Motivating risky choices increases risk taking

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Author Note

The data and other replication files described in this article are openly available in the Open Science Framework at https://osf.io/x2vj6/

Abstract

We study the impact of the mode of cognition on risk taking. In an online experiment we ask participants to make a simple decision involving risk by performing the Bomb Risk Elicitation Task. The control group undergoes no manipulation, while in the treatment group we exogenously manipulate the mode of cognition by requiring subjects to write down a text that motivates their risky choice before making a decision. Such motivation treatment is meant to induce more reflection upon the action to be taken. Our results show an effect of the motivation treatment on risk taking, suggesting that higher reflection makes subjects more prone to risk taking. The effect is stronger among participants who have a limited understanding of the probability distribution involved in the decision task. Based on these findings, we suggest that reflection and comprehension may be substitutes in decision-making when there is risk involved.

Keywords: dual process; risk taking; motivation; deliberation and intuition; bomb risk elicitation task

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Introduction

Decisions are made in different ways, with some being intuitive and requiring little effort, while others are made through conscious and reflective processes. Also, sometimes decisions are taken based on a careful analysis of motivations, i.e., a scrutiny of pros and cons involved. In light of the prevalence of risk related decisions, it is crucial to comprehend the impact of these differing decision modes under risk. This insight is particularly valuable for developing policy interventions aimed at reducing excessive or inadequate risk taking.

Experimental evidence suggests that an individual's risk preferences may not be stable across different choice situations, particularly with regards to different modes of cognition (Deck & Jahedi, 2015; Kirchler et al., 2017). While this evidence highlights the impact of cognition on risk taking behavior, there is no clear consensus on the exact nature of this effect. In the context of dual-process framework, greater reliance on intuition has been found to lead choices involving risk to be more in line with risk aversion (Kahneman & Egan, 2011). Specifically, people tend to exhibit more risk aversion when making intuitive choices involving gains. Although this result aligns with the finding that a person's score on the Cognitive Reflection Test is inversely related to risk aversion (Frederick, 2005), the causal effect of the mode of cognition on risk taking remains inconclusive. When the intuitive system is triggered under time pressure, it tends to result in increased framing effects. Specifically, individuals are prone to become more risk averse when faced with potential gains and to take more risks when faced with potential losses (Guo, Trueblood, & Diederich, 2017; Kirchler et al., 2017). Consistently, stimulating intuition by subjecting individuals to cognitive load through memorization tasks leads to a reduction in risk taking behavior (Benjamin, Brown, & Shapiro, 2013; Gerhardt, Biele, Heekeren, & Uhlig, 2016; Whitney, Rinehart, & Hinson, 2008). However, intuition has been linked to increased risk tolerance (Butler, Guiso, & Jappelli, 2013) and arousal increases risk taking (Jahedi, Deck, & Ariely, 2017), suggesting that intuition is not necessarily tied to increased risk aversion. The depletion of self-control also appears to have minimal impact (Gerhardt, Schildberg-Horisch, & Willrodt, 2017).[1] Additionally, there is evidence that lower reflection is correlated with higher probabilities to participate in risky activities (Fischer & Smith, 2004). Therefore, the impact of cognition on risk taking appears to be dependent on the method used to manipulate it.

Another potentially relevant stream of literature regards the effects of sleep deprivation or insufficient sleep on risk taking (Short & Weber, 2018; Womack, Hook, Reyna, & Ramos, 2013). Sleep deprivation and insufficient sleep are common real world occurrences that can affect decisions involving risky choices. Sleep deprivation or insufficient sleep can induce less deliberated decisions due to its disproportional impact on the prefrontal cortex activity regarding decision making (e.g., see Harrison & Horne, 2000, on this). Evidence is often in favor of greater risk taking associated with lack of sleep, but with substantial variability in terms of the risk domain and in the source of the lack of sleep and sometimes with conflicting results (see discussion in Massar, 2021). Sleepy participants appear to make riskier decisions, but at the same time they do not appear to be less rational (Castillo, Dickinson, & Petrie, 2017). The mixed evidence may also be due to the fact that sleep deprivation has various effects, such as reduced performance on subsequent tasks (Nir et al., 2017) and weakened impulse control (Bernardi et al., 2015). Additionally, sleep deprivation appears to have the potential to move towards risk neutrality by affecting risk taking behavior differently in the context of gains and losses. Specifically, McKenna, Dickinson, Orff, and Drummond (2007) found that total sleep deprivation decreased individuals' sensitivity to risk. This may be connected to the concept of local sleep, where a small group of neurons seems to deactivate while the rest of the brain remains awake (Avvenuti & Bernardi, 2022).

We contribute to this literature by investigating how risk taking is affected by the

[1] Capraro (2019) provides a comprehensive literature review on the dual-process approach to human sociality.

request to motivate one's decision. While we believe that requesting motivation is likely to induce greater reflection, it can also trigger other effects, such as reputational concerns. Nevertheless, in our opinion, requesting motivation is an interesting intervention due to its ease of implementation as a policy in a variety of circumstances. To the best of our knowledge, such a method has never been applied to study this issue.

We conducted an online experiment where participants were asked to make a simple decision involving risk using the "Bomb Risk Elicitation Task" (BRET) (Crosetto & Filippin, 2013), a validated tool for measuring risk taking behavior that has been utilized in several studies, e.g., Crosetto and Filippin (2016), Gioia (2017), Hillenbrand and Winter (2018), Spadoni and Potters (2018). Our aim is to manipulate the level of reflection by asking participants to write a text justifying their choice before making a decision. In this online experiment, our primary objective is to enhance reflection on the motivations underlying participants' choices by requesting them to provide a written rationale (as in Bilancini, Boncinelli, & Celadin, 2022; Bilancini, Boncinelli, Guarnieri, & Spadoni, 2021) with a focus on the effects on risky decisions. Our experiment was designed to be visually appealing and engaging (Holzmeister & Pfurtscheller, 2016),[2] in an attempt to address the issue of reduced attention that may arise in an online setting (Chandler, Mueller, & Paolacci, 2014).

In the BRET task, the decision that needs to be made involves determining the number of boxes that should be collected, with earnings linearly increasing with the number of boxes collected, provided that the bomb is not hidden behind one of the selected boxed, and zero earnings otherwise. Risk taking is hence increasing with the number of boxes. While we acknowledge the validity of alternative approaches used to assess risk, such as those employed by De Martino, Kumaran, Seymour, and Dolan (2006), Falk et al. (2018), Holt and Laury (2002), Mata, Frey, Richter, Schupp, and Hertwig (2018), Weber, Blais, and Betz (2002), we opted for the BRET with graphical representation because it

[2] See the screens provided in the Supplementary Information.

provides a measure of risk preferences that does not involve thoughtful introspection or complex hypothetical reasoning. Another tool similar to the BRET for assessing risk taking behavior is the Balloon Analogue Risk Task (BART) by Lejuez et al. (2002). The BART may be problematic in our setting as taking more risk could take more time, which could be associated with more reflection and interfere with our cognitive manipulation.

Our experiment shows that the request to motivate one's decision has a positive effect on risk taking, as participants in the treatment group take significantly more risk compared to the control group. This supports previous findings that decisions taken without much consideration tend to be more risk averse (Kahneman & Egan, 2011). Additionally, the treatment effect is stronger for individuals who failed the comprehension questions on probabilities of the BRET, suggesting that motivational reasoning and comprehension are substitutes in increasing risk taking or, with a different interpretation, that the effect of motivational reasoning are more pronounced under ambiguity (see the discussion for more on this). Our results provide novel evidence on the effect of cognition on risk taking and suggest the importance of reflection in shaping risk behavior.

We are not aware of any previous studies on risk taking behavior that have used the cognitive manipulation method introduced by Bilancini, Boncinelli, and Luini (2017), where subjects are required to provide a written motivation for their decisions. While the effectiveness of this method compared to traditional techniques such as time delay and priming has yet to be established (Alós-Ferrer & Garagnani, 2020; Butler et al., 2013; Kirchler et al., 2017; Kocher, Pahlke, & Trautmann, 2013; Kocher, Schindler, Trautmann, & Xu, 2019; Lotz, 2015; Peysakhovich & Rand, 2015; Rand, Greene, & Nowak, 2012; Tinghog et al., 2013), it has been demonstrated to be easily implementable and effective in an online setting (Bilancini et al., 2022; Bilancini et al., 2021).

Our results align with those found in Takemura (1993), where treated participants were instructed to contemplate a reason for their decisions and were informed that, upon completing each decision, they were required to write a justification in an open-ended manner. We stress that, while in our experiment subjects were required to rationalize their choice prior to making it, in Takemura (1993) this request was made after the decision. In this sense, we prefer using the term motivation instead of justification for our treatment, stressing that a motivation is a reason that prompts a decision, whereas justification is a reason given to account for a decision that has already been made. Although risk choices in Takemura (1993) were not incentivized, the mere request of contemplating justifications leads to a greater tendency towards taking risks, which is consistent with our findings.

Methods

This study was pre-registered on AsPredicted.org (with the pre-registration number #21007). We recruited participants through Prolific, a crowdsourcing platform commonly used for research purposes (Palan & Schitter, 2018), and our experimental design did not require simultaneous interactions among players, which is often difficult to manage in online experiments (Arechar, Gachter, & Molleman, 2018).

The experiment was conducted in March 2019 using oTree (Chen, Schonger, & Wickens, 2016)), and data were collected in a single session. On Prolific, the experiment was labeled as "An experiment on decision making", and was described as follows: "This is an experiment on decision making. We will ask you to complete a quick task, which may allow you to earn additional payments, and a short questionnaire". The sample was restricted to UK and US participants aged 18-35, with at least two previous submissions and a 50% approval rate on Prolific. We provided a show-up fee of 0.30 GBP to all participants who completed the experiment. Show-up fees and payoffs were converted to USD for US participants. All experimental participants provided informed consent. Specifically, they were informed that their data would be used anonymously for scientific purposes only. The experiment was conducted online in compliance with relevant guidelines for conducting experiments with human subjects.[3]

[3] The IMT School for Advanced Studies Lucca, requested for IRB approval, indicated the best practices to

To assess risk taking behavior, we used the BRET (Crosetto & Filippin, 2013), a widely-used method in experimental literature (Crosetto & Filippin, 2016; Gioia, 2017; Hillenbrand & Winter, 2018; Spadoni & Potters, 2018). Our implementation of the BRET required participants to choose how many boxes to collect out of a 10x10 grid with 100 boxes, with one box containing a bomb that would destroy all boxes if picked. Participants earned 0.01 GBP for each box collected, but received nothing if the bomb was picked. The bomb's location was randomly determined, and the expected performance (and earnings) was maximized at 50 boxes. To effectively capture the impact of cognitive manipulation on risk taking behavior, the BRET was played as a one-shot game with no repetitions. The formalization of subjects' decisions involves choosing their favored option among the following lotteries, which captures the balance between the potential monetary gain and the probability of achieving it:

$$L = \begin{cases} 0 & \text{with prob. } \frac{k}{100} \\ \gamma k & \text{with prob. } \frac{100-k}{100} \end{cases}$$

where $k \in [0, 100]$ is the number of boxes a subject decides to collect and $\gamma > 0$ a scale factor.

We employed a motivation treatment to manipulate the cognitive mode of participants. Participants in the treatment group were asked to write down a motivation for their decision in the BRET task before selecting the number of boxes they wanted to open. The motivation had to be at least 30 characters long. No scores or any other form of incentives were provided in relation to the content of the motivation. At the conclusion of the experiment, participants were asked to complete a questionnaire that included items on demographic information, their self-reported willingness to take risks on a scale from 0 to 10 (Dohmen et al., 2011), a test of comprehension of the task (subjects were asked: "If you have collected 35 boxes, what is the probability of getting the bomb?" and they had to

be followed for online survey-based studies, without requiring explicit approval from IRB and ethics committee.

manually enter a number (see Slide 5 in the Supplementary Information). Typical experimental protocols generally place control questions before the corresponding task. However, doing so in our study could potentially induce more deliberation, which could diminish the effectiveness of the motivation treatment in comparison to the control condition. In the last screen of the questionnaire we administered the TIPI (Rammstedt & John, 2007) to measure personality traits (not analyzed in this paper) together with a control question to verify data validity (subjects were asked: “If you’re reading this check ‘Agree a little’ ”, and they had to check as indicated; see Slide 6 in the Supplementary Information).

Results

Of the 398 participants, 9 were excluded from the dataset prior to analysis. Two of these participants failed the control question, one from the control group and one from the treatment group. Additionally, seven participants opened 100 boxes, which is a dominated strategy and likely associated with a mistake (In Appendix A, we provide analysis of the data with no restrictions). Of the remaining participants, 200 were randomly assigned to the control group, and 189 were assigned to the treatment group, where they were asked to write a motivation for their decision before completing the BRET task. On average, participants in the treatment group completed the task about 3 seconds faster than those in the control group.[4] The average completion time for the whole experiment was about 3 minutes, and the average earnings were 0.49 GBP (equivalent to around 10 GBP per hour).

Reported characteristics were similarly distributed in the treatment and control groups, indicating a balance was achieved. The distributions of gender, age, and self-reported willingness to take risks, all of which are potentially related to risk taking

[4] In Appendix B, we present a regression analysis with the time response of the BRET as the dependent variable, demonstrating that our manipulation and other variables of interest did not have a statistically significant impact on the time taken by subjects to reach a decision.

behavior, were found to be similar in the two groups based on Mann-Whitney tests (gender z = 0.034, p=0.97; age z = 0.789, p=0.43; self-reported willingness to take risk, z = 0.564, p=0.57). Furthermore, there was no significant difference in the proportion of correct answers to the comprehension question about the probability of getting the bomb in the BRET between the control group (37.5%) and the treatment group (41.3%) based on Fischer's exact test (p=0.468).

The treatment effect

We used the number of boxes opened by experimental subjects in the BRET, which ranges between 0 and 100 (referred to as "boxes"), as a measure of their risk taking behavior. A higher number of boxes opened indicates a greater level of risk taken.

The treatment had an effect on inducing experimental subjects to take more risk: the average number of boxes opened in the control group was 38.59, while the average number of boxes opened in the treatment group was 43.98, representing a statistically significant effect size of approximately 10% (Mann-Whitney test, z=2.28,p=0.028).

We can convert the BRET score into a coefficient for the utility function by assuming a CRRA utility function:

$$u(x) = x^r$$

Crosetto and Filippin (2013) estimated the values of r for the BRET, which allow us to infer the level of risk aversion for each group. The estimated value of r is approximately 0.615 for the control group and 0.765 for the treatment group, indicating that both groups are risk averse, with the control group on average being more risk averse than the treatment group.

The role of comprehension: An exploration

To ensure experimental subjects comprehended the probabilities involved in the BRET, we asked them at the end of the experiment, "If you have collected 35 boxes, what is the probability of getting the bomb?" and then they manually entered a number (see Slide 5A in the Supplementary Information). A total of 153 subjects failed to answer correctly, with 75 individuals belonging to the control group and 78 individuals in the treatment group. Additionally, 236 participants provided correct answers, comprising 125 individuals in the control group and 111 individuals in the treatment group. There were no significant differences in the answers to this comprehension question between the control and treatment groups. Additionally, there were no significant differences in the average number of boxes opened between experimental subjects who answered the comprehension question correctly and those who did not (Mann-Whitney test, z=0.94, p=0.338).

However, significant differences were found in the average number of boxes opened in the control group (Figure 1, left panel) when comparing experimental subjects who answered the comprehension question correctly to those who did not (Mann-Whitney test, z=2.54, p=0.011). Specifically, subjects who provided an incorrect answer opened fewer boxes on average than those who answered correctly. Conversely, no significant difference was found when comparing correct and incorrect responders in the treatment group (Mann-Whitney test, z=1.10, p=0.274).

This finding suggests that there may be an interaction between the treatment and the comprehension of the probabilities involved in the BRET. To further investigate this, we examined the treatment effects within two subgroups of experimental subjects: those who answered the comprehension task correctly, and those who did not. Our analysis revealed that the treatment effect was only significant for the latter group (Mann-Whitney test, z=0.28, p=0.782 and Mann-Whitney test, z=3.21, p=0.001), supporting the possibility of an interaction between treatment and comprehension. This is illustrated in Figure 1, right panel.

Additionally, we compare the mean number of boxes opened by two subgroups of participants. The first subgroup consisted of participants in the motivation treatment who answered the comprehension question correctly, while the second subgroup consisted of participants in the control treatment who answered the question incorrectly. The Mann-Whitney test did not reject the null hypothesis that the mean number of boxes opened in the two subgroups was equal (p = 0.180, z=1.34).

Regression analysis

The previous non-parametric analysis provided some insights, but in order to assess their joint statistical significance and control for demographic factors, we conducted a series of regressions as presented in Table 1. These regressions use linear regression (OLS) with the number of boxes opened as the dependent variable and treatment, comprehension, and their interaction as independent variables, along with three control variables (sex, age, and self-reported willingness to take risks).

In Model (1), we can observe that the regression confirms a positive treatment effect by including a dummy variable that takes a value of 1 when the answer to the comprehension question was correct. The estimated linear effect of the treatment indicates that, on average, about 5.5 additional boxes are opened, while comprehension does not have a significant effect in this model.

In Model (2) the interaction between the treatment and comprehension variables is added. The estimated treatment effect, net of comprehension, grows to about 11.3 (of additional boxes opened) and remains statistically significant, while the estimated coefficient of the comprehension variable is about 6.6 and becomes statistically significant. Moreover, the estimated coefficient of interaction between treatment and comprehension is about -9.6 and is statistically significant. Overall, these estimates confirm that the treatment effect is stronger among experimental subjects who did not answer correctly to the comprehension question and, further, that in the control group comprehension led to increased risk taking. These findings confirm our main result that the motivation treatment effectively increases risk taking in the BRET and, moreover, they suggest that the motivation treatment and the comprehension of the probabilities involved in the BRET are, at least to some extent, substitutes.

In Model (3), we include additional control variables, namely gender, age, and self-reported willingness to take risk. The results regarding the treatment and comprehension variables are largely consistent with those in Model (2). Notably, gender does not appear to have a significant effect on the number of boxes opened, but there is a positive relationship between self-reported willingness to take risk and the number of boxes opened. For each additional level of self-reported willingness to take risk (on a scale of 0-10), subjects tend to open three more boxes. In addition, the model suggests a mild effect of age, with older subjects opening approximately one more box for every three additional years of age (significant at the $p < 0.1$ level).[5,6]

Discussion

In this paper, we conducted an experimental investigation to examine the effects of requesting motivation on risky decisions. Previous studies in the literature have explored various forms of cognitive manipulation, and the evidence suggests that the specific form of cognitive manipulation employed plays a crucial role. In our study, we contribute to this ongoing discussion by presenting evidence from an online experiment where we sought to manipulate cognition through a motivation treatment. This treatment involved requiring experimental subjects to provide a written text that motivates their choice before they can proceed with their action. We find the motivation treatment to be a promising and easily implementable intervention that encourages individuals to consider the reasons and

[5] However, when the entire sample is analyzed this mild effect disappears (see appendix A).

[6] In appendix C, we also present regression models specifically focused on the treatment group, that incorporate text analysis variables, including a word count and a sentiment score generated by the VADER (Valence Aware Dictionary and sEntiment Reasoner) tool (Hutto & Gilbert, 2014). Both variables have a positive effect on the number of boxes opened in the BRET; however, these effects are only mildly significant at most. In Appendix D, we present regression models that distinguish by the variable Comprehension, confirming the findings obtained from the non-parametric analyses.

consequences of their choices, ultimately making them more responsible. It is important to note that while requesting motivation is likely to induce more deliberation, other cognitive effects may also arise. Investigating the mechanisms triggered by the request for providing motivation presents an avenue for future research in this field.

Our main finding is that the motivation treatment induces more risk taking, as measured by the number of boxes opened in the BRET, (Crosetto & Filippin, 2013) making individuals more prone to take risks (Kahneman & Egan, 2011). However, we also find that the treatment effect is sizeable for the subjects who did not answer correctly to the comprehension question regarding the probability distribution implied by the BRET, while the effect almost disappears for subjects who gave the correct answer. Additionally, our results suggest that the motivation treatment has no significant effect on participants' comprehension of the probability distribution in the BRET. However, we did observe a noticeable increase in risk taking behavior in response to the motivation treatment, but only among participants in the control group. Overall, the findings from our study suggest that motivational reasoning and comprehension of the involved probabilities may act as substitutes in promoting risk taking behavior. Specifically, our evidence indicates that the treatment effect is primarily driven by participants who did not pass the comprehension question. This finding raises an important methodological issue regarding the interpretation of the effect in this case. We might be tempted to interpret these findings as suggesting that requesting motivation has a greater impact on choices under ambiguity, where the probabilistic structure of the decision is not well understood, compared to choices under risk. While it may be disappointing that the treatment does not have a consistent effect, these results emphasize the importance of carefully considering the role of comprehension when evaluating treatment effects. One possible explanation is that individuals who grasp the probabilistic structure of the decision are already weighing the pros and cons of their choices, even without being explicitly asked to provide motivation. In contrast, those who do not fully understand the probabilistic structure may be more inclined to make decisions without sufficient motivational reasoning in the absence of an explicit request to do so.

Our study focuses solely on risk taking within a single task due to the need for fast and instinctive decision-making. To eliminate potential sources of confounding in our cognitive manipulation, we employ the BRET with graphical representation, which discourages deep introspection and complicated hypothetical reasoning. For comparison with other risk elicitation mechanisms, we suggest referring to Crosetto and Filippin (2013) which examines the evidence gathered with the Multiple Price List (Holt & Laury, 2002), the Ordered Lottery Choice (Eckel & Grossman, 2002), and the Investment Game (Gneezy & Potters, 1997). To address similar concerns, participants were not given the option to choose which boxes to open. While the randomness of box selection may affect the level of risk taking if participants doubt the authenticity of the selection process and have a fear of being deceived in the box extraction process, we believe that this potential confounding factor has a limited impact.

To gain a deeper understanding of the impact of comprehension of the probability distribution in choice tasks and to rule out any potential confounding variables, future research could explicitly manipulate comprehension through a treatment that enhances the probabilistic assessment of the choice task. Such experiments would provide insight into whether comprehension could be a viable policy target for influencing choices under risk or merely a measure of exogenous cognitive abilities (Brañas-Garza, Guillen, & del Paso, 2008; Brañas-Garza & Smith, 2016).

Replication files

The preregistration document and the data and code for replicating the results of this paper are available at https://osf.io/x2vj6/.

References

Alós-Ferrer, C., & Garagnani, M. (2020). The cognitive foundations of cooperation. *Journal of Economic Behavior & Organization*, *175*, 71–85.

Arechar, A. A., Gachter, S., & Molleman, L. (2018). Conducting interactive experiments online. *Experimental Economics*, *21*(1), 99–131.

Avvenuti, G., & Bernardi, G. (2022). Local sleep: A new concept in brain plasticity. *Handbook of Clinical Neurology*, *184*, 35–52.

Benjamin, D. J., Brown, S. A., & Shapiro, J. M. (2013). Who is 'behavioral'? cognitive ability and anomalous preferences. *Journal of the European Economic Association*, *11*(6), 1231–1255.

Bernardi, G., Siclari, F., Yu, X., Zennig, C., Bellesi, M., Ricciardi, E., ... Tononi, G. (2015). Neural and behavioral correlates of extended training during sleep deprivation in humans: Evidence for local, task-specific effects. *Journal of neuroscience*, *35*(11), 4487–4500.

Bilancini, E., Boncinelli, L., & Celadin, T. (2022). Social value orientation and conditional cooperation in the online one-shot public goods game. *Journal of Economic Behavior & Organization*, *200*, 243–272.

Bilancini, E., Boncinelli, L., Guarnieri, P., & Spadoni, L. (2021). Delaying and motivating decisions in the (bully) dictator game. *Available at SSRN 4163676*.

Bilancini, E., Boncinelli, L., & Luini, L. (2017). *Does focality depend on the mode of cognition? experimental evidence on pure coordination games*. Department of Economics, University of Siena.

Brañas-Garza, P., Guillen, P., & del Paso, R. L. (2008). Math skills and risk attitudes. *Economics Letters*, *99*(2), 332–336.

Brañas-Garza, P., & Smith, J. (2016). Cognitive abilities and economic behavior. *Journal of Behavioral and Experimental Economics*, *64*, 1–4.

Butler, J. V., Guiso, L., & Jappelli, T. (2013). Manipulating reliance on intuition reduces risk and ambiguity aversion. *CEPR Discussion Paper No. DP9461*.

Capraro, V. (2019). The dual-process approach to human sociality: A review. *arXiv preprint arXiv:1906.09948*.

Castillo, M., Dickinson, D. L., & Petrie, R. (2017). Sleepiness, choice consistency, and risk preferences. *Theory and Decision*, *82*, 41–73.

Chandler, J., Mueller, P., & Paolacci, G. (2014). Nonnaiveté among amazon mechanical turk workers: Consequences and solutions for behavioral researchers. *Behavior Research Methods*, *46*(1), 112–130.

Chen, D. L., Schonger, M., & Wickens, C. (2016). Otree-an open-source platform for laboratory, online, and field experiments. *Journal of Behavioral and Experimental Finance*, *9*, 88–97.

Crosetto, P., & Filippin, A. (2013). The “bomb” risk elicitation task. *Journal of Risk and Uncertainty*, *47*(1), 31–65.

Crosetto, P., & Filippin, A. (2016). A theoretical and experimental appraisal of four risk elicitation methods. *Experimental Economics*, *19*(3), 613–641.

De Martino, B., Kumaran, D., Seymour, B., & Dolan, R. J. (2006). Frames, biases, and rational decision-making in the human brain. *Science*, *313*(5787), 684–687.

Deck, C., & Jahedi, S. (2015). The effect of cognitive load on economic decision making: A survey and new experiments. *European Economic Review*, *78*, 97–119.

Dohmen, T., Falk, A., Huffman, D., Sunde, U., Schupp, J., & Wagner, G. G. (2011). Individual risk attitudes: Measurement, determinants, and behavioral consequences. *Journal of the European Economic Association*, *9*(3), 522–550.

Eckel, C. C., & Grossman, P. J. (2002). Sex differences and statistical stereotyping in attitudes toward financial risk. *Evolution and human behavior*, *23*(4), 281–295.

Falk, A., Becker, A., Dohmen, T., Enke, B., Huffman, D., & Sunde, U. (2018). Global evidence on economic preferences. *The Quarterly Journal of Economics*, *133*(4), 1645–1692.

Fischer, S., & Smith, G. T. (2004). Deliberation affects risk taking beyond sensation seeking. *Personality and Individual Differences*, *36*(3), 527–537.

Frederick, S. (2005). Cognitive reflection and decision making. *Journal of Economic Perspectives*, *19*(4), 25–42.

Gerhardt, H., Biele, G. P., Heekeren, H. R., & Uhlig, H. (2016). *Cognitive load increases risk aversion*. SFB 649 Discussion Paper.

Gerhardt, H., Schildberg-Horisch, H., & Willrodt, J. (2017). Does self-control depletion affect risk attitudes? *European Economic Review*, *100*, 463–487.

Gioia, F. (2017). Peer effects on risk behaviour: The importance of group identity. *Experimental Economics*, *20*(1), 100–129.

Gneezy, U., & Potters, J. (1997). An experiment on risk taking and evaluation periods. *Quarterly Journal of Economics*, *112*(2), 631–645.

Guo, L., Trueblood, J. S., & Diederich, A. (2017). Thinking fast increases framing effects in risky decision making. *Psychological Science*, *28*(4), 530–543.

Harrison, Y., & Horne, J. A. (2000). The impact of sleep deprivation on decision making: A review. *Journal of experimental psychology: Applied*, *6*(3), 236.

Hillenbrand, A., & Winter, F. (2018). Volunteering under population uncertainty. *Games and Economic Behavior*, *109*, 65–81.

Holt, C. A., & Laury, S. K. (2002). Risk aversion and incentive effects. *American Economic Review*, *92*(5), 1644–1655.

Holzmeister, F., & Pfurtscheller, A. (2016). Otree: The "bomb" risk elicitation task. *Journal of Behavioral and Experimental Finance*, *10*, 105–108.

Hutto, C., & Gilbert, E. (2014). Vader: A parsimonious rule-based model for sentiment analysis of social media text. In *Proceedings of the international aaai conference on web and social media* (Vol. 8, *1*, pp. 216–225).

Jahedi, S., Deck, C., & Ariely, D. (2017). Arousal and economic decision making. *Journal of Economic Behavior & Organization*, *134*, 165–189.

Kahneman, D., & Egan, P. (2011). *Thinking, fast and slow*. Farrar, Straus and Giroux New York.

Kirchler, M., Andersson, D., Bonn, C., Johannesson, M., Sørensen, E. Ø., Stefan, M., ... Vastfjall, D. (2017). The effect of fast and slow decisions on risk taking. *Journal of Risk and Uncertainty*, *54*(1), 37–59.

Kocher, M. G., Pahlke, J., & Trautmann, S. T. (2013). Tempus fugit: Time pressure in risky decisions. *Management Science*, *59*(10), 2380–2391.

Kocher, M. G., Schindler, D., Trautmann, S. T., & Xu, Y. (2019). Risk, time pressure, and selection effects. *Experimental Economics*, *22*(1), 216–246.

Lejuez, C. W., Read, J. P., Kahler, C. W., Richards, J. B., Ramsey, S. E., Stuart, G. L., ... Brown, R. A. (2002). Evaluation of a behavioral measure of risk taking: The balloon analogue risk task (bart). *Journal of Experimental Psychology: Applied*, *8*(2), 75.

Lotz, S. (2015). Spontaneous giving under structural inequality: Intuition promotes cooperation in asymmetric social dilemmas. *PLOS ONE*, *10*(7), e0131562.

Massar, S. A. (2021). Sleep loss and risk-taking: New findings in a field that needs more clarity. Oxford University Press US.

Mata, R., Frey, R., Richter, D., Schupp, J., & Hertwig, R. (2018). Risk preference: A view from psychology. *Journal of Economic Perspectives*, *32*(2), 155–72.

McKenna, B. S., Dickinson, D. L., Orff, H. J., & Drummond, S. P. (2007). The effects of one night of sleep deprivation on known-risk and ambiguous-risk decisions. *Journal of sleep research*, *16*(3), 245–252.

Nir, Y., Andrillon, T., Marmelshtein, A., Suthana, N., Cirelli, C., Tononi, G., & Fried, I. (2017). Selective neuronal lapses precede human cognitive lapses following sleep deprivation. *Nature medicine*, *23*(12), 1474–1480.

Palan, S., & Schitter, C. (2018). Prolific. ac—a subject pool for online experiments. *Journal of Behavioral and Experimental Finance*, *17*, 22–27.

Peysakhovich, A., & Rand, D. G. (2015). Habits of virtue: Creating norms of cooperation and defection in the laboratory. *Management Science*, *62*(3), 631–647.

Rammstedt, B., & John, O. P. (2007). Measuring personality in one minute or less: A 10-item short version of the big five inventory in english and german. *Journal of Research in Personality*, *41*(1), 203–212.

Rand, D. G., Greene, J. D., & Nowak, M. A. (2012). Spontaneous giving and calculated greed. *Nature*, *489*(7416), 427.

Short, M. A., & Weber, N. (2018). Sleep duration and risk-taking in adolescents: A systematic review and meta-analysis. *Sleep medicine reviews*, *41*, 185–196.

Spadoni, L., & Potters, J. (2018). The effect of competition on risk taking in contests. *Games*, *9*(3), 72.

Takemura, K. (1993). The effect of decision frame and decision justification on risky choice. *Japanese Psychological Research*, *35*(1), 36–40.

Tinghog, G., Andersson, D., Bonn, C., Bottiger, H., Josephson, C., Lundgren, G., ... Johannesson, M. (2013). Intuition and cooperation reconsidered. *Nature*, *498*(7452), E1.

Weber, E. U., Blais, A.-R., & Betz, N. E. (2002). A domain-specific risk-attitude scale: Measuring risk perceptions and risk behaviors. *Journal of behavioral decision making*, *15*(4), 263–290.

Whitney, P., Rinehart, C. A., & Hinson, J. M. (2008). Framing effects under cognitive load: The role of working memory in risky decisions. *Psychonomic bulletin & review*, *15*, 1179–1184.

Womack, S. D., Hook, J. N., Reyna, S. H., & Ramos, M. (2013). Sleep loss and risk-taking behavior: A review of the literature. *Behavioral sleep medicine*, *11*(5), 343–359.

Dependent variable:	Model	Model	Model
Number of boxes opened	(1)	(2)	(3)
Motivation (treatment)	5.460**	11.25***	10.69***
	(2.219)	(3.679)	(3.502)
Comprehension (correct answer)	1.895	6.619**	7.045**
	(2.308)	(3.159)	(2.944)
Motivation $\times$ Comprehension		-9.558**	-9.116**
		(4.594)	(4.401)
Female			0.137
			(2.188)
Age			0.378*
			(0.223)
Self-reported willingness to take risk			3.071***
			(0.534)
Constant	37.41***	34.45***	7.045
	(2.173)	(2.633)	(7.774)
Observations	389	389	389
Adjusted R^2	0.012	0.021	0.108

Table 1

Linear regressions where the dependent variable is the number of boxes opened in the BRET. Motivation is a dummy variable taking value 1 if the subject is in the treatment group; Comprehension is a dummy variable taking value 1 if the subject has correctly answered the question about the probability implied by the BRET; Female is a dummy variable taking value 1 if the subject is a woman; Age is equal to the number of years of the subject; Self-reported willingness to take risk is a variable between 0 and 10 where 10 is the maximum willingness to take risk. Robust standard errors are reported in parenthesis. Statistical significance is indicated as follows: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

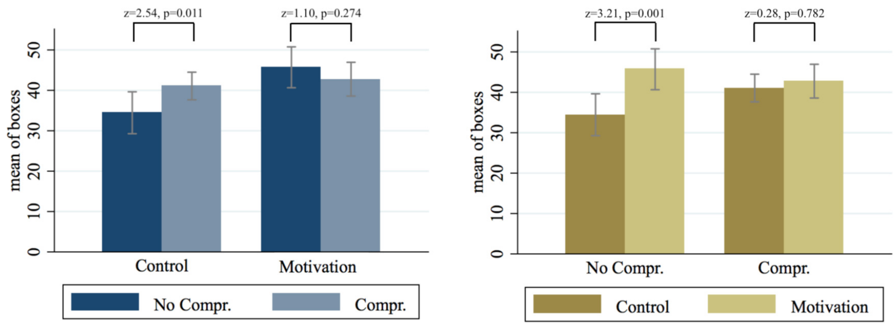

Figure 1

Left panel. *Number of boxes opened in the control and treatment groups, splitting experimental subjects in the group of those who gave a wrong answer to the comprehension question regarding the probabilities involved in the BRET (left bar) and in the group of those who gave a correct answer (right bar). No significant difference is found between the two groups for the treatment group, while in the control group we find that more boxes are opened by those who answered correctly to the comprehension question (statistics reported for Mann-Whitney tests of equal distributions).* Right panel. *Number of boxes opened by experimental subjects split in the group of those who gave a wrong answer to the comprehension question regarding the probabilities involved in the BRET (left bar) and in the group of those who gave a correct answer (right bar), further divided by control and treatment groups. No significant treatment effect is found for the group of those who answered correctly to comprehension question, while a strong treatment effect is found (from 34.5 to 45.7 boxes) for those who answered wrongly (statistics reported for Mann-Whitney tests of equal distributions). Observations: Control & No Compr., 75; Control & Compr., 125; Motivation & No Compr., 78; Motivation & Compr., 111.*

Appendix A

Unrestricted sample analysis

		Treatment		M-W test	Row Total
		Control	**Motivation**		
Comprehension	**No**	36.16 (24.86) [77]	47.20 (24.87) [82]	**p = 0.002** z=-3.04	41.85 (25.39) [159]
	Yes	42.26 (20.81) [128]	42.77 (22.40) [111]	**p = 0.984** z=0.02	42.49 (21.52) [239]
M-W test		**p = 0.017** z=2.40	**p = 0.176** z=1.35		**p = 0.504** z=0.67
Column Total		39.97 (22.55) [205]	44.65 (23.52) [193]	**p = 0.047** z=1.99	42.24 (23.12) [398]

Table A1

Mann-Whitney tests for comparing means of boxes opened by groups and subgroups generated by treatments (control and motivation) and comprehension (yes or no). Standard deviations are in round parentheses. Numbers of observations are in squared brackets. The tested hypothesis is that the mean of boxes opened by one group does not differ from the mean of boxes opened in the other group.

Dependent variable:	Model	Model	Model
Mean of boxes opened	(1)	(2)	(3)
Motivation (treatment)	4.726**	11.04***	10.45***
	(2.322)	(3.940)	(3.711)
Comprehension (correct answer)	0.887	6.102*	6.729**
	(2.434)	(3.375)	(3.127)
Motivation × Comprehension		-10.53**	-10.06**
		(4.842)	(4.612)
Female			0.469
			(2.300)
Age			0.351
			(0.234)
Self-reported willingness to take risks			3.240***
			(0.556)
Constant	39.41***	36.16***	8.191
	(2.316)	(2.829)	(8.060)
Observations	398	398	398
Adjusted R^2	0.006	0.016	0.103

Table A2

Linear regressions where the dependent variable is the number of boxes opened in the BRET. Motivation is a dummy variable taking value 1 if the subject is in the treatment group; Comprehension is a dummy variable taking value 1 if the subject has correctly answered the question about the probability implied by the BRET; Female is a dummy variable taking value 1 if the subject is a woman; Age is equal to the number of years of the subject; Self-reported willingness to take risk is a variable between 0 and 10 where 10 is the maximum willingness to take risk. Robust standard errors are reported in parenthesis. Statistical significance is indicated as follows: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Appendix B

Time Response analysis

Dependent variable:	Model	Model	Model
Time response	(1)	(2)	(3)
Motivation (treatment)	-4.142	-2.511	-3.679
	(4.719)	(7.877)	(8.024)
Comprehension (correct answer)	2.088	3.419	2.254
	(4.915)	(7.291)	(7.503)
Motivation × Comprehension		-2.692	-1.318
		(9.829)	(10.01)
Female			-6.830
			(5.097)
Age			-0.430
			(0.521)
Self-reported willingness to take risk			0.880
			(1.109)
Constant	54.45***	53.61***	65.60***
	(4.770)	(5.963)	(19.87)
Observations	389	389	389
Adjusted R^2	0.0019	0.0022	0.0126

Table B1

Linear regressions where the dependent variable is the number of seconds spent in the BRET. Motivation is a dummy variable taking value 1 if the subject is in the treatment group; Comprehension is a dummy variable taking value 1 if the subject has correctly answered the question about the probability implied by the BRET; Female is a dummy variable taking value 1 if the subject is a woman; Age is equal to the number of years of the subject; Self-reported willingness to take risk is a variable between 0 and 10 where 10 is the maximum willingness to take risk. Robust standard errors are reported in parenthesis. Statistical significance is indicated as follows: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Appendix C

Text analysis

Dependent variable:	Model	Model	Model	Model
Number of boxes opened	(1)	(2)	(3)	(4)
Comprehension (correct answer)	-4.780	-3.810	-4.852	-3.704
	(3.473)	(3.376)	(3.443)	(3.414)
Word count	0.193	0.351*		
	(0.168)	(0.196)		
VADER (sentiment score)			5.420	4.744
			(3.922)	(3.927)
Female		2.587		1.559
		(3.406)		(3.347)
Age		0.370		0.300
		(0.317)		(0.332)
Self-reported willingness to take risks		3.301***		2.952***
		(0.801)		(0.841)
Constant	44.59***	11.73	45.92***	19.92*
	(3.655)	(10.93)	(3.009)	(11.40)
N	193	193	193	193
Adjusted R^2	0.0154	0.1059	0.0181	0.0924

Table C1

Linear regressions where the dependent variable is the number of boxes opened in the BRET. Comprehension is a dummy variable taking value 1 if the subject has correctly answered the question about the probability implied by the BRET; Word count is a variable that tracks the number of words used in the motivation; VADER score ranges from -1, indicating negative sentiment, to +1, indicating positive sentiment. Female is a dummy variable taking value 1 if the subject is a woman; Age is equal to the number of years of the subject; Self-reported willingness to take risk is variable between 0 and 10 where 10 is the maximum willingness to take risk. Robust standard errors are reported in parenthesis. Statistical significance is indicated as follows: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Appendix D

Regression analysis by Comprehension

Dependent variable:	Comprehension	
Number of boxes opened	NO	YES
Motivation (treatment)	11.12***	0.492
	(3.714)	(2.710)
Female	-0.790	0.945
	(3.962)	(2.844)
Age	0.726*	0.111
	(0.399)	(0.279)
Self-reported willingness to take risks	3.219***	3.228***
	(0.833)	(0.737)
Constant	-1.734	21.34**
	(13.04)	(9.736)
N	159	239
Adjusted R^2	0.1556	0.0879

Table D1

Linear regressions where the dependent variable is the number of boxes opened in the BRET. Comprehension is a dummy variable taking value 1 if the subject has correctly answered the question about the probability implied by the BRET. Female is a dummy variable taking value 1 if the subject is a woman; Age is equal to the number of years of the subject; Self-reported willingness to take risk is variable between 0 and 10 where 10 is the maximum willingness to take risk. Robust standard errors are reported in parenthesis. Statistical significance is indicated as follows: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.