Anthropos 56 (1): 213–225 | ISSN 0587-5161 | E-ISSN 2630-4082

Effect of Cognitive Reflection on Escalation of Commitment

Petra Rekar
PhD student at the University of Ljubljana, Slovenia
petra.rekar@gmail.com

Mitja Perat
Inštitut za razvoj človeških virov, Slovenia
mitjaperat@institut.burnout.si

Abstract. Sunk costs are known to be one of the drivers of escalation of commitment. One explanation for the effect is the overgeneralization of the waste not rule, or the utilization of automatic Type 1 processing, when the more deliberate Type 2 would be needed. The objective of the study was to test if the cognitive reflection test (CRT), as a measure of an individual's tendency to engage in analytical thinking, is related to the escalation of commitment. We hypothesized that individuals scoring lower on the test will exhibit the tendency to honour sunk costs. Using a continuation with investment problem we found that CRT is not related to decision making which includes sunk cost. We can infer that CRT is not the only or the main predictor of the escalation of commitment.

Key Words: decision making, cognitive reflection, escalation of commitment, sunk costs, analytical thinking

Učinek kognitivne refleksije na stopnjevanje zavezanosti

Povzetek. Poslovno nepovratni stroški so dejavnik, ki vpliva na stopnjevanje zavezanosti k izbiri. Ena od razlag za nastanek učinka je pretirana posplošitev pravila, da se z denarjem ne razmetava, oz. uporaba avtomatiziranih hevristik prvega reda, takrat ko bi bila potrebna uporaba analitičnega razmišljanja. Namen raziskave je preverjanje, ali se test kognitivne refleksije, kot mera posameznikove nagnjenosti k analitičnemu razmišljanju, povezuje z zavezanostjo k določeni izbiri. Predvidevali smo, da bodo posamezniki, ki bodo dosegli nižjo mero kognitivne refleksije, v večji meri upoštevali nepovratne stroške pri investicijskih odločitvah. Pri nalogi nadaljevanja z investicijo smo ugotovili, da se test ne povezuje z odločanjem, ki vsebuje nepovratne stroške. Na osnovi tega sklepamo, da testa kognitivne refleksije ne moremo uporabiti kot prediktorja za ugotavljanje stopnjevanja zavezanosti.

https://doi.org/10.26493/2630-4082.56.213-225

Ključne besede: odločanje, kognitivna refleksija, stopnjevanje zavezanosti, poslovno nepovratni stroški, analitično razmišljanje

Literature Review

Honouring sunk costs is a well-documented effect, where an individual continues with an investment or endeavour once an initial amount of assets (money, time or effort) have been allocated to it (Arkes and Blumer 1985). This type of behaviour goes against the standard economic theory (Von Neumann and Morgenstern 1947), which is normative in its essence and provides a norm that is the correct course of action. The normative approach to decision making provides standards of how decisions should be made, with the aim to assist individuals to maximize the outcome. According to economic theory, the normatively correct decision is that only future (or incremental) revenues and costs should be considered when evaluating an investment (or project). A sunk cost has already occurred, is irrecoverable and as such is not affected by the decision, hence it should not be considered when evaluating an investment. However, research indicates this is not the case and that sunk costs commonly drive the escalation of commitment (Schmidt and Calantone 2002; Sleesman et al. 2012; Soman and Gourville 2001) in finance (Tan and Yates 2002), customer loyalty (Jang, Mattila, and Bai 2007; Liang, Lee, and Tung 2014), or the continuation of an activity (Åstebro, Jeffrey, and Adomdza 2007). Familiarity with economic theory or with rational decision making alone does not always reduce or eliminate this effect (Fennema and Perkins 2007; Roth, Robbert, and Straus 2015), nor is it reduced by one's cognitive ability (Haita-Falah 2017; Stanovich and West 2008). On the contrary, it has been argued that being more analytical might actually amplify the effect, as individuals who make logical arguments for a prior investment might be more inclined to allocate additional resources (Wong, Kwong, and Ng 2008). The effect is well researched from the angles of instruction (Tan and Yates 1995), frame (Klaczynski 2001; Salter and Sharp 2001), the level of sunk costs as the percentage of the total investment (Garland 1990), and the completion of an investment (Boehne and Paese 2000), as well as some differences in the characteristics of the individual. The effect is strengthened by state orientation (van Putten, Zeelenberg, and van Dijk 2010), agreeableness and conscientiousness (Fujino et al. 2016), and younger age (Bruine de Bruin, Strough, and Parker 2014; Eberhardt, Bruine de Bruin, and Strough 2019). It is believed that experience reduces the effect in older individuals; however, the type of sunk cost appears to play

a key role. When the cost is monetary, experience plays a positive role; however, experienced inventors who receive a negative review of their idea (costs were effort and time) continue to invest more assets (money and time) in further development than their more inexperienced counterparts (Åstebro, Jeffrey, and Adomdza 2007). Domain-specific knowledge is believed to be helpful, but only when the situation cues its use. In one of the studies, individuals with knowledge of standard economic theory (CPAS, MBAS, and accounting students) made more normatively correct decisions when dealing with a clearly economic decision problem (Fennema and Perkins 2007). In a similar manner, providing individuals with training in the sunk cost rule positively affected normative decision making (Larrick, Morgan, and Nisbett 1990).

There appears to be several explanations of the causes, ranging from mental accounting (Thaler 1999), loss aversion (Arkes and Blumer 1985), commitment to project completion (Boehne and Paese 2000), effort justification (Cunha and Caldieraro 2009), agency (Harrison and Harrell 1993), or the waste not rule (Arkes and Ayton 1999). Although depending on circumstances, the type of sunk costs (money, time, effort), or individuals' characteristics, any of these mechanisms could explain the effect. In the case of a monetary sunk cost, an individual acquainted with standard economic theory should be able to make a normatively correct decision, assuming they either reflect on the task (engage in analytical thinking), or they obtained sufficient relevant experience, which would facilitate a correct automatic response. Arkes and Ayton (1999) propose that the sunk cost effect is a result of the overgeneralization of the 'do not waste' rule, where ceasing the project would be considered a waste of money already spent. Essentially, they posit that the effect is a result of the so-called Type 1 processing. In cognitive science, there is a consensus that individuals switch between two qualitatively different modes of processing, namely the autonomous and fast Type 1 and the more effortful and slow Type 2. By default, individuals have a tendency to utilize Type 1, as it is cognitively less costly; however, this type of thinking can lead to 'irrational' decisions (Evans and Stanovich 2013; Toplak, West, and Stanovich 2014), as it is dependent on the cues from the environment, as well as intrinsic factors (such as motivation or mood) (Klaczynski 2001). The cognitive reflection test (CRT) is a popular measure to distinguish between individuals more prone to Type 1 processing (automatic, fast) and those who are more analytical. In spite of its wide use, it is stable over time (Stagnaro, Pennycook, and Rand 2018) and robust to multiple exposures

(Bialek and Pennycook 2017). The test is composed of 3 logical problems, which cue incorrect 'intuitive' answers that need to be suppressed to deliberate on the correct answer (Frederick 2005). The higher the number of correct answers, the more analytical an individual is. The test seems to be a good predictor of performance in tasks that require engagement in more effortful deliberation, such as heuristics and biases (Frederick 2005; Toplak, West, and Stanovich 2011). Additionally, it is related to impression management, with colour manipulations affecting judgements of less analytical (more impulsive) individuals (Cardoso, Leite, and de Aquino 2018). Stanovich (2012) proposes that deviations from normative decision making may be the result of individual differences in thinking dispositions. To successfully perform on a variety of heuristics and biases tasks, an individual needs to first detect that there is a need to override Type 1 processing and inhibition, but they also need to possess the right mindware, including knowledge (Stanovich 2018; Stanovich and West 2008). As CRT requires an individual to suppress their initial (intuitive, though incorrect) response, Ronayne, Sgroi and Tuckwell (2021) showed that the capacity for reflection predicts sunk cost effect, where the 'cost' is effort exerted.

To elicit the sunk cost effect, two types of tasks are commonly used – utilization tasks, where an individual needs to select between two equally appealing options – and progress decisions, where an individual needs to decide whether to escalate a commitment. To measure the effect of monetary sunk cost, utilization decisions could be potentially problematic, as they might not be recognized as economic decisions and individuals might not apply domain-specific knowledge. In the case of progress (or the escalation of commitment) decisions, individuals should be aware of the type of decision they are making and apply the necessary knowledge (Roth, Robbert, and Straus 2015), assuming the context cues relevant domain knowledge.

The aim of the study was to inspect whether more analytical individuals would more often reach a normatively correct decision in an escalation of commitment task. We hypothesized that if the sunk cost effect stems from the overgeneralization of the waste not rule, individuals with a higher propensity for analytical thinking should not succumb to sunk costs. We used the cognitive reflection test as a measure of propensity for analytical thinking, as it is believed to be associated with good decision making, when deliberation is paramount, such as on heuristics and biases tasks. However contrary to research so far, we failed to find an associa-

tion between CRT and sunk costs, which is a classic heuristic in the financial sphere. We demonstrated that simply being more analytical (scoring higher on the CRT), even when possessing the right knowledge, is not sufficient to overcome the fallacy.

Participants

A total of 188 participants were included in the study (127 women; 61 men; mean age = 19.54, SD = 4.24). A convenience sample was used, where the majority of the participants (n = 164) came from a pool of 4th year students of an economics high school, while a minority (n = 24) were professionals working in finance with degrees in economics or a similar subject. In the case of the students, we were allowed to modify their curriculum by including information regarding the valuation of investments (which included the treatment of sunk costs); however, no particular stress was placed on this information. This information was given roughly 5–6 weeks before the testing took place to ensure that it was not too fresh in their memory and that they could make the connection. As the valuation of projects is a part of the standard curricula at the university level, it was assumed that professionals had this knowledge. All the materials were in the Slovene language as all of the participants were native speakers.

Methodology

For the students, testing took place during their regular economics class. Upon being informed about the study they were asked to give their consent. The experiment was a paper and pencil one and consisted of a short financial assignment, a CRT test and a demographics questionnaire. Firstly, the participants were presented with an investment problem which involved sunk costs, modelled after the airline company problem by Arkes and Blumer (1985), where they had to decide whether to continue with an investment of the development of a virtual reality headset when the competition had just launched a similar product, while their company would need 3 more years to complete it. A certain amount of sunk costs related to the development so far had already been incurred, which was clearly stated. We included the information on expected revenues and the uncertainty associated with them, as this information would normally be available. Moreover, the expected revenues are vital information as it enables individuals to set a budget without using subjective expectations about the value of the investment (Heath 1995).

Table 1 Results of Statistical Analysis

Item	Whole sample	Women	Men	Students	Employees
n	188	127	61	164	24
Mean	0.840	0.630	1.280	0.683	1.920
Std. error mean	0.078	0.084	0.154	0.074	0.255
Median	0.000	0.000	1.000	0.000	2.500
Standard deviation	1.070	0.940	1.200	0.950	1.250
Variance	1.150	0.890	1.440	0.910	1.560
Minimum	0	0	0	0	0
Maximum	3	3	3	3	3
Skewness	0.953	1.390	0.275	1.190	−0.562
Std. error skewness	0.177	0.215	0.306	0.190	0.472
Kurtosis	−0.489	0.822	−1.480	0.265	−1.420
Std. error kurtosis	0.353	0.427	0.604	0.377	0.918

Table 2 Chi-Square Statistics for Sunk Cost Task by Gender

Sunk cost task	Women		Men		$\chi^2(1)$
	n	%	*n*	%	
Incorrect answer	62	32.98	29	15.43	0.027
Correct answer	65	34.57	32	17.02	

NOTES $p = 0.870$.

The participants had to decide whether they would continue with this investment. The correct solution was to continue with the project (since the projected revenues surpassed the projected costs) and disregard the sunk costs. The use of calculators was not allowed as only a very simple calculation was needed (adding/subtracting digits up to 10). Upon completion, they were given a 3-item cognitive reflection test (Frederick 2005), which was translated into Slovene using forward/backward translation. Although some have questioned the reliability of the test on adolescents, as it could be too difficult (Primi et al. 2016), we deemed it would be appropriate given that all participants were at least 18 years old at the time of taking the test. Lastly, we collected demographic data.

Results

Firstly, we inspected for any differences in the sample, where we found no differences between participants in reaching the correct decision. Employees did not perform any better than students ($\chi^2(1, n = 188) = 1.086$, $p = 0.297$). Additionally, we also found no difference with respect to gen-

Table 3 Chi-Square Statistics for Sunk Cost Task by Participants

Sunk cost task	Students		Employees		$\chi^2(1)$
	n	%	*n*	%	
Incorrect answer	77	40.96	14	7.45	1.086
Correct answer	87	46.28	10	5.32	

NOTES $p = 0.297$.

Table 4 Chi-Square Statistics Split by CRT Score

Sunk cost task	CRT_Score				$\chi^2(3)$
	0	1	2	3	
Incorrect answer	51	16	12	12	1.463
Correct answer	50	24	11	12	

NOTES $p = 0.691$.

Table 5 Chi-Square Statistics for Participants with Different Levels of Cognitive Reflection

Item	Incorrect answer	Correct answer	$\chi^2(1)$	*p*
High_analytical	12	12	0.028	0.867
Rest	79	85		
Low_analytical	51	50	0.382	0.537
Rest	40	47		
Mid_analytical	28	35	0.595	0.441
Rest	63	62		

der ($\chi^2(1, n = 188) = 0.027, p = 0.870$). To test our assumption that more analytical individuals would more often reach normatively correct solutions (would not honour sunk costs), we started by calculating the participants' CRT score. In line with other reports (Campitelli and Labollita 2010; Frederick 2005), 46.3 % of the participants correctly solved at least one problem. The average number of correct answers was 0.84 (SD = 1.073), with 21.3 % solving one problem correctly, 12.2 % solving two problems correctly and 12.8 % solving all three problems correctly. We did find some differences in how well the two groups scored on the test; employees performed better, correctly solving 1.92 tasks (students 0.68), which was statistically significant ($\chi^2(3, n = 188) = 35.694, p = 0.000$). We applied a Chi-Square test (where we separated individuals based on number of points on the test), which rejected our hypothesis. We found that CRT is not related to the escalation of a commitment in the presence of sunk

costs, ($\chi^2(3, n = 188) = 1.463, p = 0.691$). To confirm the results, we made a distinction proposed by Frederick (2005) on highly analytical participants (who solved all 3 problems correctly), medium (those who solved 1 or 2 problems correctly) and low analytical participants (who did not solve any problem correctly). Dividing the participants in this way (by separating the extremes) corroborated our initial results. For highly analytical participants, we obtained ($\chi^2(1, n = 188) = 0.028, p = 0.867$), for low analytical ones ($\chi^2(1, n = 188) = 0.382, p = 0.537$), and for participants classified as medium analytical ($\chi^2(1, n = 188) = 0.595, p = 0.441$).

General Discussion

We wanted to inspect whether the disposition towards analytical thinking can explain the results on a monetary sunk cost task in a group of individuals acquainted with standard economic theory. With respect to sunk cost fallacy being related to the age of participants, our result is contrary to other studies, where older participants were less likely to continue with the commitment to a failing plan (Bruine de Bruin, Strough, and Parker 2014; Eberhardt, Bruine de Bruin, and Strough 2019; Karns 2012). Our results did not find a connection between reaching normatively correct decisions and a CRT score, implying that analytical thinking is neither the main nor only factor preventing the sunk cost effect. These results are in line with some previous research, which shows that the sunk cost fallacy is not related to measures of executive function processes (Del Missier, Mäntylä, and Bruine De Bruin 2012). Our findings are unlike those of Ronayne and colleagues (2021); however, this could be due to a difference in the task used. The propensity for analytical thinking might be a good predictor when sunk cost is in the form of effort expended, where it would be sufficient for an individual to pause and consider the expenditure of effort so far vis-à-vis alternatives before continuing. However, in the case of money spent, reflection (switching to analytical thinking) alone might not be sufficient, even when the task is clearly from a domain the participants are familiar with and they should apply knowledge-based decision making. It is likelier that the interplay of several factors determines whether an individual will behave normatively correctly on such tasks. In our sample, even though the participants would have learned about sunk costs before, we cannot rule out the lack of appropriate mindware. Individuals first need to recognize the task and then apply the necessary knowledge, implying a certain level of the inhibition of impulse. As CRT is a measure of inhibition, we only controlled at the level when

an individual already needs to apply knowledge, whereas we did not control for how the participants interpreted the task. Although instructions pointed out that the assignment had a correct answer, we did not emphasize that it should be solved based on the knowledge they had received in class or during schooling, to keep it in line with decision making in reality. It might be that participants interpreted the assignment as if we were asking for their preference and they had not applied the necessary knowledge in the first place. Although the materials were pilot tested and we did not receive any ambiguity regarding the interpretation of the questions, such an explanation cannot be ruled out. In the cases where participants did not have much practical experience treating (monetary) sunk cost, a problem of task recognition might arise, which results in the application of the wrong decision rules, indicating that the use of knowledge in less experienced individuals needs to be prompted by the environment to prevent the sunk cost fallacy.

Furthermore, some researchers suggest that either general or statistical numeracy has greater predictive power in superior decision making than CRT (Cokely et al. 2018; Sobkow, Olszewska, and Traczyk 2020). Although we collected the average grade in mathematics class, we did not control specifically for this type of numeracy, which is a limiting factor in our research.

Certain design features also limit the ecological validity. Firstly, in reality sunk costs would normally be known to a decision maker and not necessarily explicitly stated in the analysis. By explicitly stating sunk costs, the saliency of this information might override the application of relevant knowledge. Secondly, although the use of hypothetical scenarios is common in such settings, it might be problematic. The stakes are clearly not real, which might reduce the motivation that would be present in a real world setting. Participants need to position themselves in the role of a CEO; moreover, the amounts of money (millions) can be too abstract. However, making the assignment more familiar (e.g. by using a smaller amount, investment in common items) can also be problematic, as it might be unduly influenced by recent experiences.

The biggest hurdle to the generalizability of our results is the sample size and composition. Although students are commonly used and they were supplemented with participants who work in the field of finance, our sample was relatively young and perhaps lacking some experience. To counterbalance this, the sample would need to include older individuals with more work experience in the field of finance. The task also required

a moderate cognitive effort, meaning participants needed to be motivated to engage in solving it, though we do not deem this as particularly problematic, as participation was voluntary and they could withdraw at any point.

Although the area of the escalation of commitment received significant interest, it might be prudent to inspect the effect by using new instruments that would provide a slightly different view and contribute to a better understanding of the phenomena.

References

Arkes, Hal R., and Peter Ayton. 1999. 'The Sunk Cost and Concorde Effects: Are Humans Less Rational Than Lower Animals?' *Psychological Bulletin* 125 (5): 591–600.

Arkes, Hal R., and Catherine Blumer. 1985. 'The Psychology of Sunk Cost.' *Organizational Behavior and Human Decision Processes* 35 (1): 124–140.

Åstebro, Thomas, Scott A. Jeffrey, and Gordon K. Adomdza. 2007. 'Inventor Perseverance after Being Told to Quit: The Role of Cognitive Biases.' *Journal of Behavioral Decision Making* 20 (3): 253–272.

Bialek, Michael, and Gordon Pennycook. 2017. 'The Cognitive Reflection Test Is Robust to Multiple Exposures.' *Behavior Research Methods* 50:1953–1959.

Boehne, Donna M., and Paul W. Paese. 2000. 'Deciding Whether to Complete or Terminate an Unfinished Project: A Strong Test of the Project Completion Hypothesis.' *Organizational Behavior and Human Decision Processes* 81 (2): 178–94.

Bruine de Bruin, Wändi, JoNell Strough, and Andrew M. Parker. 2014. 'Getting Older Isn't All That Bad: Better Decisions and Coping When Facing "Sunk Costs."' *Psychology and Aging* 29 (3): 642–647.

Campitelli, Guillermo, and Martín Labollita. 2010. 'Correlations of Cognitive Reflection with Judgments and Choices.' *Judgment and Decision Making* 5 (3): 182–191.

Cardoso, Ricardo Lopes, Rodrigo de Oliveira Leite, and André Carlos Busanelli de Aquino. 2018. 'The Effect of Cognitive Reflection on the Efficacy of Impression Management: An Experimental Analysis with Financial Analysts.' *Accounting, Auditing & Accountability Journal* 31 (6): 1668–1690.

Cokely, Edward T., Adam Feltz, Saima Ghazal, Jinan N. Allan, Dafina Petrova, and Rocio Garcia-Retamero. 2018. 'Decision Making Skill: From Intelligence to Numeracy and Expertise.' In *Cambridge Handbook of Expertise and Expert Performance,* edited by K. Anders Ericsson, Robert R. Hoffman, Aaron Kozbelt, and A. Mark Williams, 476–505. 2nd. ed. Cambridge: Cambridge University.

Cunha, Jr., Marcus, and Fabio Caldieraro. 2009. 'Sunk-Cost Effects on Purely Behavioral Investments.' *Cognitive Science* 33 (1): 105–113.

Del Missier, Fabio, Timo Mäntylä, and Waendi Bruine De Bruin. 2012. 'Decision-Making Competence, Executive Functioning, and General Cognitive Abilities.' *Journal of Behavioral Decision Making* 25 (4): 331–351.

Eberhardt, Wiebke, Wändi Bruine de Bruin, and JoNell Strough. 2019. 'Age Differences in Financial Decision Making: The Benefits of More Experience and Less Negative Emotions.' *Journal of Behavioral Decision Making* 32 (1): 79–93.

Evans, Jonathan St. B. T., and Keith E. Stanovich. 2013. 'Dual-Process Theories of Higher Cognition: Advancing the Debate.' *Perspectives on Psychological Science* 8 (3): 223–241.

Fennema, M. G., and Jon D. Perkins. 2007. 'Mental Budgeting Versus Marginal Decision Making: Training, Experience and Justification Effects on Decisions Involving Sunk Costs.'*Journal of Behavioral Decision Making* 21 (3): 225–239.

Frederick, Shane. 2005. 'Cognitive Reflection and Decision Making.' *Journal of Economic Perspectives* 19 (4): 25–42.

Fujino, Junya, Shinsuke Fujimoto, Fumitoshi Kodaka, Colin F. Camerer, Ryosaku Kawada, Kosuke Tsurumi, Shisei Tei, Masanori Isobe, Jun Miyata, and Genichi Sugihara. 2016. 'Neural Mechanisms and Personality Correlates of the Sunk Cost Effect.' *Scientific Reports* 6:33171.

Garland, Howard. 1990. 'Throwing Good Money After Bad: The Effect of Sunk Costs on the Decision to Escalate Commitment to an Ongoing Project.' *Journal of Applied Psychology* 75 (6): 728–731.

Haita-Falah, Corina. 2017. 'Sunk-Cost Fallacy and Cognitive Ability in Individual Decision-Making.' *Journal of Economic Psychology* 58:44–59.

Harrison, Paul D., and Adrian Harrell. 1993. 'Impact of "Adverse Selection" on Managers' Project Evaluation Decisions.' *Academy of Management Journal* 36 (3): 635–643.

Heath, Chip. 1995. 'Escalation and De-Escalation of Commitment in Response to Sunk Costs: The Role of Budgeting in Mental Accounting.' *Organizational Behavior and Human Decision Processes* 62 (1): 38–54.

Jang, Dongsuk, Anna S. Mattila, and Billy Bai. 2007. 'Restaurant Membership Fee and Customer Choice: The Effects of Sunk Cost and Feelings of Regret.' *International Journal of Hospitality Management* 26 (3): 687–967.

Karns, Tara E. 2012. 'Age, Expertise, and the Sunk-Cost Fallacy.' Master's thesis, University of West Virginia.

Klaczynski, Paul A. 2001. 'Framing Effects on Adolescent Task Representations, Analytic and Heuristic Processing, and Decision Making.' *Journal of Applied Developmental Psychology* 22 (3): 289–309.

Larrick, Richard P., James N. Morgan, and Richard E. Nisbett. 1990. 'Teaching the Use of Cost-Benefit Reasoning in Everyday Life.' *Psychological Science* 1 (6): 362–370.

Liang, Austin Rong-Da, Chia-Ling Lee, and Wei Tung. 2014. 'The Role of Sunk Costs in Online Consumer Decision-Making.' *Electronic Commerce Research and Applications* 13 (1): 56–68.

Primi, Caterina, Kinga Morsanyi, Francesca Chiesi, Maria Anna Donati, and Jayne Hamilton. 2016. 'The Development and Testing of a New Version of the Cognitive Reflection Test Applying Item Response Theory (IRT).' *Journal of Behavioral Decision Making* 29 (5): 453–469.

Putten, Marijke van, Marcel Zeelenberg, and Eric van Dijk. 2010. 'Who Throws Good Money after Bad? Action vs. State Orientation Moderates the Sunk Cost Fallacy.' *Judgment and Decision Making* 5 (1): 33–36.

Ronayne, David, Daniel Sgroi, and Anthony Tuckwell. 2021. 'Evaluating the Sunk Cost Effect.' *Journal of Economic Behavior & Organization* 186 (c): 318–327.

Roth, Stefan, Thomas Robbert, and Lennart Straus. 2015. 'On the Sunk-Cost Effect in Economic Decision-Making: A Meta-Analytic Review.' *Business Research* 8 (1): 99–138.

Salter, Stephen B., and David J. Sharp. 2001. 'Agency Effects and Escalation of Commitment: Do Small National Culture Differences Matter?' *The International Journal of Accounting* 36 (1): 33–45.

Schmidt, Jeffrey B., and Roger J. Calantone. 2002. 'Escalation of Commitment during New Product Development.' *Journal of the Academy of Marketing Science* 30 (2): 103–118.

Sleesman, Dustin J., Donald E. Conlon, Gerry McNamara, and Jonathan E. Miles. 2012. 'Cleaning up the Big Muddy: A Meta-Analytic Review of the Determinants of Escalation of Commitment.' *Academy of Management Journal* 55 (3): 541–562.

Sobkow, Agata, Angelika Olszewska, and Jakub Traczyk. 2020. 'Multiple Numeric Competencies Predict Decision Outcomes beyond Fluid Intelligence and Cognitive Reflection.' *Intelligence* 80:101452.

Soman, Dilip, and John T. Gourville. 2001. 'Transaction Decoupling: How Price Bundling Affects the Decision to Consume.' *Journal of Marketing Research* 38 (1): 30–44.

Stagnaro, Michael, Gordon Pennycook, and David G. Rand. 2018. 'Performance on the Cognitive Reflection Test Is Stable across Time.' *Judgment and Decision Making* 13 (3): 260–267.

Stanovich, Keith E. 2012. 'On the Distinction between Rationality and Intelligence: Implications for Understanding Individual Differences in Reasoning.' In *The Oxford Handbook of Thinking and Reasoning,* edited by Keith J. Holyoak and Robert G. Morrison, 433–455. New York: Oxford University Press.

———. 2018. 'Miserliness in Human Cognition: The Interaction of Detection, Override and Mindware.' *Thinking & Reasoning* 24 (4): 423–444.

Stanovich, Keith E., and Richard F. West. 2008. 'On the Relative Independence of Thinking Biases and Cognitive Ability.' *Journal of Personality and Social Psychology* 94 (4): 672–795.

Tan, Hun-Tong, and J. Frank Yates. 1995. 'Sunk Cost Effects: The Influences of Instruction and Future Return Estimates.' *Organizational Behavior and Human Decision Processes* 63 (3): 311–319.

———. 2002. 'Financial Budgets and Escalation Effects.' *Organizational Behavior and Human Decision Processes* 87 (2): 300–322.

Thaler, Richard H. 1999. 'Mental Accounting Matters.' *Journal of Behavioral Decision Making* 12 (3): 183–206.

Toplak, Maggie E., Richard F. West, and Keith E. Stanovich. 2011. 'The Cogni-

tive Reflection Test as a Predictor of Performance on Heuristics-and-Biases Tasks.' *Memory & Cognition* 39 (7): 1275–1289.

———. 2014. 'Assessing Miserly Information Processing: An Expansion of the Cognitive Reflection Test.' *Thinking & Reasoning* 20 (2): 147–168.

Von Neumann, John, and Oskar Morgenstern. 1947. *Theory of Games and Economic Behavior.* 2nd rev. ed. Princeton, NJ: Princeton University Press.

Wong, Kin Fai Ellick, Jessica Yuk Yee Kwong, and Carmen K. Ng. 2008. 'When Thinking Rationally Increases Biases: The Role of Rational Thinking Style in Escalation of Commitment.' *Applied Psychology* 57 (2): 246–171.

Appendix

Assume you are a director of a company 'Innovation Ltd.' Your company embarked on a new R&D project – a VR headset which would enable an improved experience of several popular computer games. However, at this point in time one of your competitors announced a launch of their own VR headset, which has better characteristics than yours and is cheaper.

The project is two years underway and your team informed you they would need another three years to complete it. Due to aging of technology, your team believes the bulk of the sales revenues would occur in five years after introduction, should you decide to continue with the project. Your marketing and development team provided you with the following data:

Costs incurred to date: 7 million EUR.

Costs/sales	Years				
	1	2	3	4	5
Expected future costs	3	2	2		
Expected sales	1	3	3	2	1

Note. In million EUR.

Cognitive reflection test (CRT):

1. A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost? ___ cents
2. If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets? ___ minutes
3. In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? ___ days