.456	**0.241****	0.181 – 0.320	**0.605****	0.493 – 0.742	**0.513****	0.390 – 0.674
Time (3s)	0.975	0.865 – 1.100	0.855	0.725 – 1.009	**1.098****	1.006 – 1.199	1.024	0.868 – 1.207
Need (3600)	**1.203****	1.030 – 1.406	1.168	0.950 – 1.437	0.987	0.744 – 1.310	0.889	0.643 – 1.229
Need (2800)	1.060	0.862 – 1.303	0.899	0.683 – 1.184	0.969	0.782 – 1.202	0.986	0.763 – 1.274
Frame × Time			**1.507*****	1.205 – 1.884			1.192	0.985 – 1.443
Frame × Need (3600)			**1.245*****	1.055 – 1.470			1.168	0.979 – 1.393
Frame × Need (2800)			**1.501*****	1.186 – 1.900			1.080	0.908 – 1.285
Time × Need (3600)			0.835	0.660 – 1.057			1.046	0.859 – 1.275
Time × Need (2800)			0.889	0.694 – 1.137			0.893	0.711 – 1.122
Intercept	2.583***	2.056 – 3.247	3.111***	2.358 – 4.105	1.906***	1.426 – 2.549	2.058***	1.478 – 2.864

Table 3 Experiment 2: Odds ratios obtained by GLM separate for each group with n = 32 (G1) and n = 22 (G2) participants. Number of measurements per participant varied between 554(min) and 576(max) for G1 and between 347(min) and 575(max) for G2. Dependent variable: 'Choosing the gamble'. Reference category: 'Sure option'. Model 1 main effects; Model 2 main effects and 2-way interactions; Model 3 main effect and 2-way and 3-way interactions. **p < 0.05; ***p < 0.01. 95% Wald Confidence Interval for odds ratios.

Figure 7 shows the choice proportion for 16 games within each need condition as a function of time limit conditions for the gain (A and B) and loss (C and D) frame and as a function of the frame conditions for time limit 3s (E and F) and 1s (G and H) for all three need conditions. The left column presents the results for G1 (n=32), and the right column the results for G2 (n=22). For G1 each choice proportion is based on 96 games (3 replications for each of the 32 participants), and for G2 on 66 games. Choice proportions in the upper left and lower right quadrant indicate preference reversals; off diagonal choice proportions in the upper right and lower left quadrant indicate preference shifts. Some preference reversals as a function of time limits occur in the loss frame (C and D). Substantial more preference reversals can be observed when plotting the choice proportions as a function of frames, given a specific time limit (E to H). Table 4 shows the number of framing effects and preference reversals (in parentheses) for each group and treatment. Note that the framing effects includes preference reversals and preference shifts. Preference reversals occur more often for G2 ($n = 22$) than for G1 ($n = 32$).

Group	1				2			
Need	Gain|Time	Loss|Time	3s|Frame	1s|Frame	Gain|Time	Loss|Time	3s|Frame	1s|Frame
0	10(1)	8(4)	16(7)	16(4)	11(0)	10(0)	12(6)	15(8)
2500	7(0)	7(1)	16(5)	16(4)	11(0)	12(3)	13(5)	13(7)
3500	6(0)	8(2)	16(5)	16(7)	11(2)	10(2)	11(5)	13(8)

Table 4 Number of framing effects (preference reversals) for both groups and each condition. Gain|Time means gain frame condition given both time limit conditions. 3s|Frame means 3s time limit given both frames.

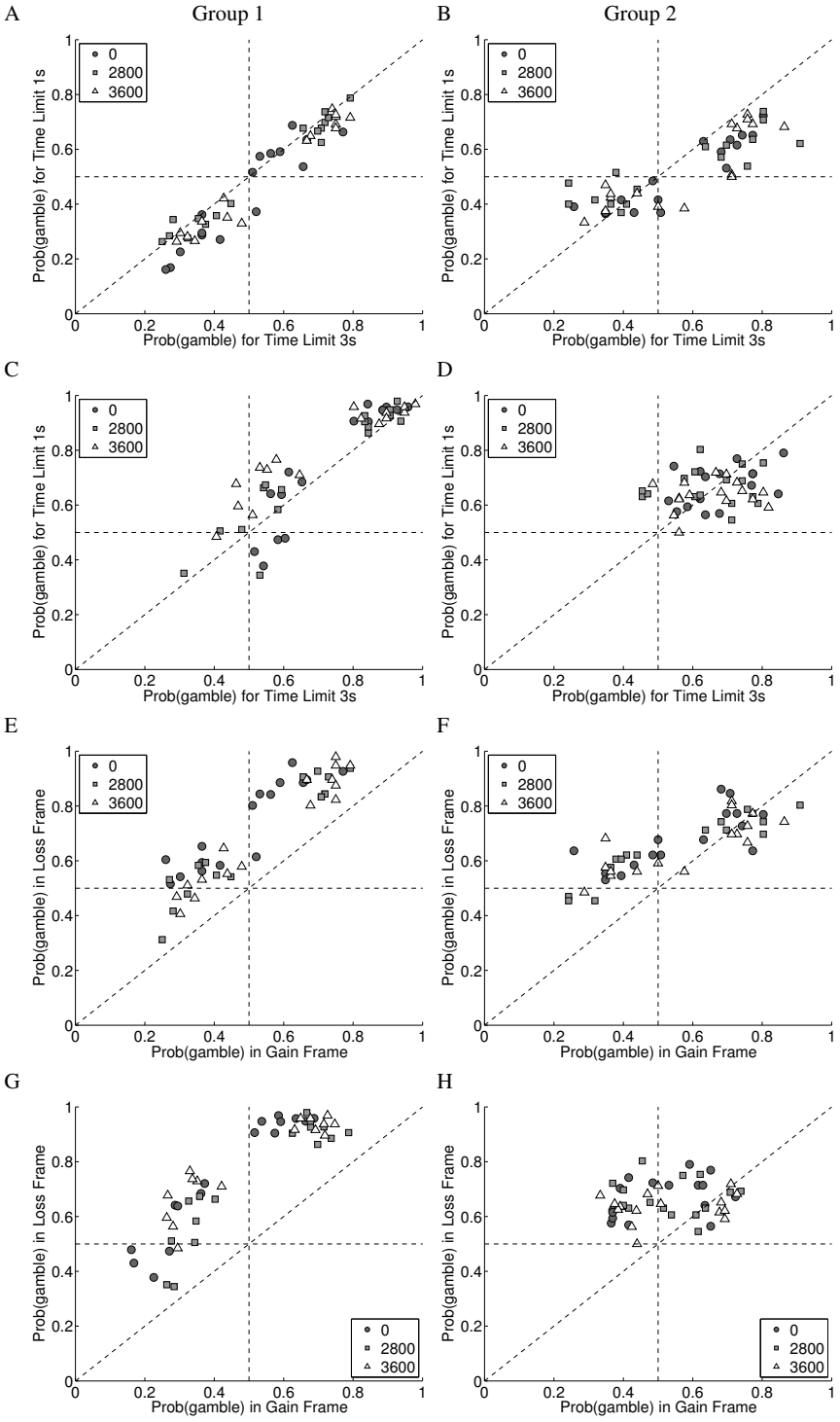

Fig. 7 Experiment 2: Choice proportions for choosing the gambles as a function of time limits for a gain frame (A and B) and a loss frame (C and D) and as a function of frames with 3s (E and F) and 1s (G and H) separated by groups. The left panels refer to G1 and the right panels to G2. The symbols and gray shades correspond to the needs conditions with darker shades to lower induced need.

As before, we investigated the framing effect on the level of gambles in more details. (Figure 8 shows the choice proportions for choosing the gamble as a function of probabilities to keep the initial amounts (A to D) as well as a function of the initial amount given across the probabilities to keep it (E to H). The left column presents the

results for G1 (n=32), and the right column the results for G2 (n=22). For both groups, the framing effect is clearly preserved in the need conditions (solid versus filled bars with different gray shades) as well across the time limits. As in experiment 1 the probability to choose the gamble depends on the probability of keeping. However, there is a striking difference between both groups when considering the choice proportions for choosing the gamble as a function of probabilities to keep the initial amounts (A to D). For G1, the smaller the probability of keeping the amount is the less often the gamble is chosen, but for G2 the pattern is reversed: the smaller the probability of keeping the amount is the more often the gamble is chosen. That is, G1 replicates the pattern of experiment 1, whereas G2 replicates the pattern of De Martino et al (2006). The probability to choose the gamble seems little to depend on the amount given (panels E to H). This is different from the results of experiment 1 where you could observe a non-monotonic relation between the amounts given and the proportions to choose the gamble. In particular, the 75 amount given condition does not stick out anymore.

Besides the different response behavior we can only speculate in what respect the two groups differ. Table lists demographic information and the results of the self-assessment scores. Age is about the same and can be neglected. The female/male ratio is 1.3 in G1 and 0.58 in G2. The scores in each subtest are higher for G2 than for G1, but not dramatically (because there is no appropriate test, the standard error serves as benchmark). The most obvious difference between the two groups is the correlation between the scores of the subtest. All subtests are meant to measure risk attitude and should highly correlate. However, for G2 there is even a negative correlation between the life-situation test scores and the lottery test scores ($-.26$). Furthermore, the correlation between the lottery test scores and the self assessment attitude score is very small. It seems that members of G2 are less consistent in their risk assessment.

			Mean score (std error)			Correlation between		
Group	Mean age	Sex	Life (Li)	Lottery (Lo)	Self (S)	Li–Lo	Li–S	Lo–S
1 (n=30)	20.3	17f/13m	13.73 (.87)	1.60 (.30)	2.53 (.20)	.26	.70	.56
2 (n=19)	21.3	7f/12m	14.79 (1.18)	2.05 (.34)	2.79(.23)	$-.26$	.51	.08

Table 5 Experiment 2: Demographic information and results of the self-assessment scores including the correlation between scores of subtests.

Summary and Discussion

The results of the second experiment partly support the previous findings. Overall, in a gain frame, the participants chose the sure option more often than in a loss frame. Time limits per se did not influence choice behavior (no statistically significant main effect; Table 8 in Appendix 5) but strengthened the framing effect (interaction between Frame and Time). Again, induced need had no main effect on choice behavior, but showed a statistically significant interaction with Frame: with increasing induced need participants became more risk taking in the gain frame.

A cluster analysis identified two groups. Different from experiment 1 the groups were similar in their risk taking behavior (about the same proportions for choosing the gamble). However, they differed with respect to response strategies. Group G1 produced the same patterns as participants in experiment 1. With increasing probabilities to keep the initial amount the choice proportion for the gamble increased. The opposite pattern could be observed for G2. With increasing probabilities to keep the initial amount, the choice proportion to choose the gamble decreases – the same pattern as in the De Martino et al (2006) study. The risk self-assessment test gave little indication to what may have led to the different strategies. The choice proportions as a function of amount given were almost flat within a given frame. None of the amounts given seems to trigger a particular choice behavior as this was the case in experiment 1. That is, the different amounts given seem not to play a major role for choosing the gamble or not.

The statistically analysis revealed further differences between both groups. Participants' choice behavior in G1 was influenced by Frame and Need (they were more risk seeking in the loss frame and with an induced need of 3600 points). Again, the interaction between frame and need shows that an induced need strengthens the framing effect. Participants' choice behavior in G2 was influenced by Frame and Time (more risk seeking in trials with longer time limits).

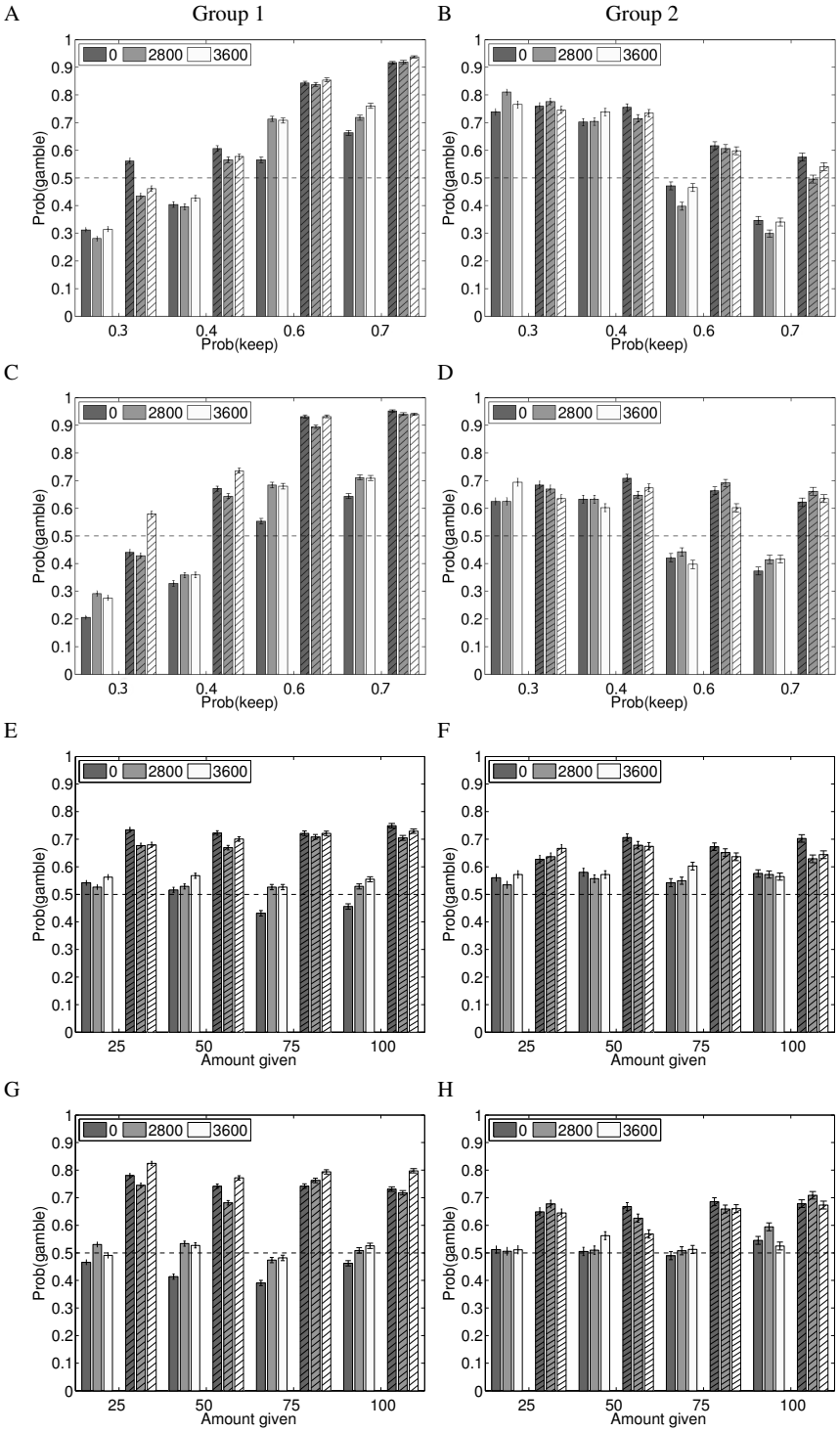

Fig. 8 Experiment 2: Choice proportions for choosing the gambles as a function of the probability of keeping across all four initial amounts within the given probability (A to D) and as a function of the ininital amount given across the probabilities of keeping it (E to H). The results of group G1 are shown in the left panels and those of G2 in the right panels. The 3s time limit condition is presented in panel A and B and in E and F; the 1s condition is presented in panel C and D and in G and H. The solid bars refer to the gain frame condition, the filled ones to the loss frame condition. The gray shades correspond to the needs conditions with darker shades to lower points.

General Discussion

How does induced need influence choice behavior? Do people become more risk taking when need is high rather than low or are they more cautious when need is high? And does a time limit in which the decision has to be made reinforce the the effect? To answer these questions we conducted two experiments in which the decision maker had a choice between a sure option and a risky gamble. The choice proportions are often taken to indicate the person's risk preference. An abundance of studies, however, have shown, that the preference is not stable but depends on the context, the situation, or the frame in which the game is offered. In a gain frame, participants tend to chose sure options, whereas in a loss frame, participants tend to choose the gamble. The experiments showed a strong framing effect: decision makers tend to choose the sure option in the gain frame and the gamble in the loss frame. Time limits reinforced the the effect. However, there is little evidence per se that induced need influenced decision behavior.

In particular, experiment 1 replicated the results by Guo et al (2015, 2017), i.e., time limits enhance the effect. The results corroborate those by De Martino et al (2006), i.e., a gain and loss frame changes the response behavior of the participant. In a gain frame, the participant chooses the sure option more often than in a loss frame. Furthermore, the study replicates the results by Guo et al (2015, 2017), i.e., time limits enhance the effect. Under short time limits the participant tends to choose the sure option much more often in the gain frame as compared to the loss frame. In addition to time limits, induced need was introduced to investigate whether a target amount, the induced need, would modify the framing effect even further. No effect of induced need on choice behavior could be observed. In experiment 2, no effect of different time limits could be observed but interactions between Frame and Need. The higher the induced need the more risk taken participants became in the gain frame.

For both experiments a more detailed analysis based on individual difference in choice behavior (two subgroups were identified by cluster analysis) were performed.

In experiment 1 group 1 was more risk taking than group 2 and the framing effect was more pronounced. However, induced need did not play a role for their preferences. In experiment 2 both groups had the same risk preference but they differed considerably with respect factors moderating their choice behavior. Frame had an effect for both groups; for group 1 time had no effect but need and for group 2 need had no effect but time on choice behavior. For both groups we also observed that the patterns of choice proportions as a function of probabilities and values of the gambles different considerably. However, the focus here was not on how specific values influence choice behavior (see e.g. Kühberger et al (1999), meta analysis involving Asian Disease type of stimuli; Levin et al (1998), analysis of different types of framing effects.) or on individual differences per se (e.g., Mahoney et al (2011), also Asian Disease type of stimuli) but on induced need on choice behavior. Why and when it sometimes moderate choice behavior and why and when not could not be answered in the current study.

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Appendix 1

The following questions to test the participants' risk attitudes were taken from the questionnaire of the "Sozio-Oekonomischen Panels 2009"

1. Human behavior is individual. Different people behave in different ways. How about You? How would you estimate your willingness to take risks in the following situations? Please choose an option on the scale. Value 0 means: "No willingness for taking risks". Value 5 means: "Willingness for taking high risks".You can adjust your choice with the values between 0 and 5. How is your willingness to take risks...

	0	1	2	3	4	5
... while car driving?						
... when you invest money?						
... in your free time; during sports?						
... regarding your career?						
... regarding your health?						
... when you trust in unknown people?						

2. Consider what you would do in the situation below: Imagine you would win 100,000 €in a lottery. Immediately after receiving the money, you get an offer for the following lottery: You have the chance to double your stake. But there is the same chance to lose the half of it. You can place all of your 100,000 €or less in the increments below. It's also possible to reject the lottery.
   How much would you bet?

Everything. The whole 100,000 €	
80,000 €	
60,000 €	
40,000 €	
20,000 €	
Nothing. I would reject the offer. 0 €	

3. How do you assess yourself? Are you a risk-averse person or are you a risk-seeking person? Please choose an option on the scale. Value 0 means: "no willingness for taking risks". Value 5 means: "willingness for taking high risks".

	0	1	2	3	4	5
My willingness for taking risks						

Appendix 2

For quantifying the framing effect across all games but separate for each need and time limit condition, the following procedure was carried out. For each participant and each game (four replications) the choice proportions to choose the gamble was determined. The difference between choice proportions in corresponding gain/loss choice games, P(gamble$_G$) and P(gamble$_L$), respectively, served, with $|\text{P(gamble}_G) - \text{P(gamble}_L)| \neq 0$, as an indicator for a framing effect. In particular, when $|\text{P(gamble}_G) - \text{P(gamble}_L)| > 0.5$ a preference reversal has occurred. In a second step the number of framing effects was related to the number of games (trials). A Friedmans Two-Way Analysis of Variance by Ranks showed no differences in the distribution of framing effects and preference reversals between all three need conditions under any time constraints condition. A Wilcoxon signed Rank Test showed differences of choice behavior depending on time pressure within the need treatments: Framing effects occurred more often under the 1s time limit for the 0 ($Z = -2.488, p < 0.05$) and 3500 need condition ($Z = -2.247, p < 0.05$). Statistically significant more preference reversals could be observed in the 1s time limit condition than in the 3s limit condition for each need condition (need 0: $Z = -3.203, p < 0.01$; 2500: $Z = -3.431, p < 0.01$; 3500: $Z = -2.641; p < 0.01$).

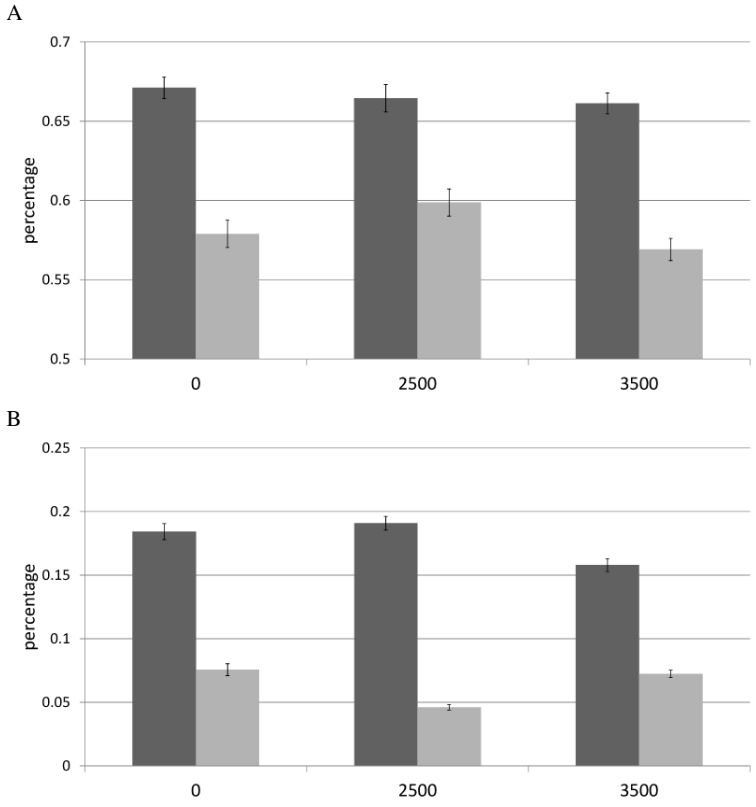

Fig. 9 Experiment 1: Relative number of framing effects (A) and preference reversals (B) across participants. Note that preference reversals are a subset of framing effects. Dark gray columns: 1s time condition; light gray columns: 3 s time condition.

Appendix 3

Results of the self-assessment risk questionnaire for each of the 19 participants and group membership according to clustering.

P	Self-rated	Willingness in	Behavior							Risk	H-Cluster	K-Cluster
	Risk Attitude	Betting	Money	Leisure	Health	Driving	Career	Trust	Sum	R	G	
1	2	1	0	3	0	0	1	5	9	2	2	2
2	1	1	2	3	1	1	3	0	9	2	1	1
3	3	0	1	3	2	1	1	0	8	2	2	2
4	1	1	2	2	1	1	3	3	12	1	2	2
5	2	1	2	1	1	4	1	3	12	1	2	2
6	2	2	3	5	2	1	4	1	16	1	1	1
7	2	0	1	3	1	1	3	1	10	2	2	2
8	1	0	1	2	2	0	3	0	8	2	2	2
9	1	1	3	2	0	0	1	1	7	2	3	1
10	3	0	3	4	1	1	2	1	13	1	1	1
11	4	2	3	3	0	1	4	0	11	1	3	1
12	2	3	3	3	1	1	3	1	12	1	2	2
13	1	1	1	3	0	0	3	0	9	2	1	1
14	3	1	3	4	1	1	5	1	15	1	1	1
15	1	2	2	3	0	1	1	0	7	2	1	1
16	2	2	1	4	3	2	2	3	15	1	2	2
17	1	2	2	2	1	2	0	1	8	2	2	2
18	3	0	2	2	5	1	5	5	20	1	1	1
19	2	1	1	3	1	1	3	1	10	2	2	2

Table 6 Experiment 1: Individual scores of the sub-sclaes for each of the participants. Sum refers to the sum of the six sub-sclale scores describing risky behavior in daily life. The median of the sum serves to divide the groups in two with R 1 refering to the lower scores and R 2 to the higher scores. H-Cluster and K-Cluster refer to the clustering results with hierarchical and k-means methods, respectively.

Appendix 4

GLM analysis (IBM SPSS Statistics 24, method: generalized linear model, model type: binary logistic regression, clustered subjects) separate for group 1 and group 2.

	Group 1				Group 2			
	Model 1		Model 2		Model 1		Model 2	
	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
Frame (Gain)	**0.343*** **	0.212 – 0.554	**0.241*** **	0.135 – 0.433	**0.450*** **	0.344 – 0.588	**0.332*** **	0.211 – 0.522
Time (3s)	**1.312*** **	1.071 – 1.608	1.032	0.800 – 1.332	**1.145** **	1.026 – 1.278	**0.781** **	0.636 – 0.959
Need (3600)	1.264	0.790 – 2.022	1.398	0.770 – 2.538	1.222	0.910 – 1.641	1.175	0.796 – 1.735
Need (2800)	0.954	0.758 – 1.200	1.007	0.601 – 1.685	0.983	0.767 – 1.261	0.825	0.542 – 1.255
Frame × Time			**1.893*** **	1.417 – 2.529			**1.702*** **	1.469 – 1.973
Frame × Need (3600)			1.093	0.767 – 1.557			0.931	0.676 – 1.281
Frame × Need (2800)			1.032	0.719 – 1.483			1.191	0.882 – 1.608
Time × Need (3600)			0.730	0.527 – 1.012			1.165	0.836 – 1.623
Time × Need (2800)			0.860	0.689 – 1.073			1.184	0.966 – 1.451
Intercept	3.707***	2.030 – 6.770	4.274***	2.064 – 8.850	1.567***	1.229 – 1.998	1.936***	1.391 – 2.696

Table 7 Experiment 1: Odds ratios obtained by GLM separate for each group with n = 9 (G1) and n = 10 (G2) subjects. Number of measurements per subject varied between 745(min) and 767(max) for G1 and between 758(min) and 768(max) for G2. Dependent variable: 'Choosing the gamble'. Reference category: 'Sure option'. Models: (1) main effects, (2) main effects and 2-way interactions. **p $<$ 0.05; ***p $<$ 0.01. 95% Wald Confidence Interval for odds ratios.

Appendix 5

Statistical analysis for data of experiment 2 across all participant. Table 8 shows the overall analysis of main effects and interactions of experiment 2 with a GLM. The same method as in experiment 1 was used. Figure 10 shows scatter plots as a function of time limits and frames to visualize changes in preferences and framing effects. In Figure 11 choice proportions are plotted as a function of probabilities to keep the amount and as a function of the amount given, separate for frame and need conditions.

	Model 1		Model 2	
	Odds ratio	95% CI	Odds ratio	95% CI
Frame (Gain)	**0.451*** **	0.381 – 0.533	**2.608*** **	0.264 – 0.413
Time (3s)	1.024	0.945 – 1.110	0.330	0.820 – 1.045
Need (3600)	1.108	0.952 – 1.289	0.926	0.858 – 1.255
Need (2800)	1.022	0.879 – 1.187	1.038	0.773 – 1.136
Frame × Time			**0.937*** **	1.163 – 1.587
Frame × Need (3600)			**1.358*** **	1.073 – 1.380
Frame × Need (2800)			**1.217*** **	1.114 – 1.534
Time × Need (3600			1.307	0.783 – 1.082
Time × Need (2800)			0.920	0.749 – 1.058
Intercept	2.276***	1.895 – 2.733	0.890	2.098 – 3.243

Table 8 Experiment 2: Odds ratios obtained by GLM separate for each group with n = 54 subjects. Number of measurements per subject varied between 347(min) and 576(max). Dependent variable: 'Choosing the gamble'. Reference category: 'Sure'. Model 1: main effects, Model 2 main effects and 2-way interactions. **p $<$ 0.05; ***p $<$ 0.01. 95% Wald Confidence Interval for odds ratio.

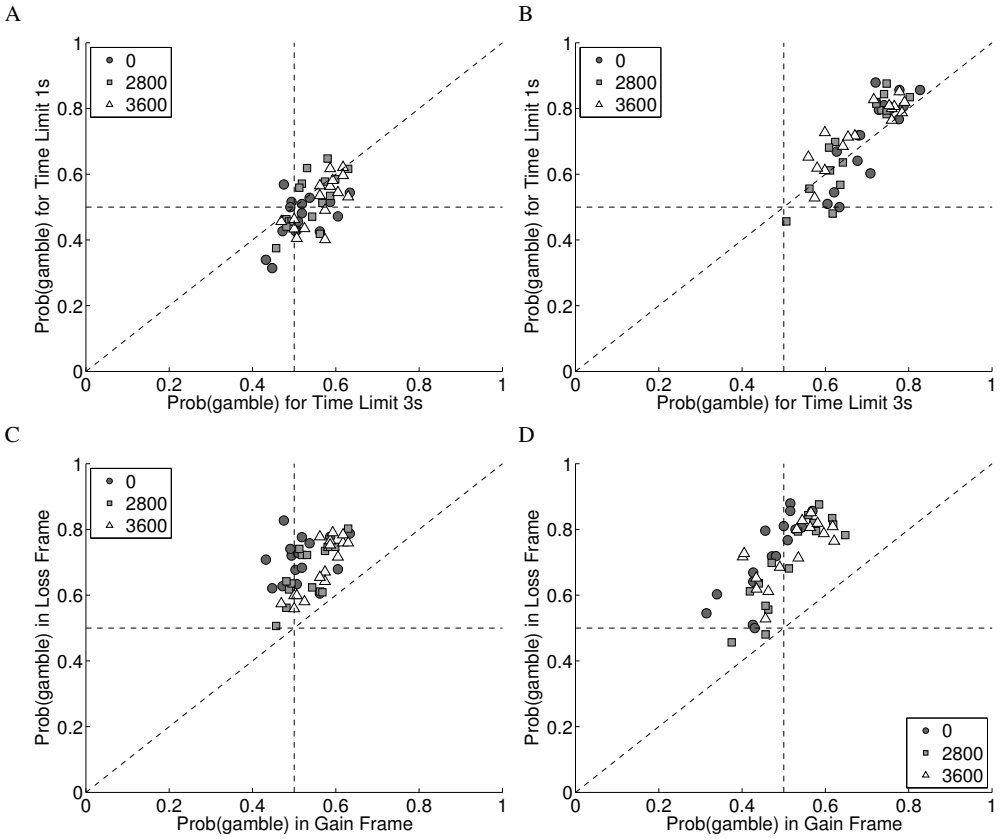

Fig. 10 Experiment 2: Choice proportions for choosing the gambles as a function of time limits for a gain frame (A) and a loss frame (B) and as a function of frames with 3s (C) and 1s (D). The symbols and gray shades correspond to the needs conditions with darker shades to lower points.

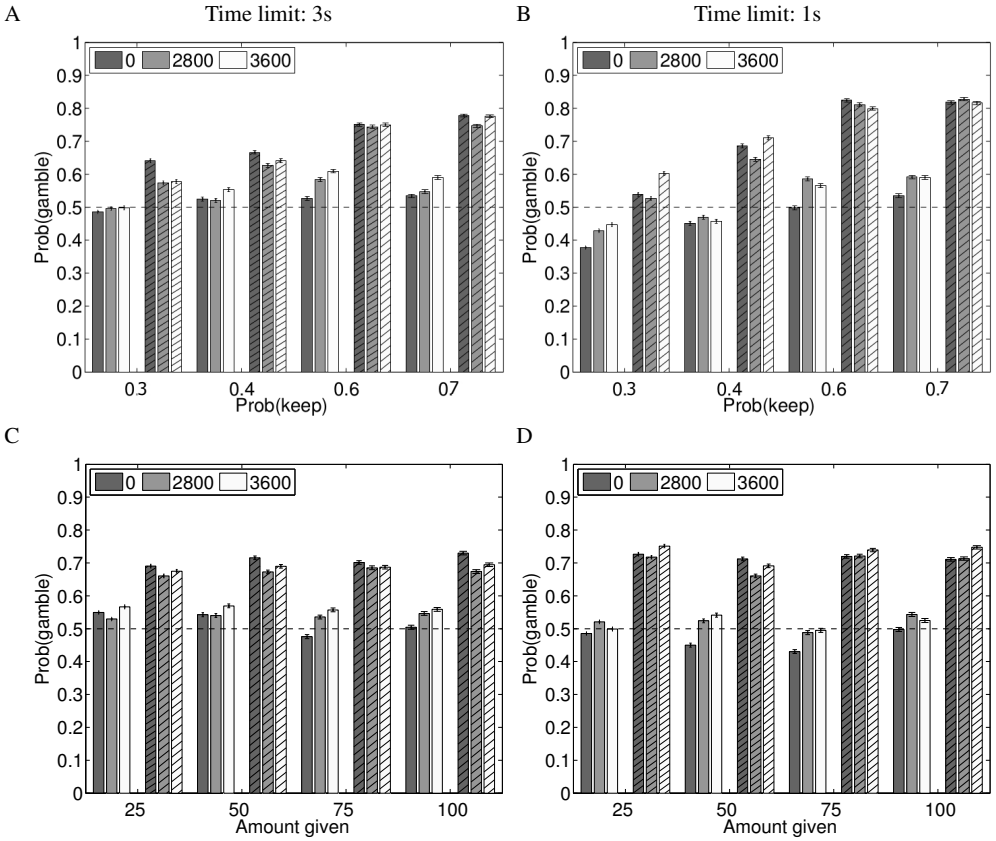

Fig. 11 Experiment 2: Choice proportions for choosing the gambles as a function of the probability of keeping across all four initial amounts within the given probability (panel A and B) and as a function of the initial amount given across the probabilities of keeping it (panel C and D). The 3s time limit condition is presented in the left panels; the 1s condition in the right panels. The solid bars refer to the gain frame condition, the filled ones to the loss frame condition. The gray shades correspond to the needs conditions with darker shades to lower points.

For quantifying the framing effect across all games but separate for each need and time limit condition, the same procedure as in experiment 1 was carried out. Friedmans's Two-Way Analysis of Variance by Ranks shows that there are no differences in the distribution of framing effects and preference reversals between all three need conditions under time pressure (1s response time). Without time pressure (3s) the participants showed both more framing effects (2800: F_R = 0.380; $p < 0.05$, and 3600: F_R = 0.426; $p < 0.05$ compared to 0 need condition) and preference reversals (2800: F_R = 0.500; $p < 0.01$, and 3600: F_R = 0.500; $p < 0.01$ compared to 0 need condition). A wilcoxon signed Rank Test shows differences of choice behavior depending on time pressure within the need Treatments: framing effects occurred more often under time pressure in 2800 (Z = -2.733, $p < 0.01$) and 3600 condition (Z = -4.079, $p < 0.01$). There are significant more preference reversals under time pressure the following need conditions (2800: Z=-2.565, p<0.01; 3600: Z=-3.407; p<0.01).

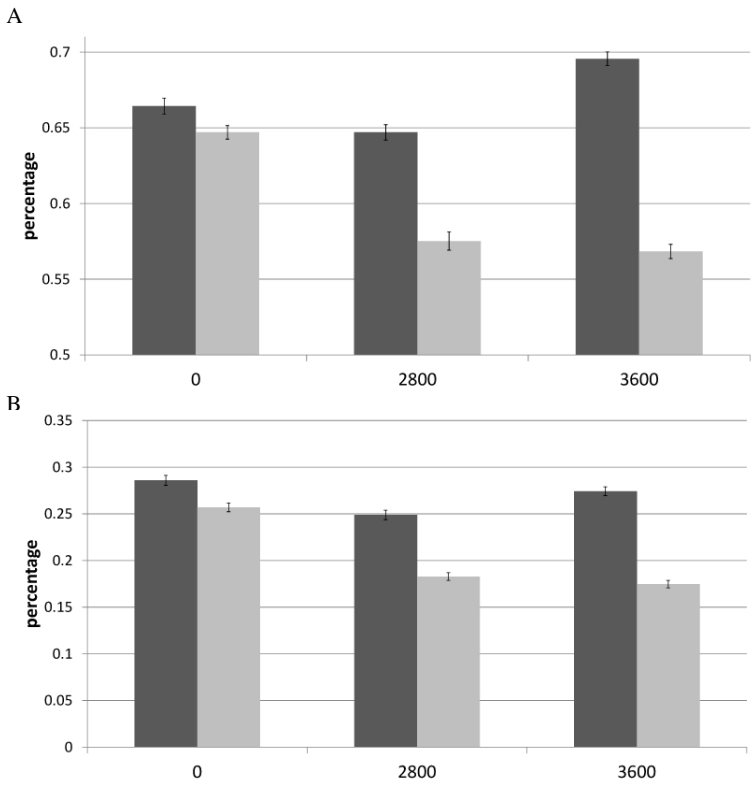

Fig. 12 Experiment 2: Relative number of framing effects (A) and preference reversals (B) across participants. Note that preference reversals are a subset of framing effects. Dark gray columns: 1s time condition; light gray columns: 3 s time condition.

Appendix 6

Results of the risk self-assessment test summarized across 49 participants. Figure 13 shows the frequency distributions of the three subtests and the overall scores.

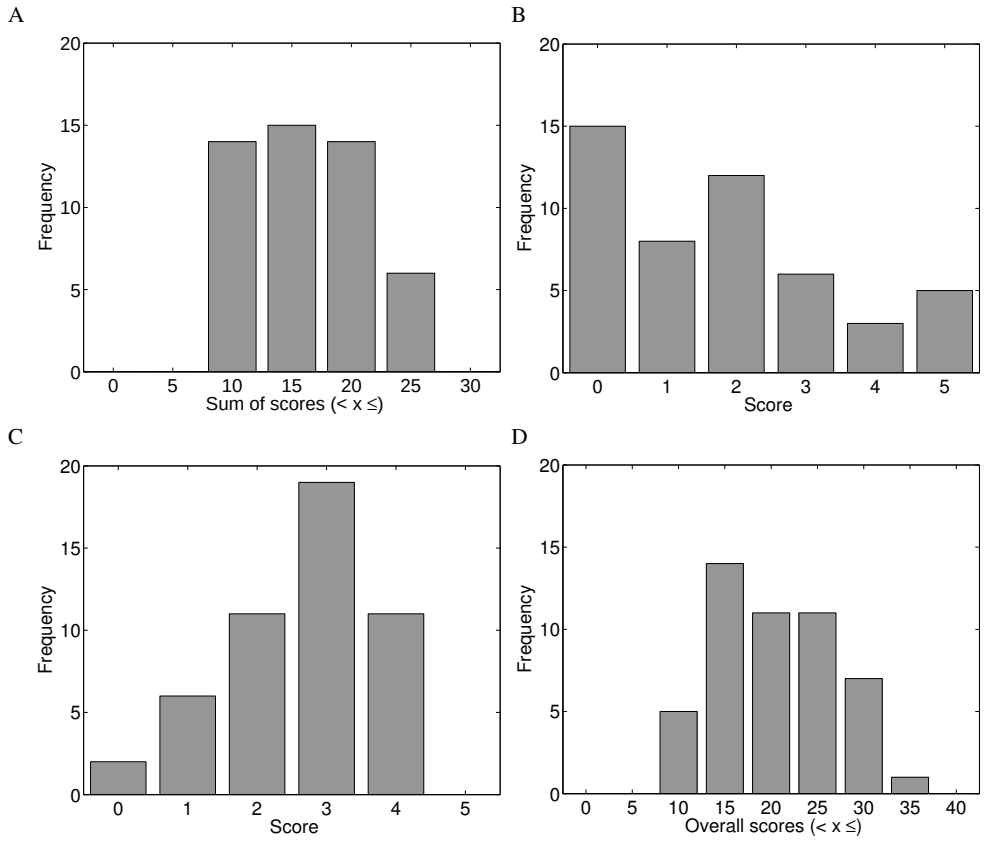

Fig. 13 Experiment 2: Frequency distributions of scores obtained in three subtests and overall scores based on 49 participants. A: Distribution of sum of scores for six items refering to risky behavior in daily life situations. B: Distribution of scores for the willingness to bet in a lottery. C: Distribution of scores for risk self-rating. D: Distribution of overall scores.

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– Latest Contributions

2017:

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Guo, Lisa, Trueblood, Jennifer S. and Diederich, Adele: Thinking Fast Increases Framing Effects in Risky Decision-making. Working Paper Nr. 2016-04. http://bedarfsgerechtigkeit.hsu-hh.de/dropbox/wp/2016-04.pdf

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