Cognitive Biases and Debiasing in Strategic Decision Making

D I S S E R T A T I O N

of the University of St.Gallen,

School of Management,

Economics, Law, Social Sciences,

International Affairs and Computer Science

to obtain the title of

Doctor of Philosophy in Management

submitted by

Christian Muntwiler

from

Remetschwil (Aargau)

Approved on the application of

Prof. Dr. Martin J. Eppler

and

Prof. Dr. Thomas Schumacher

Dissertation no. 5302

D-Druck Spescha, St. Gallen 2023

The University of St.Gallen, School of Management, Economics, Law, Social Sciences, International Affairs and Computer Science, hereby consents to the printing of the present dissertation, without hereby expressing any opinion on the views herein expressed.

St. Gallen, October 24, 2022

The President:

Prof. Dr. Bernhard Ehrenzeller

Acknowledgements

The research leading to this dissertation would not have been possible without the support, encouragement, and guidance of others. Therefore, it is my pleasure to thank those who have accompanied and supported me over this intensive phase of my live.

I am extremely grateful to my supervisor Prof. Dr. Martin J. Eppler for giving me the opportunity to research cognitive biases in strategic decisions, for his great support during the whole process, his ideas, the mutual exchange, the discussions, and, especially, his great commenting and editing of our articles, always on spot and giving that extra something.

I would like to extend the same degree of appreciation to my co-supervisor Prof. Dr. Thomas Schumacher, the combination of providing me both guidance and freedom for my research was of great support and helped to avoid blind alleys in my work.

I am deeply grateful to my family, my mother Hedi, my aunt Lore, and my kids Caroline and Constantin who supported me during this path (and, as for my kids, brought an often-welcome distraction from the theoretical realm of research).

Last, I want to express my special thanks to Anna who accompanied me during this endeavor with her love, patience, thoughts and her heartful smiles. I am extremely happy to have her by my side.

Rehetobel, November 2022

Christian Muntwiler

Table of Contents

Acknowledgements ..... **I**
Table of Contents ..... **II**
List of Figures ..... **VI**
List of Tables ..... **VII**
Summary ..... **VIII**
Zusammenfassung ..... **IX**
1. Introduction **1**
1.1 Motivation - The Case for Cognitive Biases in Strategic Decision Making 1
1.2 Research Questions and Research Methods 2
1.2.1 Research Question 1: Mapping Cognitive Biases in Strategic Decisions 3
1.2.2 Research Question 2: The Prevalence and the Awareness of Bias Susceptibility and Individual Bias Blind Spots in Managerial Decisions 5
1.2.3 Research Question 3: Debiasing Interventions in Strategic Decision Making 6
1.2.4 Research Question 4: Visualization as Debiasing Technique 7
1.3 Structure of the Dissertation 8
1.4 Overview of Articles 10
1.4.1 Article 1: Mapping Cognitive Biases in Strategic Decisions 10
1.4.2 Article 2: The Prevalence and the Awareness of Bias Susceptibility and Individual Bias Blind Spots in Managerial Decisions 11
1.4.3 Article 3: Debiasing Interventions in Strategic Decision Making 12
1.4.4 Article 4: Visualization as Debiasing Technique 13
2. Theoretical Background **14**
2.1 Strategic Decision Making in Strategy Research 14
2.2 Bounded Rationality in Strategic Decision Making 15
2.3 Limits of Rationality 16
2.3.1 External Factors as Limits of Rationality 17
2.3.2 Internal Factors as Limits of Rationality 19
2.4 Cognitive Biases in Strategic Decision Making 22
2.4.1 Cognitive Biases Driven by Heuristics 22
2.4.2 Cognitive Biases Driven by Motivation 24
2.5 Cognitive Biases and Bounded Rationality 24

3. BIASMAP – Developing a Visual Typology and Interface to Explore and Understand Decision Making Errors in Management 26
3.1 Introduction 26
3.2 A Typology of Cognitive Biases 27
3.2.1 Analysis of Existing Classificatory Frameworks 27
3.2.2 Developing a New Typology of Cognitive Biases in Strategic Decision-Making Processes 28
3.3 A Knowledge Map of Cognitive Biases 30
3.3.1 Theoretical Placement – Organizing the Knowledge 30
3.3.2 The BIASMAP Application 31
3.4 Conclusion and Limitations 31
4. The Awareness of Bias Susceptibility and Individual Bias Blind Spots in Managerial Decisions 32
4.1 Introduction 32
4.2 Theoretical Background 34
4.2.1 The Awareness of Susceptibility to Cognitive Biases 34
4.2.2 Decision Styles and Cognitive Biases 35
4.2.3 The Bias Blind Spot 36
4.3 Research Design 37
4.3.1 Choosing the Top 15 Biases 37
4.3.2 Design of the Survey 39
4.3.3 Sample Characteristics 40
4.4 Results 41
4.4.1 The Prevalence of Cognitive Biases 41
4.4.2 The Susceptibility to Biases Based on Individual Decision Styles 43
4.4.3 Susceptibility Comparison of Top 25 vs. Bottom 25 per Decision Style. 45
4.4.4 The Bias Blind Spot(s) 48
4.4.5 Blind Spots per Decision Style (Top 25) 51
4.5 Discussion 53
4.5.1 Rational Decision Style 53
4.5.2 Intuitive Decision Style 55
4.5.3 Dependent Decision Style 56
4.5.4 Avoidant Decision Style 57
4.5.5 Spontaneous Decision Style 57
4.5.6 Explorative Factor Analysis GDMSI 58

4.6 Conclusion 61
4.6.1 Implications for Research 62
4.6.2 Implication for Practice 62
4.6.3 Limitations 63
5. Debiasing Management Decisions: Overcoming the Practice/Theory Gap within the Strategy Decision Process 64
5.1 Introduction 64
5.2 Debiasing: Theoretical Background 65
5.2.1 Decision Readiness 66
5.2.2 Decision Process 67
5.3 Debiasing Approaches and Techniques During the Decision Process 68
5.3.1 Modify the Environment 68
5.3.2 Modify the Person 70
5.4 Applying a Practice Perspective on Debiasing 73
5.4.1 Research Questions and Hypothesis 73
5.4.2 Experimental Design 75
5.5 Results 75
5.5.1 Card Sorting 75
5.5.2 Survey 78
5.6 Practice-oriented Framework of Debiasing Techniques – Towards a Practice Oriented Debiasing Procedure 79
5.6.1 Finding Clusters 79
5.6.2 Towards a New Structure to Understand Debiasing Management Decisions 81
5.7 Conclusion and Limitations 86
6. When Ignorance isn't Bliss: Managers' Illusion of Explanatory Depth for Emerging Digital Technologies and the Promise of Visualization 88
6.1 Introduction 88
6.1.1 Understanding Emerging Digital Technologies 88
6.1.2 The Effect of Exceeding Confidence in One's Own Knowledge 89
6.1.3 Calibration of Knowledge and the Promise of Visualizations 91
6.2 Hypotheses 93
6.2.1 The Impact of an IOED and its Calibration in Strategic Decision Making 93
6.2.2 The Visual Self-Calibration of Explanatory Knowledge 94

6.3 Methods 95
6.3.1 Experiment 1 95
6.3.2 Experiment 2 97
6.3.3 The Coding of the Self-Explanations (Textual and Visual) 98
6.4 Results 102
6.4.1 Experiment 1 102
6.4.2 Experiment 2 104
6.5 Discussion, Conclusion, and Limitations 108
6.5.1 Discussion 108
6.5.2 Conclusion 109
6.5.3 Limitations 110
7. Contributions, Limitations, and Future Research 112
7.1 Theoretical Contributions 113
7.2 Practical Contributions 114
7.3 Limitations and Future Research 114
References 116
Appendix A: Ideal Types of Cognitive Biases, BIASMAP 172
Appendix B: Overview of Classified Cognitive Biases 174
Appendix C: Authoritative Averaged References 223
Curriculum Vitae 245

List of Figures

Figure 1: Overview Dissertation 8
Figure 2: Boundedness of Rationality in Strategic Decisions 22
Figure 3: Cognitive Biases and Bounded Rationality in the Context of Strategic Decision Making 25
Figure 4: Prevalence of Cognitive Biases in the Decision of Others 41
Figure 5: Self-reported Prevalence of Cognitive Biases in One's Own Decision 42
Figure 6: Ranking of Negative Impact on Decisions 42
Figure 7: Self-other Assessment (Difference in Percentage) per Bias 49
Figure 8: Debiasing Interventions 67
Figure 9: Theoretically Developed Clustering of Debiasing Techniques 68
Figure 10: Overview Typology of Cognitive Biases 74
Figure 11: Dendrogram of the Card-sorting Results (Ward's Linkage Method) 77
Figure 12: Debiasing Approaches Used in Managerial Practice 78
Figure 13: Cuts to Cluster the Dendrogram of Debiasing Techniques 80
Figure 14: 9 Clusters of Debiasing Techniques 80
Figure 15: Overview Debiasing Management Decisions - a Practitioners' View 86
Figure 16: Coding of the Groups After the Self-explanation 102
Figure 17: Investment Proposals per Group 104

List of Tables

Table I: Overview Information for Article 1 10
Table II: Overview Information for Article 2 11
Table III: Overview Information for Article 3 12
Table IV: Overview Information for Article 4 13
Table V: External and Internal Factors Affecting the Limits of Rationality in Strategic Decision Making 17
Table VI: List of Top 15 Cognitive Biases for the Survey 39
Table VII: Inter-correlations Among the Key Variables – Self-reported Bias Susceptibility 44
Table VIII: Self-reported General Bias Susceptibility per Decision Style 46
Table IX: Significant Self-reported Susceptibilities per Decision Style for the Cognitive Biases 48
Table X: Inter-correlations Among the Key Variables – Bias Blind Spots 50
Table XI: Significant Self-reported Bias Blind Spots for the Top 25 Quartile per Decision Style for the Cognitive Biases 53
Table XII: Individual "Bias Risks" for Biased Decision Behavior and Blind Spots – Rational Decision Style 55
Table XIII: Individual "Bias Risks" for Biased Decision Behavior and Blind Spots – Intuitive Decision Style 56
Table XIV: Individual "Bias Risks" for Biased Decision Behavior and Blind Spots – Dependent Decision Style 56
Table XV: Individual "Bias Risks" for Biased Decision Behavior and Blind Spots – Avoidant Decision Style 57
Table XVI: Individual "Bias Risks" for Biased Decision Behavior and Blind Spots – Spontaneous Decision Style 58
Table XVII: Factor Loading Analysis of GDSMI Factors 59
Table XVIII: Co-occurrences (Similarities) of the 20 Debiasing Techniques 76
Table XIX: Clustered Debiasing Techniques and Where They Work 85
Table XX: Contingency Analysis Experiment 2 106
Table XXI: Contingency Analysis Experiment 2 for Male/Female Overestimation . 107

Summary

Cognitive biases and their impact on decision making in general and specifically on strategic decision making have been recognized in psychological and management-related research over a long period. The vast research on this topic has unveiled more than 180 such potential flaws of decisions.

The goal of this dissertation is to develop a better understanding of the role of cognitive biases in strategic decisions, how to detect and identify them and how to mitigate their influence in strategic decision practices.

The articles of this dissertation provide four major contributions to the theoretical and practical knowledge on cognitive biases in strategic decision making: 1) This dissertation adds a mapping of more than 180 known cognitive biases based on the five phases of strategic decision-making processes and the three motivational backgrounds of cognitive biases. This mapping helps managers and other strategic decision makers to identify "what can go wrong" during their decision-making processes and allow them to recognize and anticipate these flaws, diagnose them, and take a next step towards a corrective intervention. 2) This dissertation shows for the first time the connection between the most prevalent cognitive biases, bias blind spots, and individual decision styles of managers. The resulting ranking of cognitive biases helps practitioners to focus on the "tip of the iceberg" and focus their corrective interventions on the most prevalent and impactful biases. The insights showed that rational and spontaneous decision makers report a smaller susceptibility for cognitive biases combined with bigger bias blind spots than other decision styles, and that intuitive decision makers have a higher awareness of their own bias susceptibility without showing bigger bias blind spots. 3) This dissertation integrates a more practice-oriented view of understanding (and communicating) debiasing techniques. This more practice-oriented understanding of debiasing techniques and the "know how" and where they might work supports the successful facilitation of decision-making practices in strategy. 4) And finally, this dissertation shows the relevance of the illusion of explanatory depth for strategic decisions. The results of these experiments demonstrate the need for a certain humility of managers concerning their knowledge of strategy-relevant digital technologies and that the technique of self-drawn, visual explanations might help to overcome the individual overestimation of that knowledge.

Zusammenfassung

Kognitive Verzerrungen ("cognitive biases") und deren Einfluss auf strategische Entscheidungen sind sowohl seitens der psychologischen wie auch der betriebswirtschaftlichen Forschung seit längerer Zeit erforscht und anerkannt. In zahlreichen wissenschaftlichen Arbeiten wurden über die letzten Jahrzehnte mehr als 180 solcher Entscheidungsverzerrungen beschrieben.

Das Ziel dieser Dissertation ist es, ein besseres Verständnis für die Rolle kognitiver Verzerrungen bei strategischen Entscheidungen zu entwickeln und aufzuzeigen, wie diese entdeckt bzw. identifiziert werden können und wie deren Einfluss in strategischen Entscheidungsprozessen eliminiert oder zumindest abgeschwächt werden kann.

Diese Dissertation fügt im Rahmen vierer Aufsätze folgende Erkenntnisse zur Theorie und Praxis der kognitiven Verzerrungen und deren Einfluss auf strategische Entscheidungen hinzu: 1) Die Klassifizierung von mehr als 180 bekannten kognitiven Verzerrungen anhand zweier Dimensionen (Phasen strategischer Entscheidungen/motivatorische Hintergründe) in 15 Idealtypen ermöglicht eine Kartierung dieser Entscheidungsverzerrungen. Diese Typologie hilft Entscheider:innen, die Verzerrungen bei strategischen Entscheidungsprozessen frühzeitig zu identifizieren, so dass Interventionen zur Verbesserung dieser Prozesse angestossen werden können. 2) Die Ergebnisse der erstmaligen Verknüpfung von individuellen Entscheidungsstylen, der Prävalenz kognitiver Verzerrungen und "Bias Blind Spots" unterstützen Führungskräfte darin, zu erkennen, welche Entscheidungsverzerrungen in der Praxis oft vorkommen und wo Interventionen daher priorisiert werden sollten. Hierbei zeigt sich, dass rationale und spontane Entscheider:innen eine geringere Anfälligkeit für kognitive Verzerrungen wahrnehmen als andere Entscheidungstypen, dies aber mit einem signifikant höheren "Bias Blind Spot" kombiniert ist. Intuitive Entscheidungstypen hingegen zeigen ein hohes Bewusstsein für die eigenen Anfälligkeit auf kognitive Verzerrungen bei einem geringeren "Bias Blind Spot". 3) Die Integration einer praxisorientierten Perspektive in die Debiasing-Forschung ermöglicht ein besseres Verständnis, Einordnen und Kommunizieren von Debiasing-Techniken. 4) Die Resultate der Experimente zur "Illusion of Explanatory Depth" bei strategischen Entscheidungen zeigen auf, dass Manager:innen mehr Bescheidenheit bei ihrer Selbsteinschätzung zum Verständnis digitaler Technologie gut anstünde und wie selbst gezeichnete Visualisierungen des eigenen Wissens helfen können, dieses besser zu kalibrieren.

1. Introduction

1.1 Motivation - The Case for Cognitive Biases in Strategic Decision Making

Effects of cognitive biases or cognitive simplifications on strategic decision making have first been emphasized by Schwenk (1984, 1988) and Barnes (1984) based on the groundwork of Simon's concept of bounded rationality (March & Simon, 1958; Simon, 1955, 1972). The integration of a more behavioral understanding of strategic decision making and the influence of cognitive limitations found further support from Bateman and Zeithaml (1989), Eisenhardt and Zbaracki (1992), Lovallo and Kahneman (2003), Hodgkinson and Clarke (2007), Powell, Lovallo, and Fox (2011), and others. The combination of theoretical perspectives and methods from "the full spectrum of social science disciplines" (Hodgkinson & Clarke, 2007, p. 251), and the merge of "cognitive and social psychology to strategic management theory and practice" (Powell et al., 2011, p. 1371) aimed to "re-humanize" the field of strategy research (Hodgkinson & Healey, 2008; Hodgkinson, Sadler-Smith, Burke, Claxton, & Sparrow, 2009; Hodgkinson, Langan-Fox, & Sadler-Smith, 2008; Vaara & Whittington, 2012) into a behavioral way of understanding strategy work (Levinthal, 2011; Lovallo & Sibony, 2010; Sibony, Lovallo, & Powell, 2017). Consequently, the existence and influence of cognitive biases in strategic decision making is highly recognized in research.

Popular management articles have also acknowledged the influence of cognitive biases on strategic decisions (Oreizy, 2019), the importance of integrating a behavioral perspective onto management decisions (Dmitracova, 2020), and how critical it is to mitigate cognitive biases in decision making (Lancefield, 2021; McNulty, 2021).

Examples from practitioners show the different kinds of how cognitive biases can manifest themselves in managerial decision making (all quotes are from C-1 managers from Forbes 2000 companies out of the bias survey in article 2, chapter 4):

- "One of my coworkers after learning that the average price for the report is a certain amount, he now believes that any amount less than that is a good deal, and he didn't look for better deals. He set the expectations." (Anchoring bias)
- "There was a case where two fresh graduates applied for the same job at the same time. Both have the same qualifications. The gender is the only difference. In the recruiting choice made by the interviewer, the compensation offered to the male

candidate was somewhat more than the salary offered to the female candidate." (Stereotyping)

- "We had to make a decision quickly this time, so we used the only facts we had at the time which led us to make the wrong decision because we hadn't given it much thought." (Availability bias)
- "We were working with the other team to work on some important strategy to implement it and both the teams had different opinions for that due to which we had to go with the familiar approach that we used in the past project so that there will not be any misunderstanding." (Problem-solving set)
- "We once had a project in which we invested a lot of time and money and thought we could finish it, so we pushed ourselves to finish it even though we knew we couldn't, and as a result, we failed miserably." (Sunk cost neglect)
- "One of my colleagues in my department does not trust the advice of their own team members so he prefer to make decisions on his own without consulting his colleagues." (Illusory superiority)

As these examples show, cognitive biases impact managerial decisions and the understanding and examination of cognitive biases and their influence may help strategists to be more effective in decision making (Das & Teng, 1999). But as the literature on cognitive biases (generally and specifically in the context of strategy research) is highly fragmented, there is still the need to map the influence of these biases on strategic decision making and design systems and mechanisms that allow to mitigate their influence (Hutzschenreuter & Kleindienst, 2006; Leiblein, Reuer, & Zenger, 2018).

The goal of this dissertation is to conceptualize the role of cognitive biases as a factor of strategic decision making under bounded rationality, and to develop and answer research questions aiming at overcoming or at least mitigating the influence of cognitive biases in strategic decision making. To answer the four research questions a broad scope of research methods is applied: from an integrative literature analysis to the development of a typology, surveys, different kinds of experiments and miscellaneous statistical analyses.

1.2 Research Questions and Research Methods

Research on cognitive biases in strategic decision making should help strategists "to recognize their own cognitive limitations, to temper their assessments of strategy risk" (Barnes, 1984, p. 135), and "provide intervention techniques and tools than can be

applied by strategists during decision making" (Hutzschenreuter & Kleindienst, 2006, p. 707) to guide and support managers "in the design of appropriate administrative mechanisms" (Burgelman et al., 2018, p. 539). Corrective interventions and the choice of intervention techniques and tools in the facilitation of strategic decision making depend on two preliminary phases: the recognition of symptoms and the diagnosis of the underlying patterns, the sequence: recognition – diagnosis – intervention (Westley & Waters, 1988).

1.2.1 Research Question 1: Mapping Cognitive Biases in Strategic Decisions

To recognize one's own or third party's cognitive limitations as strategic decision makers, Leiblein et al. (2018) formulate the need for a mapping of cognitive biases in strategic decisions. A mapping that provides insights about the presence of cognitive biases in various stages of a general strategic decision making process (Das & Teng, 1999) and allows corrective interventions within a decision-making process. Ideally, the mapping provides insights about the "when" a cognitive bias occurs (recognition) and the "why", the underlying cognitive patterns of cognitive biases (diagnosis) and – as a result – supports the facilitation of strategic decision making towards "procedures that can help direct us to more optimal decisions" (Bazerman & Moore, 2009, p. 181) and help to debias strategic decision making.

Schwenk (1984) developed a framework connecting strategic decision process stages with major biases, but "only a small group of simplification processes from earlier research have been identified in this paper for discussion in the context of strategic management" (Schwenk, 1984, p. 125). Das and Teng (1999) discussed four key types of cognitive biases linked with five basic modes of strategic decision making (rational, avoidance, logical incrementalist, political, garbage can) but only assessed a limited amount of cognitive biases. As a result, both existing classifications of cognitive biases in strategic decision making lack the scope needed to support the recognition ("when") and diagnosis ("why") of individual cognitive limitations. As, until now, more than 150 cognitive biases are known in literature (Dimara, Franconeri, Plaisant, Bezerianos, & Dragicevic, 2020), a classificatory framework is needed that integrates the full scope of known cognitive biases and supports the facilitation of strategic decision-making processes to limit their influence on decisions.

Consequentially this leads to the first research question of this dissertation:

RQ1: Which classification (or typology) of the identified 150+ cognitive biases supports strategists in the recognition and diagnosis of cognitive biases in strategic decision-making processes?

A classification or typology for a specific topic has to provide categories that are consistent, unique, mutually exclusive, and complete (Bowker & Star, 1999). To answer research question 1, an integrative literature review was conducted with the goal of synthesizing the findings into a conceptual classification or an alternative model or framework (Torraco, 2016). In cases, where researchers apply a combination of perspectives to create a new model, Snyder (2019) recommends an integrative literature review. Compared with a systematic or a semi-systematic literature review, the integrative approach answers specific research questions and "generates new knowledge about the topic reviewed" (Torraco, 2016, p. 404). Hence, for this analysis a "double-sided systematic snowball" procedure (Wong, Greenhalgh, Westhorp, Buckingham, & Pawson, 2013, p. 27) for existing classificatory frameworks was applied. The articles were identified with the keywords (and combinations) in title, topic and abstract, no restrictions in year, author, and source (journal, conference paper, etc.) on the EBSCOHost Database: bias, cognitive bias, cognitive illusion, classification, typology, taxonomy, classificatory framework. The forward and backward snowballing led to a final set of literature with an (at least) classificatory framework for cognitive biases with a connection to cognitive human decision making – articles concerning medical research areas like neurology, neurophysiology or cognitive biases concerning animals were ruled out. These 24 existing classificatory frameworks of cognitive biases in decision making were then searched for patterns based on the source of publication, the research background of the authors, the classification approach, and their main goal for the classification to develop a systematic structure for the existing classifications and to critically analyze whether they already fulfill the aim of both recognition *and* diagnosis of cognitive biases in strategic decision-making processes. The synthesis, the development of a new classificatory framework, consisted of four steps: Developing a central classification theme (Rich, 1992), the theoretical deduction of the categories or dimensions based on the literature analysis (Rich, 1992; Sanchez, 1993), the creation of "ideal types" (Doty & Glick, 1994), and the theoretical placement of the cognitive biases into the new framework (Rich, 1992). The application and the results of this research led to article 1 (chapter 3 of this dissertation).

1.2.2 Research Question 2: The Prevalence and the Awareness of Bias Susceptibility and Individual Bias Blind Spots in Managerial Decisions

A second research question within the scope of mapping the influence of cognitive biases on strategic decisions concerns the prevalence of these biases. How susceptible and vulnerable are decision makers to cognitive biases? The recognition of one's own susceptibility is the starting point for debiasing interventions (Larrick, 2004; Zwaan et al., 2017). Exploring the individual differences may support this recognition and, consequentially, the evaluation of one's own individual susceptibility to specific cognitive biases or ideal types of biases (Sklad & Diekstra, 2014). Existing research indicates a tendency for rational decision makers to be less flawed by cognitive biases (Bruine de Bruin, Parker, & Fischhoff, 2007; Curşeu & Schruijer, 2012; Parker, De Bruin, Fischhoff, & Weller, 2017; Stanovich & West, 2008). Yet, until now there is no analysis of the connection between individual decision styles and the individual susceptibility to cognitive biases. This leads to the second research question of this dissertation:

RQ2: What are the most prevalent cognitive biases in strategic decision making and do decision styles help to anticipate one's own susceptibility ("bias risk maps") and bias blind spots concerning these biases?

Research on the prevalence of cognitive biases in managerial decisions is scarce. Kreilkamp et al. (2021) surveyed the frequency of nine cognitive biases in the management accounting environment, other authors focused on cognitive biases in topics like architecture decision making (Zalewski, Borowa, & Ratkowski, 2017) or tourist decision making (Wattanacharoensil & La-ornual, 2019). Numerous popular online sources speak of the "most common cognitive biases" but do not unveil the foundation for the "popularity" of a certain bias in general, and do not link them to managerial decisions in particular. To learn more about the prevalence of cognitive biases in managerial decisions and their connection to individual decision styles, a survey with a list of 15 pre-evaluated "top" biases (prelist of 30 biases from the BIASMAP, pilot survey to condense, and a cross-check with other bias rankings) was conducted. As managers often are not that familiar with the concept of cognitive biases – they mostly occur unconsciously – and they are hard to query directly, we followed the approach of Kreilkamp et al. (2021) to ask the participants of the survey not directly about cognitive biases, but about specific decision behaviors they observed on others and on themselves in managerial decisions. The results enabled an explorative ranking of these top 15 biases concerning the prevalence from the perspective and experience of

practitioners in oneself and in others. In addition, the combination with the survey and individual decision styles, using the decision style inventory from Scott and Bruce (1995), allowed a more thorough understanding of the susceptibility to cognitive biases and the identification of bias blind spots for different decision styles. This included a mapping of bias risks for each of the five decision styles (article 2; chapter 4 of this dissertation).

1.2.3 Research Question 3: Debiasing Interventions in Strategic Decision Making

The request for mechanisms (Burgelman et al., 2018; Leiblein et al., 2018) and intervention techniques and tools (Hutzschenreuter & Kleindienst, 2006) to mitigate the influence of cognitive biases leads to a third research question: debiasing decisions. Debiasing means interventions by the decision maker herself or a decision making facilitator in "a continuum, ranging from the reframing or repackaging of existing information to the provision of new strategies for thinking about information" (Soll, Milkma, & Payne, 2015, p. 925). The literature on debiasing decision making is highly fragmented with several theoretical frameworks towards debiasing (Arkes, 1991; Fischhoff, 1982; Kenyon & Beaulac, 2014; Larrick, 2004) and a few general overviews collecting and discussing experimental proven debiasing and intervention techniques (Kaufmann, Carter, & Buhrmann, 2010; Soll et al., 2015) but none in the context of strategic decision making and its VUCA environment. The goal of debiasing is to increase the effectiveness of the decision (Schwarz, 2017) in terms of reducing the external and internal distractions (like cognitive biases) (McFadzean & Nelson, 1998), "enhancing the level of discursive validity" (Gregory & Romm, 2001, p. 454) and "to overcome the processing tendencies associated with their cognitive style" (Hodgkinson & Clarke, 2007, p. 250). Thus, the goal is, to provide decision makers or facilitators of strategic decisions with a structured overview of existing tools and techniques for debiasing in this specific context. The provision of such tools "would mean to increase the relevance of strategy research for practitioners" (Hutzschenreuter & Kleindienst, 2006, p. 707). This generates research question three:

RQ3: Which interventions support strategists or facilitators of strategic decisions to mitigate or debias the influence of cognitive biases and how can they be structured?

For the comparison of debiasing techniques from a theoretical perspective with the practitioners' view on this issue, a card-sorting experiment combined with a survey was conducted. Based on a theoretically developed clustering of twenty theoretically acknowledged debiasing techniques the card sorting measures the perceived connection

and similarities between these techniques. As a research methodology, card sorting is a method to elicit user preferences (Hannah, 2005) and provide a graduation of the similarities between the objects (Coxon, 1999). Card sorting is a combination of qualitative and quantitative methods (Brown, 1996). The result of a card-sorting experiment, the hierarchical clustering, can be visualized as a dendrogram (Aggarwal & Reddy, 2014) to compare different forms of clustering visually and statistically (by using the Rand index (Rand, 1971)). This led to the development of a new framework to structure and communicate debiasing techniques (see article 3; chapter 5 of this dissertation).

1.2.4 Research Question 4: Visualization as Debiasing Technique

A special technique of cognitive support with growing recognition in research are visualizations like sketches, drawings, graphs, flow charts, histograms, charts, diagrams, pictures, maps, metaphors etc. (Eppler & Burkhard, 2007; Ertug, Gruber, Nyberg, & Steensma, 2018). Visualizations are acknowledged in strategy research as remedy to overconfidence in strategic decisions (Russo & Schoemaker, 1992), to provide help with cognitive, social and emotional aspects in strategic planning processes (Eppler & Platts, 2009), to visualize strategic consensus (Tarakci et al., 2014), to produce knowledge in workshops and strategic episodes (Paroutis, Franco, & Papadopoulos, 2015), to create strategic visibility and enhance strategic resonance (Knight, Paroutis, & Heracleous, 2018), and to support open strategy (Paroutis & Knight, 2019). Visualizations improve comprehension (Tversky & Kessell, 2014) and reasoning (Bauer & Johnson-Laird, 1993) because they visualize thought (Tversky, 2011) and serve as mental representations to enable managers "to see things they were not aware of, and this insight helps them to define new questions, hypotheses, and models of their data" (Van Wijk, 2005, p. 3). This leads to an additional fourth research question:

RQ4: How can visual techniques support decision makers and facilitators in the debiasing of cognitive biases in strategic decision making?

To examine the effect of visualizations (self-drawn sketches to assess one's uncertainty about a certain topic) two experiments were conducted. The first experiment investigated the impact of the illusion of explanatory depth (Rozenblit & Keil, 2002) on decisions to show the importance of this bias in strategic decision making. The second experiment focused on the size of the illusion of explanatory depth for strategy-relevant digital technologies and the debiasing impact of self-drawn sketches vs. a textual assessment of one's uncertainty. Both experiments partially replicated the original

experiment of Rozenblit and Keil (2002). To analyze the influence of the visual and textual self-assessment, the results of the participants were coded by applying an authoritative average reference based on publicly available sources (the average knowledge about these topics one can expect a manager to have). As a result, the size of the illusion of explanatory depth, its impact on decisions and the debiasing effect of textual and visual self-assessments (and their difference) was measured (see article 4; chapter 6 of this dissertation).

1.3 Structure of the Dissertation

To respond to the research questions this dissertation is organized in 7 chapters (see Figure 1).

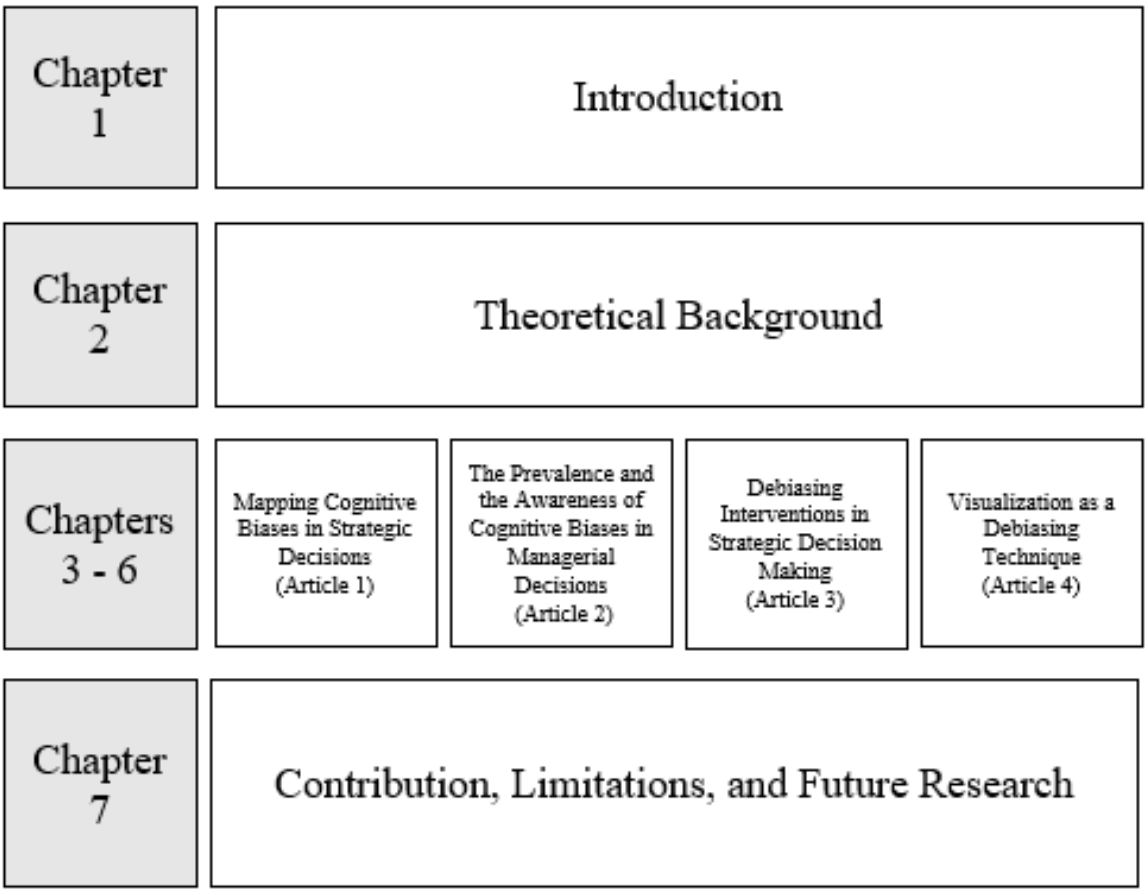


Figure 1: Overview Dissertation

Following the introductory part, the next chapter highlights the specific characteristics of strategic decisions and – as a consequence – the external and internal limitations of rationality in strategic decision making. Both perspectives are linked to show why strategic decisions are especially prone to cognitive biases and thus, why the mapping

and classification of cognitive biases in a strategic decision-making context and the analysis of intervention techniques to mitigate the influence of cognitive biases on strategic decisions are of great importance.

Chapter 3 focuses on an answer to research question one, the mapping of cognitive biases with a strategic decision-making lens, based on an integrative literature analysis.

Chapter 4 analyses the prevalence of and susceptibility to cognitive biases and bias blind spots in managerial decisions with the aim to support managers to recognize their own "bias risk maps" in decisions.

Chapter 5 uses card sorting to compare the theoretical and practice-oriented view on debiasing techniques to develop a more practice-oriented framework to communicate and implement debiasing techniques in strategy practice.

Chapter 6 investigates the illusion of explanatory depth and the potential of visualizing one's own knowledge to reduce the impact of this specific bias.

The final chapter 7 summarizes the major contributions of the four articles on behalf of both, the academic community, the research on cognitive biases, and the practice community, the strategists. General limitations of this research are mentioned and an outlook to further research endeavors is made.

1.4 Overview of Articles

1.4.1 Article 1: Mapping Cognitive Biases in Strategic Decisions

Title:	BIASMAP – Developing a Visual Typology and Interface to Explore and Understand Decision Making Errors in Management
Authors:	Martin J. Eppler, Christian Muntwiler
Outlet:	Human Interaction, Emerging Technologies, and Future Applications IV. IHIET-AI 2021. Advances in Intelligent Systems and Computing, vol 1378
Year:	2021
Status:	Published (Eppler & Muntwiler, 2021)
Keywords:	Visual interface, cognitive biases, strategic decision making, typology, knowledge map
Abstract:	In this paper we develop a novel interactive and highly visual interface to make current research about cognitive biases in strategic decision-making processes widely available to non-experts in management, administration, and engineering. Cognitive biases play a major role in the process of strategic decision making. Thus, the recognition, compilation, and understanding of these biases is crucial to develop approaches to debias decisions. The literature on cognitive biases is highly fragmented and includes various research fields. This makes it difficult to gain an overview or find relevant biases quickly. To structure this knowledge, we have developed a typology of cognitive biases based on existing classificatory frameworks and an integrative literature analysis. This led to a two-dimensional typology combining the psychological view on cognitive biases with a decision process-oriented perspective. As a result, knowledge about 187 cognitive biases that affects decision making is presented in a practice-oriented structure (viewable at bias.visual-literacy.org).

Table I: Overview Information for Article 1

1.4.2 Article 2: The Prevalence and the Awareness of Bias Susceptibility and Individual Bias Blind Spots in Managerial Decisions

Title:	The Awareness of Bias Susceptibility and Individual Bias Blind Spots in Managerial Decisions
Authors:	Christian Muntwiler, Martin J. Eppler, Matthias Unfried, Fabian Buder
Year:	2022
Status:	Under submission Published as working paper on alexandria.unisg.ch
Keywords:	Cognitive biases, bias blind spot, decision styles, bias susceptibility
Abstract:	This article explores managerial decision styles as potential predictors of individual bias awareness and bias blind spots. A survey with 500 C-1 level managers from Forbes 2000 companies also provides a ranking of the most prevalent perceived cognitive biases in managerial decisions. The results show that the awareness of one's susceptibility and the bias blind spots are highly different depending on an individual's decision style and type of cognitive bias. Decision makers with a strong tendency towards a rational or spontaneous decision style see themselves as less vulnerable to cognitive biases, but also show a much stronger bias blind spot than those with the tendency towards other decision styles. On the other hand, decision makers with a strong tendency towards an intuitive decision style tend to recognize their own vulnerability to cognitive biases and show even a negative blind spot – thus seeing themselves more flawed by cognitive biases than others. As a result, the individual decision style may serve as a predictor for one's own susceptibility for cognitive biases and bias blind spots.

Table II: Overview Information for Article 2

1.4.3 Article 3: Debiasing Interventions in Strategic Decision Making

Title:	Debiasing Management Decisions: Overcoming the Practice/Theory Gap within the Strategy Decision Process
Author:	Christian Muntwiler
Outlet:	Proceedings of TAKE 2021 - Theory and Applications in the Knowledge Economy Conference
Year:	2021
Status:	Published (Muntwiler, 2021)
Keywords:	Debiasing, management decisions, framework, card sorting
Abstract:	The impact of cognitive biases on (managerial) decisions has been recognized over the last decades with a recent surge due to the COVID-19 based policy making. This article analyzes existing debiasing techniques to mitigate the influence of cognitive biases on (managerial) decisions and links the theoretical perspective with the practice. As debiasing techniques have a surprisingly little awareness among managers a card-sort experiment was applied to search for a more practice-oriented understanding and structure of debiasing techniques with the goal of developing a framework that helps practitioners to integrate debiasing techniques more easily in their decision processes. The result of the experiment shows 9 clusters of debiasing techniques (checklists, preparation, what if?, group debiasing, reason analogically, in-process debiasing, starting viewpoints, involvement, and calibration) which can be implemented in different phases of a decision process and thus may help to improve (managerial) decisions in times of uncertainty.

Table III: Overview Information for Article 3

1.4.4 Article 4: Visualization as Debiasing Technique

Title:	When Ignorance isn't Bliss: Managers' Illusion of Explanatory Depth for Emerging Digital Technologies and the Promise of Visualization
Authors:	Martin J. Eppler, Christian Muntwiler
Year:	2022
Status:	Under submission Published as working paper on alexandria.unisg.ch Earlier version with first results and analyses submitted and accepted for Academy of Management Conference Proceedings (Muntwiler & Eppler, 2019)
Keywords:	Debiasing, illusion of explanatory depth, overestimation, strategic decision making, visualization
Abstract:	This article examines the effect of visualizing one's own understanding of digital technologies on the self-calibration of knowledge in the context of a specific knowledge bias, the "illusion of explanatory depth". In two experiments, we investigate the size and impact of this illusion on experienced managers and their understanding of contemporary and strategy-relevant emerging digital technologies and examine the potential debiasing effect of self-sketched visualizations on the self-calibration of managerial knowledge. The findings show that experienced managers suffer from a significant illusion concerning their understanding of strategy-relevant emerging digital technologies and that visualizing one's current level of understanding supports the accurate calibration of one's knowledge. Thus, this research stimulates the extension of existing theory on overconfidence and especially overestimation in strategic management. The findings point to the promise that sketched visualizing is a helpful modality for the detection and subsequent re-calibration of biased knowledge.

Table IV: Overview Information for Article 4

2. Theoretical Background

2.1 Strategic Decision Making in Strategy Research

Strategic decision making has been recognized as a major part of strategy process research from different perspectives and by a vast amount of scholars: as deliberate choice processes in strategic planning and formulation (Ansoff, 1965; Armstrong, 1982; Eisenhardt & Zbaracki, 1992; Fredrickson, 1984; Schwenk, 1995; Shrivastava & Grant, 1985), as (sometimes unintentional) consequences of an emerging (or evolutionary/organic) strategizing process (Farjoun, 2002; Lovas & Ghoshal, 2000; Mintzberg, 1978; Mintzberg & Waters, 1985), as influenced and shaped by politics and power (Eisenhardt & Zbaracki, 1992; Pettigrew, 1977), and cognition and emotions (Brundin & Liu, 2015; Huy & Zott, 2019; Kiesler & Sproull, 1982; Laamanen & Wallin, 2009; Vuori & Huy, 2016).

Decisions are "the cornerstone of strategy" (Schrager & Madansky, 2013, p. 81) in a behavioral understanding of strategizing (Cyert & March, 1963; Powell et al., 2011; Sibony et al., 2017). Following the understanding of strategy as a social practice, strategic decisions are shaped by practices like discourses, episodes, actions and interactions that lead to a strategy (Hendry, 2000; Hendry & Seidl, 2003; Jarzabkowski, Balogun, & Seidl, 2007; Whittington, 1996).

But what makes a decision strategic? A managerial or organizational decision is specified as strategic if the decision is "concerned with the *long-term development of the enterprise*" (Andrews, 1971, p. 29), an important specific *commitment to action* (Mazzolini, 1981; Mintzberg, Raisinghani, & Théorêt, 1976), a fundamental decision *shaping the course of the firm* (Eisenhardt & Zbaracki, 1992) or a series of decisions (Bateman & Zeithaml, 1989) forming a strategy like "a pattern in a stream of decisions" (Mintzberg & Waters, 1985, p. 257). A strategic decision is *infrequent* (Eisenhardt & Zbaracki, 1992; Mazzolini, 1981), *irreversible* (Ghemawat, 1991), *reliable* (Van den Steen, 2017), and "*interdependent with other decisions* – interdependent across contemporaneous decisions, across the decisions of other economic actors, and across time" (Leiblein et al., 2018, p. 570).

Another perspective lies in the context of strategic decisions, like the decision environment and the organizational situation (Elbanna, Thanos, & Jansen, 2020). This environmental and organizational context is influenced by *complexity* (Armstrong, 1982; Farjoun, 2002; Hodgkinson, Bown, Maule, Glaister, & Pearman, 1999;

Hutzschenreuter & Kleindienst, 2006; Leiblein et al., 2018; Mintzberg et al., 1976; Powell et al., 2011; Schwenk, 1984; Shrivastava & Grant, 1985; Wolf & Floyd, 2017), *uncertainty* (Dean & Sharfman, 1993; Fredrickson, 1984; Hodgkinson et al., 1999; Hutzschenreuter & Kleindienst, 2006; Klingebiel & De Meyer, 2013; Schwenk, 1984; Shrivastava & Grant, 1985; Sibony et al., 2017), *ambiguity* (March & Olsen, 1976; Mintzberg et al., 1976; Schwenk, 1984; Van den Steen, 2017; Wolf & Floyd, 2017), and they are often determined by a *volatile* environment (Grant, 2003; Kellermanns, Walter, Lechner, & Floyd, 2005). Thus, strategic decision making is decision making under VUCA conditions: volatility, uncertainty, complexity, and ambiguity (Bennett & Lemoine, 2014; Mack & Khare, 2016).

To sum it up, the definition of a strategic decision consists of three complementing characteristics: a) an infrequent decision and/or a pattern of decisions forming the fundament and the commitment for the long-term development of an organization, b) interdependent with other internal and external decisions, and c) embedded in a VUCA decision environment and conditions.

How rational are strategic decisions and how rational can strategic decisions be, considering volatility in the environment, uncertainty, complexity, and ambiguity? In the next paragraphs, I will address the recognition of cognitive limitations and boundaries in rationality in strategic decision making, with an additional analysis of the specific role of cognitive biases in and on bounded rational decisions.

2.2 Bounded Rationality in Strategic Decision Making

The notion of deviations from rational decision models and the integration of a psychological perspective in organizational decision making led to the definition of an "approximate" rationality by Simon (1955). Accepting the psychological limits of an organism in terms of computational and predictive abilities, and in contrast to the concept of "economic man" ("homo economicus") and its assumption of perfect rationality, Simon developed a different behavioral model of rational choice (Simon, 1955). The traditional concept of rational choice focuses on optimal decisions in "a highly specified, and clearly defined environment" (March & Simon, 1958, p. 137) with certainty about the consequences of a decision or accurate knowledge about the probability distribution of alternatives. This bases upon the assumptions that the alternatives of a decision are given, all consequences are known, and the decision maker has a rational ordering of utilities for all options (March & Simon, 1958). Thus, a concept which is applicable for decision making with no uncertainty and ambiguity.

Accepting the characteristics of organizational and strategic decisions, the uncertainty and ambiguity of (available) information and outcomes, the interdependence with other (external and internal) actors and their decisions, combined with the cognitive limitations of individuals speaks in favor of an understanding of rationality in strategic decision making as "relative to a frame of reference"(March & Simon, 1958, p. 138) or shaped by "boundaries of rationality" (March & Simon, 1958, p. 171). As a consequence, the concept of "bounded rationality" in decision making introduced a behavioral perspective in organizational (Cyert & March, 1963; Greve, 2013; March & Olsen, 1976; March & Simon, 1958) and strategic decision making (Das & Teng, 1999; Dean & Sharfman, 1993; Eisenhardt & Zbaracki, 1992; Elbanna, 2006; Mazzolini, 1981; Schrager & Madansky, 2013; Schwenk, 1986) recognizing limitations in knowledge and cognitive abilities of decision-making actors.

2.3 Limits of Rationality

Simon (1972, p. 169) defines three limits on perfect rational choices: "*uncertainty* about the consequences that would follow from each alternative, *incomplete information* about the set of alternatives, and *complexity* preventing the necessary computations from being carried out". All three limits are affected by external and internal factors (external and internal from the perspective of the decision maker, see Table V):

	External Factors	Internal Factors
Uncertainty	"The cognitive limits are not simply limits on specific information. They are almost always also limits on the adequacy of the scientific theories that can be used to predict the relevant phenomena." (Simon, 1990, p. 16)	"uncertainty introduced … by inability – *computational inability*" (Simon, 1972, p. 170) "limited *ability to forecast the future*, also play a central role in the evaluation of alternatives."(Simon, 1990, p. 16)
Incomplete Information	"*Selective exposure to environmental stimuli*" (March & Simon, 1958, p. 153)	"What a person wants and likes influences what he sees; what he sees influences what he wants and likes", "*selective perception and rationalization*" (March & Simon, 1958, p. 151, 152) "Cognitive limits, in this case lack of knowledge"(Simon, 1990, p. 16)
Complexity	"use formal decision procedures in actual *real-world situations of considerable complexity*" (Simon, 1972, pp. 174, 175)	"because of limits on complexity, human alternative-generating behavior observed in the laboratory is usually best described as *heuristic search aimed at finding satisfactory alternatives*", "The assumption of a utility function postulates a consistency of human choice that is not always evidenced in reality. The assumption of maximization may also place a *heavy (often unbearable) computational burden on the decision maker*." (Simon, 1990, p. 16)
In General		"*Psychological limits of the organism* (particularly with respect to computational and predictive ability)"(Simon, 1955, p. 101) "very limited information-gathering and computing capacity of human beings" (Simon, 1972, p. 176)

Table V: External and Internal Factors Affecting the Limits of Rationality in Strategic Decision Making

2.3.1 External Factors as Limits of Rationality

External factors influencing limits of rationality in strategic planning and strategic decision making have been researched following the logic of the contingency theory.

The contingencies in strategic decisions can be structured into two categories "organizational contingencies", conditions within the organization, and "environmental contingencies", the influence of the environmental context (Wolf & Floyd, 2017). This structure also mirrors the differentiation between internal and external environment by Duncan (1972).

Uncertainty

Environmental and organizational contingencies affect uncertainty, "the perceived degree of predictability of the various components compromising the environment" (Javidan, 1984, p. 384), due to their dynamics. The stronger a contingency is dynamic, the stronger it contributes to uncertainty (static = factors remain basically the same over time vs. dynamic = a process of change with importance and frequency of change as subdimensions (Duncan, 1972)). A second contributor to uncertainty is not knowing the outcome of a specific decision and the inability to assign probabilities regarding how environmental factors affect the outcome of a decision (Duncan, 1972). Milliken (1987, p. 136) defines this as a "state uncertainty", the uncertainty about the state of the environment and future changes (with or without the decision). Other aspects to consider are "effect uncertainty", the impact of environmental change on one's own organization, and "response uncertainty", what options the organization will have available (both Milliken, 1987, p. 137).

Incomplete Information

External contingencies limit rationality due to a potential lack of information about environmental and organizational factors (Duncan, 1972). This is because of shortcomings in the information acquisition, a gap "between the information required … and already obtained" (Elenkov, 1997, p. 288), "there are always limits to the amount of information that can be collected that is relevant to an issue, limits of resources needed for the search process and limits to the time available" (Citroen, 2011, p. 494). Another explanation for a lack of information is due to a gap between organizational perception and the objective environmental characteristics (Javidan, 1984; Miles, Snow, & Pfeffer, 1974).

Complexity

The complexity of external contingencies in strategic decision making can be arranged on a simple-complex dimension of environmental factors, a narrow vs. wide variety of factors to consider (Duncan, 1972): "the number of and dissimilarity of the considered

situational factors" (Axelsson & Rosenberg, 1979, p. 47). Factors of complexity include multiple unclear goals, singularity in its occurrence, lacking criteria of evaluation (Astley, Axelsson, Butler, Hickson, & Wilson, 1982), market variability, opportunistic behavior of a partner, natural calamity, internal riot (Rahman & De Feis, 2009), interdependencies and interactions between decisions, actions and outcomes (Anderson, 1999; Mischen & Jackson, 2008; Rahman & De Feis, 2009).

To sum it up, external antecedents supporting an approximate or bounded rationality in strategic decision making are a) uncertainty due to a dynamic internal and external environment and the lack of predictability of the effects of one's own decision on the environment and for the organization itself, b) incomplete information due to organizational perception of completeness and the lack of resources and time, and c) complexity based on a wide variety of interdependent and interacting factors outside the influence of a decision maker. It supports the notion that a VUCA environment raises the odds for boundaries in rationality, thus, in strategic decision making.

2.3.2 Internal Factors as Limits of Rationality

Another set of limiting factors of rationality in strategy processes due to individual characteristics of decision makers is the personal and cognitive context of the strategist herself, the individual predisposition (Hutzschenreuter & Kleindienst, 2006). By following the argumentation of Simon (March & Simon, 1958; Simon, 1972, 1990) these predispositions can be structured into three internal factors: cognitive ability, perception, and individual decision strategies.

Cognitive Ability

The computational ability of decision makers introduces *uncertainty* in the evaluation of alternatives and thus limits rational choice (Simon, 1972, 1990): the "psychological limits of the organism (particularly with respect to computational and predictive ability)" (Simon, 1955, p. 101). Individual differences in cognitive abilities have an impact on judgment and decision making (Frederick, 2005; Stanovich & West, 1998; Stanovich, West, & Toplak, 2016). According to the model of a tripartite mind, these individual differences can be structured into differences of the autonomous, the algorithmic, and the reflective mind (Stanovich, 2009; Stanovich et al., 2016). The autonomous mind reflects the concept of system 1 or type 1 thinking (Evans, 2008; Evans & Stanovich, 2013; Kahneman, 2003), based on heuristics and intuition, with few individual differences (Stanovich, 2009). The algorithmic mind is determined by fluid intelligence, the efficiency of processing, determined through intelligence tests

(Stanovich, 2009). The reflective mind, or thinking dispositions or cognitive styles, concerns "beliefs, belief structure, and, importantly, attitudes toward forming and changing beliefs, … a person's goals and goal hierarchy. Examples of some thinking dispositions that have been investigated by psychologists include: actively open-minded thinking, need for cognition, consideration of future consequences, need for closure, and dogmatism" (Stanovich et al., 2016, p. 25).

Perception

A second internal limiting factor of rationality is the individual, selective perception of information (Duncan, 1972; March & Simon, 1958; Schneider & De Meyer, 1991), leading to a lack of knowledge *and incomplete information* (Simon, 1990). This starts with the "very limited information-gathering and computing capacity of human beings" (Simon, 1972, p. 176) and goes on to the way decision makers "conceptualize their environment and industry" (Schwenk, 1988, p. 46) as "it is not objective antecedent characteristics such as environmental complexity but the respective perception of them that is decisive for subsequent decisions" (Hutzschenreuter & Kleindienst, 2006, p. 694). Individual perception of information in strategic decision making includes subject perception of the "environmental and internal characteristics" (Anderson & Paine, 1975, p. 813), the process of individual problem sensing (Kiesler & Sproull, 1982), blind spots in considering decisions from other actors (Zajac & Bazerman, 1991), different perception of the task itself (Einhorn & Hogarth, 1981) and the construction of individual mental models (Barr, Stimpert, Huff, Wiley, & Barr, 1992), or individual cognitive maps (Schwenk, 1988).

Decision Strategies

Normative decision models follow the concept of utility maximization, such as the subjective expected utility (Dean & Sharfman, 1993). The internal limitations of the ability to deal with *complexity* is partially influenced by the other two internal factors, cognitive ability and perception. The inability to maximize utility in an environment full of uncertainty, incomplete information, complexity, and limited by cognitive resources leads to a judgement and choice behavior "best described as a heuristic search aimed at finding satisfactory alternatives" (Simon, 1990, p. 16). These limitations to deal with complexity in decision making and the flaws of the assumption of maximization are recognized by behavioral decision theory (Dean & Sharfman, 1993; Einhorn & Hogarth, 1981; Schwenk, 1984). Heuristics in decision making are methods, strategies, or principles reducing the cognitive effort via simplification (Shah & Oppenheimer, 2008),

algorithms for near-optimal inferences (Gigerenzer & Goldstein, 1996) by ignoring more or less information (Gigerenzer & Gaissmaier, 2011), a rule for the aspiration level and the optimal amount of information search leading to "satisficing", a not optimal, but satisfying decision (Simon, 1972). The literature of cognitive psychology and decision making recognizes heuristics either as a part of the intuitive, autonomous system 1 thinking (Evans, 2007; Evans & Stanovich, 2013; Kahneman, 2003; Stanovich & West, 1998; Stanovich, 2009; Stanovich et al., 2016) or as both, unconscious, associative and deliberate, conscious processes (Gigerenzer & Gaissmaier, 2011). This is complemented by the differentiation between skilled intuitions and heuristics, enabled by an environment with valid cues, feedback and thus the opportunity to learn, and incomplete intuitions based on biased heuristics (Kahneman & Klein, 2009). As a consequence, differences in skills, application of decision strategies, and the use of individual decision heuristics contribute to the degree of bounded rationality in strategic decision making. The role and influence of heuristics on the strategy process has been recognized from different scholars (Artinger, Petersen, Gigerenzer, & Weibler, 2015; Bingham & Eisenhardt, 2011; Maitland & Sammartino, 2015; Schwenk, 1984; Vuori & Vuori, 2014).

To sum it up, the internal antecedents of bounded rationality in strategic decision making are a) the cognitive ability of the decision maker herself, b) the individual selective perception of information due to the individual conceptualization of the environment, and c) the availability and choice of heuristics and decision strategies of the decision maker to deal with complexity.

Both, internal and external, factors combined raise the probability for a strategic decision making under a bounded rationality (BR) condition (see Figure 2) as the "boundedness" can be defined as BR = BR(e) x BR(i) with the external factors BR(e) (=uncertainty, incomplete information, complexity) and the internal factors BR(i)(=cognitive ability, perceptions, decision strategies). Thus, the bigger the uncertainty, the degree of incomplete information and complexity on the environment and the stronger the limits of the cognitive ability of the decision makers, their limits of perception and their limitations due to their heuristics dealing with complexity, the stronger is the probability to decide under the condition of bounded rationality, and the stronger is the probability of a deviation from a rational strategic decision.

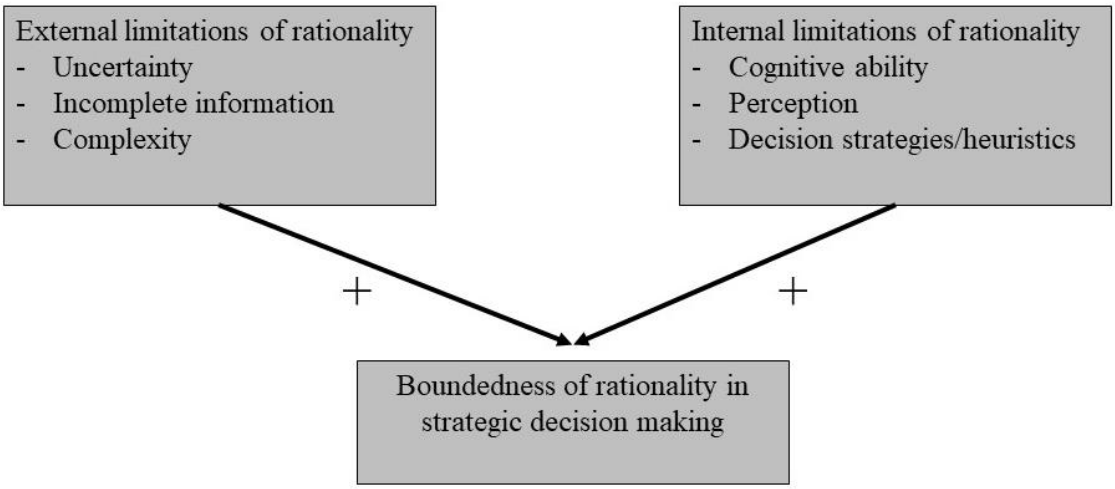


Figure 2: Boundedness of Rationality in Strategic Decisions

2.4 Cognitive Biases in Strategic Decision Making

A special factor contributing to the internal limitations of rational decisions are cognitive biases. Described as cognitive simplifications (Schwenk, 1984), thinking errors (Stanovich et al., 2016), or cognitive illusions (Pohl, 2017a), cognitive biases are *systematic* (Blanco, 2017; Das & Teng, 1999; Kahneman, Slovic, & Tversky, 1982; Tversky & Kahneman, 1974), *non-random*, thus predictable (Arnott, 2006; Blanco, 2017) *errors in "perception, judgement and memory*" leading to a deviation from rationality (Pohl, 2017a, p. 4). Cognitive biases are a violation of logic (Haselton et al., 2015) and "commonly accepted normative principles" (Montibeller & Winterfeldt, 2015, p. 1230). They evolve from "reliance on judgmental heuristics" (Tversky & Kahneman, 1974, p. 1130) or have motivational reasons (Montibeller & Winterfeldt, 2015).

2.4.1 Cognitive Biases Driven by Heuristics

The biases induced by the use of heuristics result "from evolutionary or information processing constraints; mechanisms work well in most circumstances, but are prone to break down in systematic ways" or artifacts of the inappropriate application of heuristics (Haselton et al., 2015, p. 726), a "negative consequence of adopting heuristics" (Das & Teng, 1999, p. 760). These types of biases are known as simplification biases (Oreg & Bayazit, 2009) due to cognitive miserliness or mindware gaps (Stanovich, Toplak, & West, 2008; Stanovich et al., 2016).

There is an ongoing scientific debate about whether the use of heuristics in decision making has negative or positive effects. Scholars following the naturals decision making

approach (NDM) or the "fast and frugal" (or probabilistic mental model, PMM) understanding of heuristics emphasize the positive role of heuristics in decision making and judgement. This is due to satisficing cognitive algorithms like recognition, or "take the best" (Gigerenzer & Goldstein, 1996), described as search rules, stopping rules, and decision rules (Gigerenzer & Gaissmaier, 2011) or due to decision skills and expertise (Klein, 1997). The *simple rules* that strategist and organizations may learn from their experience (Bingham & Eisenhardt, 2011, 2014). On the other hand, the "heuristic and biases" scholars argue for systematic failures of heuristics based on a strong research tradition showing the deviations from rationality in experiments (Fischhoff, Slovic, & Lichtenstein, 1978; Kahneman et al., 1982; Slovic, Fischhoff, & Lichtenstein, 1977; Stanovich et al., 2008; Tversky & Kahneman, 1974 and more). They acknowledge the value of heuristics in decision making: "In general these heuristics are quite useful, but sometimes they lead to severe and systematic errors" (Tversky & Kahneman, 1974, p. 1124). Thus, the focus should be on the *sometimes* or asked vice-versa: "In what environment does a given strategy (heuristic or otherwise) succeed?" (Gigerenzer & Gaissmaier, 2011, p. 473) as both sides of the argument agree that the environment or the context of a heuristic determines its usefulness or exposure to simplification biases (Artinger et al., 2015; Kahneman & Klein, 2009; Vuori & Vuori, 2014). Is the decision environment "benign", with useful cues, or "hostile" (Evans & Stanovich, 2013, p. 229)?

Vuori and Vuori (2014) provide a framework of four dimensions to show that the environment of strategic decision making plays an important role for cognitive biases induced by malfunctioning heuristics: redundancy, stability, timeframe for decision-making, and user(s) of heuristics. Heuristics work in environments with moderate or high redundant elements in a system (e.g. environment), stable contexts, very short decision timeframe (from seconds to hours), and single decision makers (Vuori & Vuori, 2014). The combination of volatility, complexity, uncertainty, and ambiguity as the environmental context for most strategic decisions, the difference in the timeframe ("managers are more likely to measure decision-making timescales with the calendar than with the stopwatch" (Vuori & Vuori, 2014, p. 1691)), and the decision entity of strategic decisions which is more often a group than one individual leads to the firm assumption that heuristics in a strategic context may have a high probability to be predisposed to cognitive biases. As "decision-makers may become more susceptible to cognitive biases in the face of additional complexity and time pressures" (Rahman & De Feis, 2009, p. 44), the use of heuristics, cognitive simplifications, may thus help in many decisions in a "decision friendly" environment but in a blurred and hostile

environment like in most strategic decisions the danger of a negative impact of cognitive biases due to simplifications seems to rise.

2.4.2 Cognitive Biases Driven by Motivation

Moreover, there are more "facilitators" of cognitive biases in decision making. The motivational background of cognitive biases are the needs for consistency in individual self-perception processes (verification biases) and for approaching pleasure and avoiding pain in decisions (regulation biases) (Oreg & Bayazit, 2009). Both, the individual concept of the self and individual evaluation-disabling properties based on rewards and punishment lead to mindware contaminations (Stanovich et al., 2008). Haselton (2015) describes these biases with an evolutionary perspective as error management biases, where biases are favored toward the less costly error – which explains positive illusions. These motivational reasons lead to biases of "desirability or undesirability of events, consequences, outcomes, or choices" (Montibeller & Winterfeldt, 2015, p. 1231) or subconscious risk-averse/risk-seeking behavior based on individual thinking dispositions following the prospect theory (Kahneman & Tversky, 1979; Oreg & Bayazit, 2009).

2.5 Cognitive Biases and Bounded Rationality

As a consequence, both reasons, malfunctioning heuristics and individual motivational factors, contribute to a failure to override system 1 (or type 1 thinking) and failing a sustained cognitive decoupling towards rational thinking in a decision-making process (Stanovich, Toplak, & West, 2008; Stanovich et al., 2016). Thus, the degree of influence of cognitive biases on strategic decision making is driven internally by the thinking dispositions of the decision maker(s), the self-perception, and the individual loss/gain regulation, and externally by the degree of volatility, complexity, uncertainty, and ambiguity of the environment as this "hostility" of the decision environment provokes malfunctioning heuristics. Themselves, cognitive biases influence the perception of the environment and the choice of decision strategies by the decision maker(s), having a reciprocal connection to the internal limiting factors of rationality.

Or, to sum it up: cognitive biases are a consequence *and* a driving factor of bounded rationality in the specific context of strategic decision making and its mostly decision-hostile environment (see Figure 3). This shows the importance of research on finding ways to help strategists to mitigate the impact of cognitive biases on strategic decisions. As this may help to reduce the boundedness of rationality in decision making.

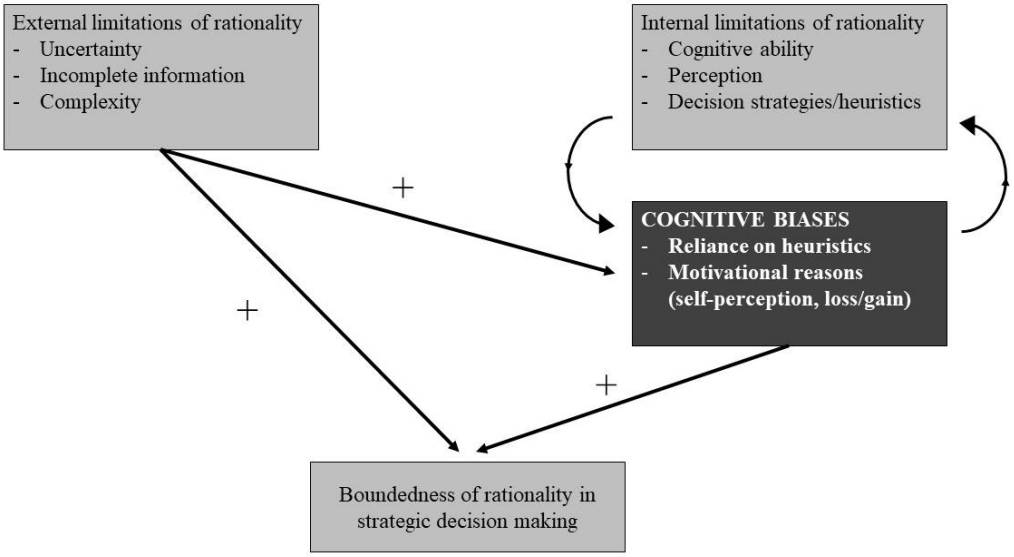


Figure 3: Cognitive Biases and Bounded Rationality in the Context of Strategic Decision Making

The next chapter will now start this research endeavor with a focus on the mapping of cognitive biases by a strategic decision-making lens. This is followed by articles on an analysis of the prevalence of and susceptibility to cognitive biases, on a framework of debiasing techniques integrating a practitioner's perspective, and on the investigation of the illusion of explanatory depth and the potential of visualizing one's own knowledge to reduce the impact of this bias.

3. BIASMAP – Developing a Visual Typology and Interface to Explore and Understand Decision Making Errors in Management

Martin J. Eppler, Christian Muntwiler

3.1 Introduction

Cognitive biases are systematic, non-random, thus predictable deviations from rationality in judgement or decision making (Arnott, 2006; Blanco, 2017; Das & Teng, 1999; Kahneman et al., 1982; Tversky & Kahneman, 1974a). Their impact on strategic decision-making has been recognized over the last four decades by many researchers (Barnes, 1984; Bateman & Zeithaml, 1989; Das & Teng, 1999; Hodgkinson & Clarke, 2007; Lovallo & Kahneman, 2003; Powell et al., 2011; Schwenk, 1984, 1986, 1995; Simon, 1987). They follow a "Meliorist" position with the assumption that by recognizing these biases, human reasoning can be improved. This is in contrast to a "Panglossian" or "Apologist" position, where little motivation and potential is recognized for correction (Stanovich, 1999). Thus, the facilitation of a strategic decision process plays a vital role to "assist the self-organizing process of the episode, helping to establish temporary routines that are suited to the purpose of strategic reflection" (Hendry & Seidl, 2003, p. 190), as "good process, in short, isn't just good hygiene; it's good business" (Lovallo & Sibony, 2010, p. 6). To improve reasoning, strategists need to "1) identify when they have acted inconsistently [thus, when they were biased] …, 2) explore the conditions that created this [what led to this specific bias], and 3) change these conditions to generate better results [intervention]" (Schwarz, 2017, p. 29). This leads to the sequence recognition – diagnosis – intervention (Westley & Waters, 1988). As the literature on cognitive biases is highly fragmented and from different research areas and streams, this article follows the call for mapping cognitive biases in strategic decision making (Leiblein et al., 2018) to recognize the potential cognitive limitations of decision makers in the strategy process (Barnes, 1984; Schwenk, 1984).

A knowledge visualization in this context is a visual representation to improve management (Eppler & Burkhard, 2007). It captures and depicts knowledge, supports the facilitation of processes, makes knowledge communicable and supports new discoveries (Eppler, 2011). The goal of this article is to develop a knowledge map of cognitive biases in strategic decision making. This provides a basis to later design intervention mechanisms and systems allowing to reduce the influence of cognitive

biases (debiasing) (Burgelman et al., 2018; Hutzschenreuter & Kleindienst, 2006) and therefore making strategic decision making more efficient (Das & Teng, 1999).

In a first step we structure the knowledge on cognitive biases in a typology that helps to identify *when* a bias might occur and *why* these cognitive biases interfere with a decision. In a second step, known cognitive biases are placed within the map and its features are explained.

3.2 A Typology of Cognitive Biases

As the research area of cognitive biases has seen a lot of attention during the last 50 years, there are already many different classificatory frameworks following different approaches. In terms of scope, we have analyzed existing frameworks and if they provide consistent and unique, mutually exclusive, and complete categories (Bowker & Star, 1999) to support the recognition and diagnosis of cognitive biases in strategic decision making processes. Following the recommendation of Snyder (2019) for studies which include different disciplines and a broad topic with different conceptualizations, we have conducted an integrative literature review of existing classificatory frameworks. This also serves the aim to later synthesize existing knowledge to "enable new theoretical frameworks and perspectives to emerge" (Snyder, 2019, p. 335). We have summarized the review in a conceptual framework to "weave the streams of research together" (Torraco, 2005, p. 362).

3.2.1 Analysis of Existing Classificatory Frameworks

The systematic search provided 24 existing classificatory frameworks for cognitive biases in decision making. By analyzing the source of publication, the research background of the authors, the classification approach, and their main goal for the classification two different approaches to structure cognitive biases were identified: *exploratory* approaches and *explanatory* approaches.

One approach how researcher classified cognitive biases is exploratory, focusing on the recognition of cognitive biases in decision-making processes. On this basis, cognitive biases were clustered using different procedures such as card sorting (Carter, Kaufmann, & Michel, 2007; Dimara et al., 2020), perceived similarities (Arnott, 2006; Bhandaria & Hassanein, 2012; McFadden, 1999), and a generic structure of decision making processes (Hogarth, 1987; Klotz, 2011; Remus & Kottemann, 1986; Schwenk, 1984).

The second kind of approaches focuses on a more diagnostic perspective: the explanation of "why" cognitive processes in human judgment, choice and decision

making lead to a systematic, involuntarily, and hard to avoid deviation in perception, judgment and memory from the normative reality (Pohl, 2017a, p. 4). Dimara et. al. (2020) identify these classifications as "explanatory". These diagnostic frameworks can be structured into explanations based on conceptual cognitive processes (Keren, 1990; Pohl, 2017a), heuristics (Bazerman & Moore, 2009; Gilovich et al., 2002; Peón et al., 2017; Tversky & Kahneman, 1974a), general thinking mechanisms and contaminations of the human mind (Baron, 2000; Korteling et al., 2018; Stanovich et al., 2016; Wilson & Brekke, 1994), the satisfaction of motivational end states of people making decisions (Oreg & Bayazit, 2009), an evolutionary perspective (Arkes, 1991; Haselton et al., 2009), the concept of formal autonomy (Blumenthal-Barby, 2016), or simply by using quantitative methods (Ceschi, Costantini, Sartori, Weller, & Di Fabio, 2019).

For successful corrective debiasing in strategic decision making both perspectives are needed (Larrick, 2004; Schwarz, 2017). But this is not provided by existing classificatory frameworks as they each focus on only one perspective. Thus, there is a need for a combination of both perspectives, the when (within the process of strategic decision making) and the why (the psychological background of a cognitive bias), as this may help to find the right "cure" to mitigate.

3.2.2 Developing a New Typology of Cognitive Biases in Strategic Decision-Making Processes

In contrast to an empirical taxonomy, a typology is based on conceptually developed ideal types (Doty & Glick, 1994), "to yield conceptually clear-cut types or classes" (Sanchez, 1993, p. 75). To develop a typology a theoretical "a priori" conceptualization of classes is followed by the placement of classified items into these conceptualized classes (Rich, 1992). This conceptual classification is based on few dimensions (Sanchez, 1993) which are "theoretically derived, and more or less intuitively categorized, qualities of observed phenomena" (Rich, 1992, p. 761). The "central classification theme (such as cui bono)" (Rich, 1992, p. 765) in our case is to help a strategist recognize when and why the process of strategic decision making is flawed by cognitive biases.

Creation of Categories from the Exploratory Perspective

The general requirements for classificatory principles in a typology are consistency and uniqueness, mutually exclusiveness, and completeness (Bowker & Star, 1999), that they are simple and parsimonious, easily understandable and natural (Gregor, 2006) – and theoretically derived (Rich, 1992).

To support recognition of cognitive biases the "natural" steps or phases within the process of decision making may be of help. The classificatory frameworks of Einhorn and Hogarth (Einhorn & Hogarth, 1981; Hogarth, 1987) and Schwenk (1984) are both based on this perspective. They are easier to understand and more natural from the perspective of a decision maker or facilitator than perceived similarity, which "is incomplete, and has considerable overlap" (McFadden, 1999, p. 84).

Based on the analysis of further general process models of (strategic) decision making, five generic phases can be extracted from theory, the same structure is also supported by Acciarini et al. (2020): *information acquisition, option generation, evaluation & choice, planning & implementation,* and *review & feedback*.

The five generic phases of strategic decision making provide five theoretically derived categories for the first classificatory dimension "recognition" as classification criteria for the theoretical placement.

Creation of Categories from the Explanatory Perspective

For the development of categories for the second perspective, the explanatory one, the existing classification criteria focusing on cognitive processes and perceived relationships between the biases face two disadvantages. First, "taxonomies that focus on the mechanisms behind the origin of biases (e.g. heuristics) are often not exhaustive when it comes to include all biases, but rather give examples of biases from specific reasoning processes" (Dimara et al., 2020, p. 3) – thus "the spectrum of biases considered was relatively narrow" (Oreg & Bayazit, 2009, p. 179). Second, for a strategist and facilitator the underlying cognitive processes and relationships in the individuals are hard to detect, hurting the principles of simple and parsimonious, easily understandable and natural (Gregor, 2006). This leads to the conclusion that the categories that show how cognitive biases help "to satisfy one of the three motivational end states" of individuals (simplification biases, verification biases, and regulation biases) (Oreg & Bayazit, 2009, p. 176) can give an explanation for the why, the diagnosis, of a particular cognitive bias and are easy to communicate. The concept behind this perspective is "that biases are consequences, or side effects, of individual's attempts to satisfy basic motivations. Given the existence of guiding motivational forces, certain dispositions can ultimately lead to biased perceptions, judgements and responses", and therefore this approach classifies "biases within the same category if they arise in the process of aiming for the same motivational goal" (both Oreg & Bayazit, 2009, p. 176). This concept is also supported by the findings of Ceschi et al. (2019).

Theoretically Developed Ideal Types of Cognitive Biases in Strategic Decision-Making Processes

The combination of the classificatory principles from the exploratory, decision process-oriented perspective and the explanatory, psychological perspective leads to 15 ideal types of cognitive biases in strategic decision-making processes ensued (overview see bias.visual-literacy.org and Appendix A).

3.3 A Knowledge Map of Cognitive Biases

To develop a knowledge map for cognitive biases, known biases were at first theoretically placed within the ideal types of the typology, the sections of the map. For the development and design of this knowledge map, we utilized the main principles of the field of knowledge visualization, namely: visual variety, visual unfreezing, visual discovery, visual playfulness, and visual guidance (Eppler, 2011).

3.3.1 Theoretical Placement – Organizing the Knowledge

The last step in the creation of a typology according to Rich (1992) is the theoretical placement of existing items into the structure of the typology. The rules to include cognitive biases in this typology were: recognized as a cognitive bias by the academic community, occurring in one of the 5 identified phases of decision making, and relatable to one of the three psychological-based categories (simplification, verification, regulation).

As there is currently no existing research canon of cognitive biases, the theoretical placement started with the list of 154 cognitive biases developed by Dimara et al. (2020) based on Wikipedia and verified with scientific sources. In a second iteration, we cross checked with other existing classifications of cognitive biases. This led to the addition of further biases neglected by other sources. The result is 187 identified cognitive biases in strategic decision making (see Appendix B [now with 190 cognitive biases as three were added after the publication of this article]). To classify the cognitive biases, we carried out a textual analysis using the same sources provided by the existing classificatory frameworks. If these articles were not extensive enough for the theoretical placement into the ideal types, additional scientific papers with more descriptive details had been added.

As not all biases are yet researched in the same depth concerning the psychological and motivational background, the theoretical placement is based on the current research status and is therefore – as new knowledge to some of the biases will be discovered –

up for future amends, with the current typology serving as a “letter case for the meaningful”.

3.3.2 The BIASMAP Application

To present this knowledge, a visual interface was developed with the help of five knowledge visualization principles:

1. Visual variety: The bias map combines an overview diagram connecting both axis of the typology (psychological axis, managerial axis) with a textual explanation of the biases, the theoretical background for the placement, and for some of the biases, short video sequences with a practical example.
2. Visual unfreezing: Biases can be chosen, and an individual list of biases can be extracted for further use.
3. Visual discovery: The map allows to detect new patterns, new biases and connect them to the phases of managerial and strategic decision making.
4. Visual playfulness: Bias journeys are provided, and users can generate their own bias journeys from their experience.
5. Visual guidance: Filters for specific kind of biases, and filters for the ideal types and both axes help users to explore the knowledge on cognitive biases.

This finally led to the BIASMAP (bias.visual-literacy.org) where managers and researcher can explore 187 [now 190] known cognitive biases.

3.4 Conclusion and Limitations

Our knowledge map of cognitive biases in strategic decision-making processes makes three contributions to the academic community: as a typology for future research on cognitive biases in strategic decision making, by showing potential research gaps (ideal types without identified biases), and foremost by providing a visual representation of knowledge on cognitive biases to support the facilitation of strategic decision-making processes by easing the knowledge acquisition and understanding. By knowing and understanding what the problem is, a strategist can start to intervene correctively by using appropriate debiasing methods within the strategic decision-making process.

But there is one major limitation in the typology as basis for this visual representation: The actual placement is based on the current status of research, thus as the classified cognitive biases are researched in more detail (especially the motivational background), the present typology can become more accurate over time and biases may be rearranged within the typology.

4. The Awareness of Bias Susceptibility and Individual Bias Blind Spots in Managerial Decisions

Christian Muntwiler, Martin J. Eppler, Matthias Unfried, Fabian Buder

4.1 Introduction

Since the seminal work of Kahneman and Tversky (1974) the influence of cognitive biases on decision making in general and managerial decision making specifically has been recognized by various scholars (Hodgkinson & Clarke, 2007; Kahneman, Lovallo, & Sibony, 2019; Kahneman et al., 1982; Powell et al., 2011; Schwenk, 1984). Cognitive biases are systematic and non-random deviations from rationality in decision making (Das & Teng, 1999). More than 180 documented cognitive biases have the potential to negatively impact managerial decision making (Eppler & Muntwiler, 2021). While the concept of cognitive biases is well established in judgement and decision-making studies, and the cognitive mechanisms that lead to biases are well described in the literature, a question remains wide open: How aware are managers of these flaws? Do they recognize biased decision-making behavior? Or do individual bias blind spots prevent the recognition of these thinking errors in actual decisions, making it harder to mitigate the influence of cognitive biases on managerial decision making?

Our research thus aims at exploring the awareness of susceptibility and bias blind spots of managers. In this study, we combine two perspectives, the individual awareness of biased decision-making behavior in managerial decisions and the individual bias blind spot (i.e., seeing the risk of a bias in others, but not in oneself). In addition, we use the concept of decision styles to analyze whether specific ways of making decisions correlate with the bias awareness of managers (and their bias blind spots). The results provide research and practice with insights about potential gaps in the awareness of crucial cognitive biases and enable to draw a "risk map", helping individuals to identify their risks in bias awareness based on their individual decision style.

Existing research has focused mainly on two perspectives. The first one is a decision-process and result oriented perspective recognizing the role that cognitive biases play in managerial decision making (Barnes, 1984; Bazerman & Moore, 2009; Das & Teng, 1999; Kahneman et al., 2019; Montibeller & Winterfeldt, 2015; Schwenk, 1984). The second perspective highlights the psychological foundations of cognitive biases in decision making helping to understand why cognitive biases flaw the decision process of individuals and groups (Arkes, 1991; Oreg & Bayazit, 2009; Stanovich & West, 1998;

Stanovich et al., 2016; Tversky & Kahneman, 1974). To support the growing need for academic research on cognitive biases with an impact for practice (Brooks, Curnin, Owen, & Bearman, 2020) these two perspectives need to be integrated: "Although knowledge of such biases may help to understand specific behavior, it provides only limited help to overcome such biases" (Hutzschenreuter & Kleindienst, 2006, p. 707). Integrating both research perspectives may provide a basis for practitioners to identify specific bias-risky situations, personality profiles or configurations, as well as settings that are conductive to decision biases (Bruine de Bruin, Parker, & Fischhoff, 2020). The recognition of one's susceptibility (or the recognition of a blind spot for one's susceptibility) to cognitive biases serves as a foundation for corrective debiasing precautions.

As Kreilkamp, Schmidt, and Wöhrmann (2021) show, the application of debiasing techniques in companies helps to reduce the prevalence of cognitive biases. But, to applicate specific debiasing techniques in managerial practice managers first must understand their own susceptibility to cognitive biases in their management decisions. The understanding of individual differences in the awareness and susceptibility to cognitive biases is considered as crucial for the mitigation of these biases in a professional environment (Berthet, 2022), especially as "individual differences have been largely neglected in this endeavor" (Berthet, 2021, p. 3). Thus, "the exploration of individual differences in cognitive biases can also help us understand how susceptible people are to the individual decision biases" (Aczel, Bago, Szollosi, Foldes, & Lukacs, 2015, p. 1), and – as a result – enabling the elicitation (Gertner, Zaromb, Schneider, Roberts, & Matthews, 2016) and the evaluation of the individual susceptibility (Sklad & Diekstra, 2014) to cognitive biases.

Existing research showed the influence of cognitive ability and thinking dispositions on individual decision making (Bruine de Bruin et al., 2007; Stanovich & West, 1998; Stanovich et al., 2016; Toet et al., 2016) and the role of personality traits to explain the susceptibility to specific cognitive biases (Ahmad, 2020; Bergers, 2021; Caputo, 2014; Dewberry, Juanchich, & Narendran, 2013; Durand, Fung, & Limkriangkrai, 2019; Fujino et al., 2016; Gertner et al., 2016; Toet et al., 2016; Zelenski & Larsen, 2002).

In this article we focus on managerial *decision styles* as potential predictors of individual bias awareness and bias blind spots with the potential to raise the susceptibility to certain cognitive biases. Decision styles are the individual, habitual, and characteristic patterns and modes people use to take decisions (Scott & Bruce, 1995). These patterns can be

evaluated by specific tests to measure the decision-making preferences (Spicer & Sadler-Smith, 2005).

Our results show a surprising outcome: The awareness of one's susceptibility and the bias blind spots vary greatly depending on the individual decision style and type of cognitive bias. The self-reported awareness of cognitive biases (described in a specific flawed behavior) shows significant discrepancies by comparing different decision styles; as does the analysis of bias blind spots: The participants did not only show a significant bias blind spot overall, but also significant differences in the blind spot per each analyzed cognitive bias and per individual decision style. Before we present these results in more detail, we will briefly review the theoretical background of our study as well as its design and scope.

4.2 Theoretical Background

4.2.1 The Awareness of Susceptibility to Cognitive Biases

Toet et al. (2016) provide an overview of research on individual characteristics that may predict cognitive biases in decision making. Their literature review identifies four major characteristics with an influence on bias susceptibility: *cognitive abilities, expertise, personality, and cultural background*.

The results in the context of forecasting cognitive biases are mixed. In general, *intelligence* does not predict a specific proneness to biases, but "highly intelligent people will display fewer reasoning biases when you tell them what the bias is and what they need to do to avoid it" (Stanovich & West, 2008, p. 690). The individual thinking style (deliberate processing vs. heuristic processing) seems to have an influence on certain biases like framing, or base rate neglect but not with others (such as conjunction fallacy).

The *expertise* of decision makers determines the deployment of a specific thinking style based on the context and thus the susceptibility to cognitive biases (e.g. experts are "more likely to select the thinking style appropriate for the context" (Toet et al., 2016, p. 7)). A high emotional intelligence helps to reduce emotionally induced cognitive biases (Fallon et al., 2014). Toet et al. summarize these results as "in general it can be concluded that cognitive ability does not safeguard an individual against bias, but it may in some cases help in deploying countering mechanisms that reduce, or prevent subsequent behavioral effects" (Toet et al., 2016, p. 6).

The relation between cognitive biases and *personality* traits has been researched by several studies. Individuals with high openness and agreeableness are more susceptible

to anchoring (Caputo, 2014) and the sunk cost effect (Fujino et al., 2016), a high extraversion leads to a higher proneness for bandwagon bias, overconfidence (Ahmad, 2020), and mood-affected biases (Zelenski & Larsen, 2002) but also reduces the impact of loss aversion biases (Durand et al., 2019). Conscientiousness is positively related to decision-making competence (Weller, Ceschi, Hirsch, Sartori, & Costantini, 2018) and "specifically extraversion and neuroticism were negatively associated with decision-making competence (Dewberry et al., 2013, p. 787). Toet et al. (2016, p. 8) recapitulate these results as "it is not easy to determine the mechanisms underlying the relationships between personality traits and susceptibility to cognitive bias. Summarizing, personality appears to relate to bias susceptibility because it determines how people weigh and process information". The influence of the *cultural background* on the susceptibility to cognitive biases can – again following the words of Toet et al. – be summarized as follows: "While it is possible that culture affects sensitivity to bias (e.g., as a result of different preferred thinking styles or levels of self-efficacy), only a few studies on this topic have been conducted and their results are mixed" (Toet et al., 2016, p. 8).

These results show the difficulty to link single individual characteristics to one's proneness to cognitive biases in decision-making situations. This difficulty may be the result of two aspects: a) the cross-sectionality of cognitive biases in the context of personalities and cognitive abilities (Erceg, Galic, & Bubic, 2020), and b) the focus of cognitive bias research on their existence and robustness vs. the empirical closure on their underlying causes (Gertner et al., 2016). Considering the difficulties with cognitive abilities, expertise, personality, and cultural background as predictors for individual bias susceptibility, we introduce a different lens to explore and analyze the individual susceptibility for cognitive biases and bias blind spots: decision styles.

4.2.2 Decision Styles and Cognitive Biases

As individual decision styles reflect "a combination of intellectual, motivational, emotional, and experience based skills" (Bruine de Bruin et al., 2020, p. 188), they address this cross-sectionality of cognitive biases. Decision styles are "learned, habitual response patterns exhibited by an individual when confronted with a decision situation" (Scott & Bruce, 1995, p. 820), "a surface manifestation of more deep seated personality constructs" (Spicer & Sadler-Smith, 2005, p. 146). Thus, decision styles could act as potential predictors for one's individual susceptibility to cognitive biases in managerial decision making and thus influence the individual awareness of flawed decision-making behavior.

The General Decision Style Inventory (GDSMI) (Scott & Bruce, 1995) has been recognized as the "most encompassing, validated, and widely used conceptual approach" (Fischer, Soyez, & Gurtner, 2015, p. 525). The five decision styles are characterized as (Spicer & Sadler-Smith, 2005, pp. 137–138):

- Rational: logical and structured approaches to decision making;
- Intuitive: reliance upon hunches, feelings and impressions;
- Dependent: reliance upon the direction and support of others;
- Avoidant: postponing or avoiding making decisions;
- Spontaneous: impulsive and prone to making "snap" or "spur of the moment" decisions

Existing research connects decision styles with the level of collaboration (Tsai, Melia, & Hinsz, 2019), problematic decision making (Bruine de Bruin et al., 2007; Parker, Bruine De Bruin, & Fischhoff, 2007), and the level of rationality in decisions (Curşeu & Schruijer, 2012). The results of these studies indicate a tendency for rational decision makers to be more decisive and make more deliberate decisions (Curşeu & Schruijer, 2012), and to have a higher Adult Decision-Making Competence (A-DMC) (Parker et al., 2007).

Based on these results we ask the following research question (RQ1): *Do decision styles influence the awareness of one's own susceptibility to specific cognitive biases in managerial decisions?*

Another way of asking this question is this one: If managers are made aware of their decision style, can they then identify the biases that they are most likely to fall into when making a decision? If this is the case, then research can help managers immunize themselves against relevant cognitive biases.

4.2.3 The Bias Blind Spot

We tend to see others more affected by biases than ourselves. This phenomenon is called the bias blind spot (Pronin, Lin, & Ross, 2002) and is grounded on two phenomena: the introspect illusion (Ehrlinger, Gilovich, & Ross, 2005; Pronin, 2009; Pronin & Kugler, 2007) and naïve realism (Pronin, Gilovich, & Ross, 2004). The awareness of a bias blind spot is a prerequisite for the application of debiasing techniques: "When people are unaware of their bias, they are unlikely to adopt corrective strategies to avoid the sources of bias that influence their judgment. Consequently, people who are more susceptible to bias blind spot are less prone to improve their decision making by engaging in bias

reduction strategies, responding to training, and taking advice" (Scopelliti et al., 2015, p. 2483). A bias blind spot even leads to a higher susceptibility to specific biases like the omission bias: "Ironically, consumers who believe that they are less vulnerable to omission neglect may be more susceptible to omission neglect" (Han, 2011, p. ii).

The bias blind spot seems to be independent from a general decision-making competence (Scopelliti et al., 2015). Research on individual differences of bias blind spots is still scarce, even if this gap is acknowledged (Kukucka, Kassin, Zapf, & Dror, 2017; Zappala, Reed, Beltrani, Zapf, & Otto, 2018). West, Meserve, and Stanovich (2012) show that bias blind spots do not correlate negatively with measures of cognitive ability like SAT or CRT or thinking dispositions like need for cognition or the actively open-minded thinking test. On the contrary, they showed that *bias blind spots are even more apparent among individuals with a higher cognitive sophistication*. This finding is confirmed by the suggestions that people with a high need-for-cognition and a higher self-esteem believe they are less susceptible to cognitive biases (Scopelliti et al., 2015).

To support the awareness of one's own susceptibility to bias blind spots and not only the susceptibility to specific cognitive biases we ask a second research question (RQ2): *Do decision styles help to identify individual differences in the susceptibility to bias blind spots?*

4.3 Research Design

For the exploration of both research questions, we conducted a survey which included 15 of the most important cognitive biases in managerial decisions.

4.3.1 Choosing the Top 15 Biases

For feasibility reasons (enabling the participants to assess the cognitive biases properly and in a reasonable amount of time as for managers time is money) we have followed a stringent selection process for the most prevalent and important cognitive biases we confronted the participants with. To evaluate them, we applied a two-step procedure:

- Step 1: We conducted a pilot survey to assess the managerial decision-making relevance of thirty (highly cited) cognitive biases, based on an existing compilation and classification of 187 documented cognitive biases (Eppler & Muntwiler, 2021). In this survey we asked 45 experienced managers (with a mean age of 32.9 years and an average of 10.3 years leadership experience) how often they recognized the corresponding behavioral patterns of these 30 cognitive

biases in others. This provided us with a ranking of bias perception regarding their occurrence in managerial practice.

- Step 2: The ranking of these 30 biases was then compared to other surveys providing a ranking of prevalence for cognitive biases. Kreilkamp et al. (2021) analyzed 9 cognitive biases and their occurrence. Brooks et al. (2020) analyzed 5 biases associated with information overload and 8 biases associated with creating meaning/understanding. Zalewski et al. (2017) identified the most 11 relevant cognitive biases in architecture decision making by letting participants poll out of a list of 105 biases. The analysis of Saposnik et al. (2016) resulted in 19 cognitive biases that affect the decision making of physicians. Wattanacharoensil and La-ornual (2019) identified the most prevalent cognitive biases in tourist decision making based on a literature review and provided 24 different biases. For the final choice of the top 15 biases for our own survey we thus applied the following criteria: the resulting ranking in our pilot survey, the rankings in the other surveys, feasibility (including explainability) for the survey, plausibility for managerial decisions, debiasing potential (i.e., is there something that managers can do to prevent the bias from occurring).

As the knowledge of managers on theoretical definitions and explanation of cognitive biases as provided in the literature is scarce and biases occur unconsciously, managers are often not familiar with bias labels or descriptions. As a consequence, cognitive biases and their perceptions are difficult to measure directly (Kreilkamp et al., 2021). We hence followed their approach to describe each bias as a specific "decision-making behavior" (of others or oneself) and asked the participants of the survey about specific decision behaviors that they have observed in others and themselves. The decision behaviors are based on the description of the 15 cognitive biases in the typology of cognitive biases by Eppler and Muntwiler (2021) and were pretested for comprehensibility. This led to the following list of cognitive biases and the corresponding behavior descriptions as basis for the survey (Table VI):

Cognitive Bias	Decision-making Behavior
Stereotyping	I (they) assigned characteristics to business partners or collaborators based on their membership to a certain group (gender, nationality, profession, age etc.).
Availability	I (they) used only the information I (they) could recall quickly and easily for a decision.
Problem-solving Set	I (they) favored a familiar solution over a non-familiar solution, even if I (they) do not know the potential success rate of both.
Imaginability	I (they perceived events as more likely to happen when I (they) could imagine them vividly.
Curse of Knowledge	In a business discussion, I (they) falsely assumed that my (their) colleagues have the same level of knowledge as I (they) do.
Confirmation Bias	I (they) favored information that confirmed my (their) existing opinions instead of looking for contradicting evidence.
Illusion of Explanatory Depth	I (they) believed to understand a complex phenomenon better than I (they) actually did.
In-group Bias	I (they) preferred people from my (their) own department over people from other departments, just because they are from my (their) own department.
Anchoring Bias	I (they) was (were) influenced by a starting offer (like the starting price of a negotiation) and could not break away from this reference point later.
Planning Fallacy	I (they) planned too optimistically, even if I (they) should have had enough experience from past planning failures.
Framing	I (they) perceived positively framed information different than the same information if it was negatively framed (example: “40 out 100 people buy from us” vs. “60 out of 100 do not buy from us”).
Bandwagon Effect	I (they) did things just because other people did them too.
Sunk Cost Fallacy	I (they) continued a (hopeless) project since I (they) had already invested time and money in it.
Functional Fixedness	I (they) used tools, resources, or data only in the traditional way and did not envision other ways of how they could be used more effectively.
Illusory Superiority (Overestimation)	I (they) assessed my (their) own capabilities as better than those of others and as above average.

Table VI: List of Top 15 Cognitive Biases for the Survey

4.3.2 Design of the Survey

The survey consists of a questionnaire in mix-mode design: Computer-aided-telephone interviews with screen sharing for questions with longer lists of items (call to screen). A mix-mode design reduces “coverage and nonresponse error at reasonable survey costs and with improved timeliness” (De Leeuw & Berzelak, 2016, p. 149). We used the following survey procedure and elements:

1. Basic questions on participants data (age, gender, occupation, industry, experience etc.)
2. The participants first name up to 5 behaviors from the list above (Table VI) that they believe are most common among decision makers in their organization (randomized list).
3. Based on the same list, the participants choose up to 5 behaviors they believe to have the greatest *negative* impact on decisions in their organizations.
4. For those 5 behaviors with the greatest negative impact they are asked, if they remember the occurrence of any of such decision-making behaviors and can briefly describe the situation and its impact.
5. Based on the list of the 15 cognitive biases they are asked to select all behaviors that they have observed on themselves at least once in the last 6 months.
6. Decision style inventory: The participants rate the 25 statements of the GDSMI (Scott & Bruce, 1995) regarding their decision style.
7. The participants evaluate 13 debiasing techniques according to how helpful they see them for their decision practice and how often they actually use them.

4.3.3 Sample Characteristics

The survey included 500 participants working for companies listed in the Forbes Global 2000 (https://www.forbes.com/lists/global2000/#1737558d5ac0) list of the world's biggest public companies with headquarters in the USA (72% of the participants), EU (15%, Germany, Spain, Italy, France, Netherlands), the UK and Switzerland (13%). The distribution of countries (assessed through location of headquarter) in the sample follows the distribution of countries in the 2021 edition of the Forbes 2000 list. Participants work in one of two broadly formulated business functions: Business Strategy/Market Development and Growth/Marketing/ Communications/Advertising. They are all C-suite direct reports, meaning they are reporting directly to a member of the executive board in their company. Thus, we ensured that respondents have the responsibility for business decisions and are accountable in terms of success or failure of those decisions.

186 respondents were females, while 314 were males, with an average age of 49.3 years. 53.4% of the participants had more than 15 years of management experience, 30.8% 10 – to 15 years, and 15.8% less than 10 years of experience. Participants' job titles included different types of Directors (63.8%) and Vice President roles (36.0%) plus other high-level roles (0.2%).

4.4 Results

4.4.1 The Prevalence of Cognitive Biases

The participants reported the in-group bias, the confirmation bias, and the illusory superiority as the top three biases in the decision making of others (see Figure 4). The top 5 of the observed cognitive biases in their own decision making were availability bias, imaginability, problem-solving set, illusion of explanatory depth, and illusory superiority (see Figure 5).

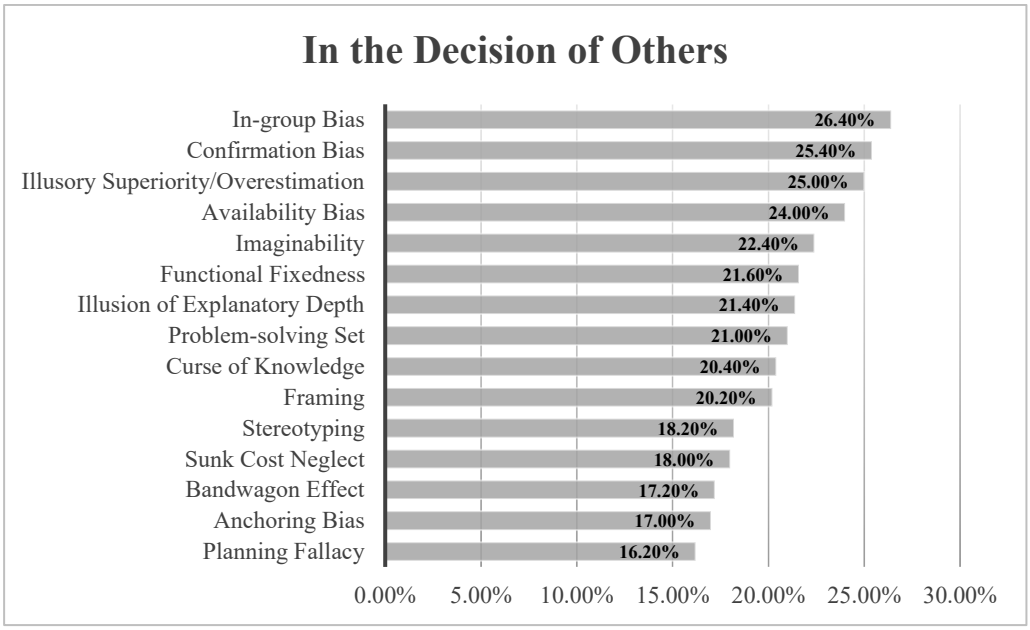


Figure 4: Prevalence of Cognitive Biases in the Decision of Others

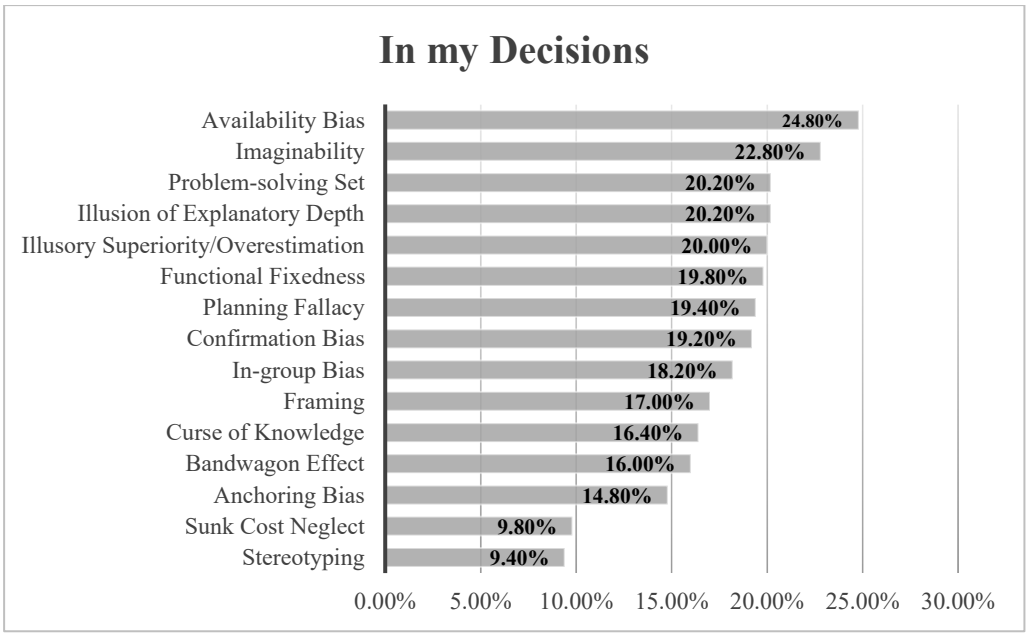


Figure 5: Self-reported Prevalence of Cognitive Biases in One's Own Decision

The rating of the highest negative impact on decision making resulted in the following influential biases: functional fixedness, in-group bias, and planning fallacy (see Figure 6).

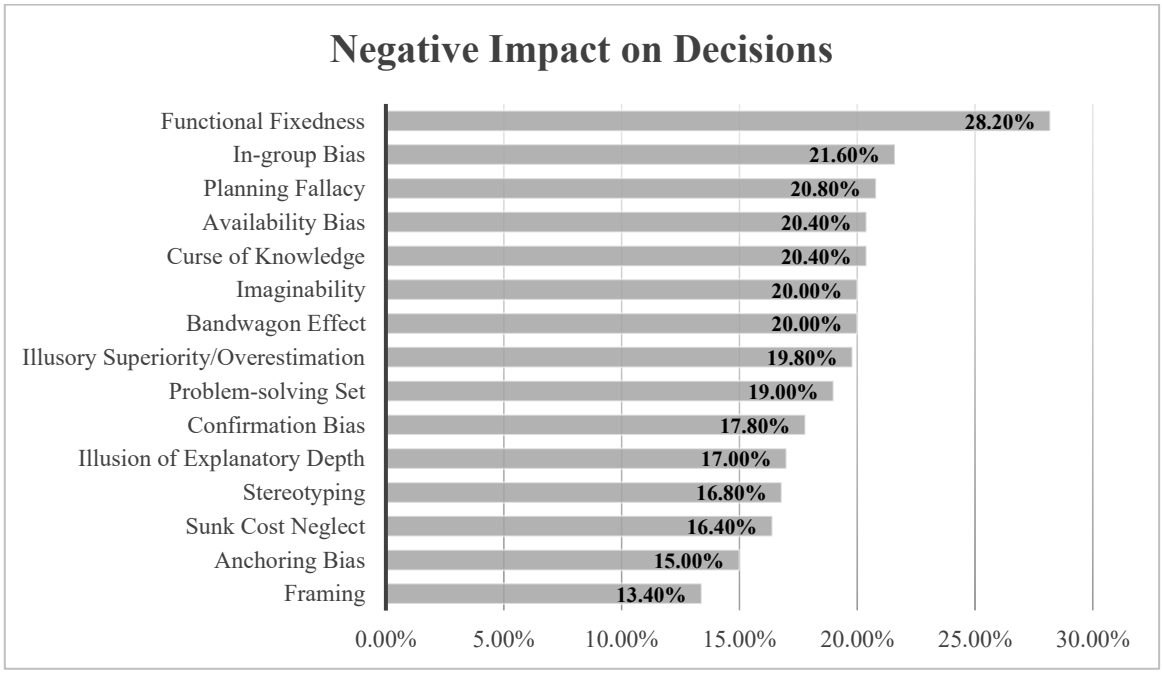


Figure 6: Ranking of Negative Impact on Decisions

4.4.2 The Susceptibility to Biases Based on Individual Decision Styles

The susceptibility to cognitive biases was measured based on the number of decision-making behaviors (out of the list of 15) the participants have observed in their own behavior over the last 6 months (overall: n=500, m=2.678, SD=.6443, range 1.0 – 5.0). The decision styles were measured according to the GDSMI inventory (resulting means (n=500); rational: m=4.3116, SD=.4542; intuitive: m=3.1648, SD=.5825; dependent: m=2.9416, SD=.7775; avoidant: m=2.2052, SD=.5852; spontaneous: m=2.1952, SD=.6039).

Table VII shows the inter-correlation matrix of the 15 cognitive biases, the five decision styles, age, and gender. The composite of susceptibility to all biases shows a highly significant negative correlation with the rational and the spontaneous decision style, and a positive one with the intuitive decision style. This indicates that rational and spontaneous decision makers identify less biases in their own behavior, and intuitive decision makers have a high awareness for their own cognitive biases.

Variable	Susceptibility (SUS)															Susceptibility composite, decision style measures (DS), and control variables (CV)							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1. SUS1	—																						
2. SUS2	-.026	—																					
3. SUS3	-.008	-.047	—																				
4. SUS4	-.028	-.091*	-.012	—																			
5. SUS5	-.069	-.042	-.048	-.151***	—																		
6. SUS6	-.105*	-.104*	-.106*	-.120**	-.038	—																	
7. SUS7	-.077	-.116**	-.055	-.120**	-.021	-.005	—																
8. SUS8	-.010	-.091*	-.095*	-.009	-.097*	-.046	-.057	—															
9. SUS9	.039	-.044	-.083	-.052	-.109*	-.089*	-.013	-.094*	—														
10. SUS10	-.035	-.139**	-.106*	-.071	-.010	-.096*	-.005	-.059	-.060	—													
11. SUS11	-.018	-.087	-.095*	-.068	-.071	-.058	-.095*	.021	-.054	-.031	—												
12. SUS12	-.085	-.049	.066	-.068	-.134**	-.019	-.084	-.121**	-.059	-.088*	-.038	—											
13. SUS13	-.083	.056	-.049	-.067	-.092*	-.058	-.032	-.016	-.024	-.092*	-.096*	.003	—										
14. SUS14	.012	-.041	-.025	-.091*	-.030	-.038	-.088	-.026	-.094*	-.038	-.118**	.016	-.012	—									
15. SUS15	-.007	-.056	-.040	.050	-.073	-.104*	-.052	-.042	-.025	-.091*	-.093*	-.123**	-.047	-.123**	—								
16. SUSC	.161***	.136**	.205***	.124**	.003	.031	.136**	.155***	.086	.062	.044	.108*	.117*	.194***	.134**	—							
17. DS1	-.122**	-.049	.032	-.031	.048	.037	-.034	-.095*	-.093*	.066	.018	.003	-.129**	-.071	-.050	-.250***	—						
18. DS2	.110*	.001	.094*	.043	-.005	.014	.063	.103*	.151***	-.033	-.029	-.090*	.112*	.078	.056	.373***	-.245***	—					
19. DS3	-.053	-.015	.014	.018	-.040	-.026	-.029	.090*	.073	.005	.016	-.074	-.041	-.005	.043	-.002	-.312***	.178***	—				
20. DS4	.028	.027	.033	.016	-.054	.001	-.042	.030	.073	-.032	-.019	-.006	.071	.001	-.004	.060	-.351***	.278***	.473***	—			
21. DS5	-.135**	-.013	-.039	-.054	-.009	.012	-.100*	-.067	-.002	.044	.048	.020	-.007	-.044	-.132**	-.279***	.110*	-.080	.225***	.371***	—		
22. CV1	-.059	.038	-.024	.057	-.080	.025	.036	.043	.026	.029	-.014	-.010	-.175***	-.026	-.059	-.079	-.081	-.002	.218***	.124**	.073	—	
23. CV2	-.007	.075	-.027	-.004	-.017	-.026	-.006	.023	-.030	.003	-.029	.003	.011	-.071	-.012	-.065	-.029	-.111*	-.026	.026	.048	-.163***	—

* = p < 0.05, ** = p < 0.01, *** = p < 0.001

Table VII: Inter-correlations Among the Key Variables – Self-reported Bias Susceptibility

SUS1: Stereotyping; SUS2: Availability; SUS3: Problem-solving Set; SUS4: Imaginability; SUS5: Curse of Knowledge; SUS6: Confirmation Bias; SUS7: Illusion of Explanatory Depth; SUS8: In-Group Bias; SUS9 : Anchoring Bias; SUS10: Planning Fallacy; SUS11 : Framing Bias; SUS12: Bandwagon Effect,; SUS13: Sunk Cost Neglect; SUS14: Functional Fixedness, SUS15: Illusory Superiority; SUSC; Composite Susceptibility; DS1: Rational Decision Style; DS2: Intuitive Decision Style; DS3: Dependent Decision Style; DS4: Avoidant Decision Style; DS5: Spontaneous Decision Style; CV1: Age; CV2: Gender

The inter-correlations between the individual cognitive biases and the decision styles show strong negative correlations between the *rational* decision style and the biases stereotyping, in-group bias, anchoring, and the sunk cost neglect. This means, that managers who perceive themselves as more rational in their decision making, rarely indicate to be victims of those biases. The intuitive decision style on the other hand is positively correlated with stereotyping, problem-solving set, in-group bias, and sunk cost neglect and negatively with the bandwagon effect. The only correlation for the dependent decision style is the in-group bias (negative). For the spontaneous decision style, we found negative correlations with stereotyping, the illusion of explanatory depth, and illusory superiority. The avoidant decision style shows no correlation with a single cognitive bias. As a result, avoidant decision makers cannot predict a specific susceptibility to certain cognitive biases from their own decision style.

The inter-correlations between the cognitive biases show 33 significant correlations, but all negative. Interesting side results show the significant negative correlation of age and the sunk cost neglect (the older you get, the more you are willing to cut your losses), the positive correlation of age and the decision styles dependent and avoidant (the older you get, the more you rely on others or delay decisions), and the negative correlation of gender (male) with the intuitive decision style (indicating that women generally tend to be more intuitive decision makers).

The significant correlations provide us with an answer to the first research question: There are differences in perceived bias susceptibility depending on the individual decision style.

4.4.3 Susceptibility Comparison of Top 25 vs. Bottom 25 per Decision Style

We also conducted a detailed analysis from the perspective of the five decision styles to identify not only correlations of decision style and cognitive biases as above, but to see whether the most typical decision style participants are specifically aware of and prone to certain biases. For this reason, we grouped the results of the GDSMI into quartiles for each decision style and compared the results of the top 25 (participants in the quartile with the highest scores per decision style) with the bottom 25 group (participants in the quartile with the lowest scores per decision style). The overview of the general self-reported susceptibility to cognitive biases in their decision behavior (Table VIII) shows that more rational and/or spontaneous decision makers (top 25 quartile) tend to report a significant *lower* susceptibility to biased decision behavior. Intuitive decision makers recognize a significant *higher* susceptibility and for the decision styles of dependent and

avoidant decision maker there was no significant difference between the top 25 and the bottom 25 per decision style which is according to the inter-correlation matrix.

Decision Style	**Rational**	**Intuitive**	**Dependent**	**Avoidant**	**Spontaneous**
Cognitive Biases	m(top25)=2.5 SD(top25)=.040 m(bottom25)=2.976 SD(bottom25)=.053 F(1/331)=50.9501 p<0.0001*	m(top25)=2.93798 SD(top25)=.057 m(bottom25)=2.344 SD(bottom25)=.509 F(1/252)=53.3941 p<0.0001**	m(top25)=2.82424 SD(top25)=.046 m(bottom25)=2.881 SD(bottom25)=.054 F(1/281)=0.6419 p=0.4237	m(top25)=2.83562 SD(top25)=.053 m(bottom25)=2.791 SD(bottom25)=.061 F(1/254)=0.33055 p=0.5809	m(top25)=2.43243 SD(top25)=.044 m(bottom25)=2.984 SD(botom25)=.049 F(1/269)=70.1489 p<0.0001*

Table VIII: Self-reported General Bias Susceptibility per Decision Style

*(Top 25 per decision style: * = significant lower self-reported susceptibility, ** = significant higher self-reported susceptibility)*

The analysis for each of the 15 different cognitive biases (see Table IX) showed no significant difference in the self-reported susceptibility to several of those biases: curse of knowledge, confirmation bias, and framing bias. For *stereotyping*, the top 25 rational and spontaneous decision makers show a lower self-reported susceptibility than the bottom 25 and the top 25 of intuitive decision makers a higher one. The biases problem-solving set, imaginability, and functional fixedness show significantly stronger reported susceptibility for the top 25 intuitive decision makers, in contrast to the other four decision styles. For the illusion of explanatory depth and the illusory superiority, only the top 25 spontaneous decision makers show a (in the first case weak) significance in lower reported susceptibility than the others. The most avoidant and dependent decision makers report a higher susceptibility to the in-group bias (which means for the dependent decision makers that the top 25 show a significant higher susceptibility to this bias than the bottom 25 but still having a negative correlation with this specific bias over all (see results from Table VII)).

Rational decision makers report a lower susceptibility to the anchoring bias and the sunk cost bias – in contrast to intuitive decision makers, they report a higher susceptibility to both biases. The planning fallacy shows a lower self-reported susceptibility to the top 25 avoidant decision makers, and the bandwagon effect a lower one for the top 25 intuitive decision makers. We can thus report that certain decision-making styles struggle more with certain biases than others (in the self-awareness of the decision makers).

Decision Style	Cognitive Bias	Top 25		Bottom 25	Statistic
Rational	Stereotyping	n=208		n=125	F(1/331)=8.3828
		m=.058	<	m=.152	p=.004
		SD=.020		SD=.026	
	Availability Bias	n=208		n=125	F(1/331)=3.404
		m=.221	<	m=.312	p=.0659
		SD=.030		SD=.024	One tailed p-test p=.033
	In-Group Bias	n=208		n=125	F(1/331)=3.4693
		m=.144	<	m=.224	p=.0634
		SD =.026		SD=.034	One tailed p-test p=.0317
	Anchoring Bias	n=208		n=125	F(1/331)=6.9004
		m=.111	<	m=.216	p=.009
		SD=.025		SD=.032	
	Sunk Cost Neglect	n=208		n=125	F(1/331)=6.2206
		m=.063	<	m=.144	p=.0131
		SD=.020		SD=.026	
Intuitive	Stereotyping	n=129		n=125	F(1/252)=7.575
		m=.124	>	m=.032	p=.0063
		SD=.023		SD=.024	
	Problem-solving Set	n=129		n=125	F(1/252)=6.3010
		m=.240	>	m=.120	p=.0127
		SD=.034		SD=.034	
	Imaginability	n=129		n=125	F(1/252)=3.0362
		m=.248	>	m=.160	p=.0826
		SD=.035		SD=.036	One tailed p-test p=.0413
	Anchoring Bias	n=129		n=125	F(1/252)=6.8411
		m=.220	>	m=.104	p=.0094
		SD=.032		SD=.033	
	Bandwagon Effect	n=129		n=125	F(1/252)=5.3064
		m=.116	<	m=.224	p=.0221
		SD=.033		SD=.033	
	Sunk Cost Neglect	n=129		n=125	F(1/252)=4.0945
		m=.163	>	m=.080	p=.0441
		SD=.029		SD=.029	
	Functional Fixedness	n=129		n=125	F(1/252)=4.4838
		m=.209	>	m=.112	p=.0352
		SD=.032		SD=.033	
Dependent	In-Group Bias	n=165		n=118	F(1/281)=4.7312
		m=.218	>	m=.119	p=.0305
		SD=.030		SD=.035	

Avoidant	In-Group Bias	n=146		n=110	F(1/254)=3.6176
		m=.220	>	m=.127	p=.0583
		SD=.032		SD=.036	One tailed p-test p=.0292
	Planning Fallacy	n=146		n=110	F(1/252)=3.6641
		m=.151	<	m=.245	p=.0567
		SD=.033		SD=.037	One tailed p-test p=.0284
Spontaneous	Stereotyping	n=148		n=123	F(1/269)=11.9627
		m=.041	<	m=.163	p=.0006
		SD=.024		SD=.026	
	Illusion of Explanatory	n=148		n=123	F(1/269)=2.8063
	Depth	m=.155	<	m=.236	p=.0951
		SD=.032		SD=.036	One tailed p-test p=.0475
	Illusory Superiority	n=148		n=123	F(1/269)=8.6090
		m=.135	<	m=.276	p=.0036
		SD=.032		SD=.036	

Table IX: Significant Self-reported Susceptibilities per Decision Style for the Cognitive Biases

(Top 25 vs. bottom 25 per decision style)

4.4.4 The Bias Blind Spot(s)

The size of the blind spot was measured with the difference of the number of behavioral patterns recognized on oneself and on others, and this overall and per cognitive bias (overall n= 500, m=.466, SD=.885, range -2.00 to 4.00).

The comparison between the number of cognitive biases attributed to others and to oneself showed a significant difference and revealed a general bias blind spot among managers (mean others=3.144, mean oneself=2.678, ANOVA F(1/998)=135.8620, p<.0001). By considering that, for the first question, the participants could name up to 5 biases that they observed on others and up to 15 biases that they observed on themselves, the general bias blind spot is even more apparent.

The analysis per bias revealed that the top three biases with a strong blind spot for managers are *stereotyping, in-group bias, and sunk cost neglect* (see Figure 7), meaning that the managers see them generally much more in others than themselves. The three biases imaginability, availability, and planning fallacy showed a reversed blind spot. They are more observed on oneself than on others (which in the case of the planning fallacy confirms earlier research: people claim to be more biased by this fallacy than their peers (Pronin et al., 2002)).

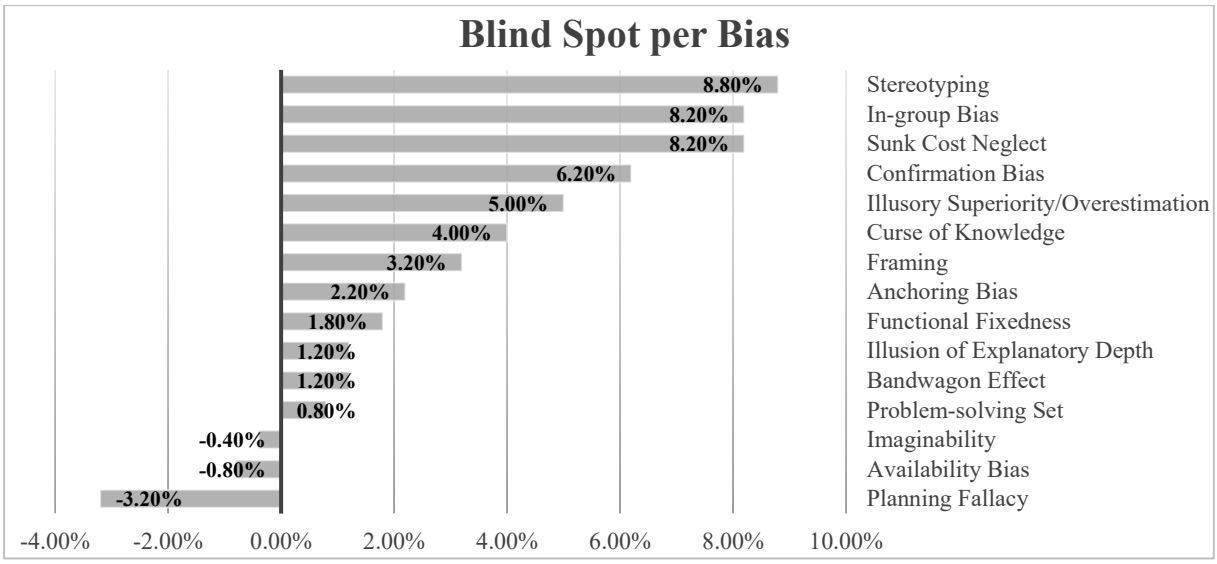


Figure 7: Self-other Assessment (Difference in Percentage) per Bias

(Top 4 with significant blind spot: stereotyping, p=.002; in-group bias, p<.001; sunk cost neglect, p<0.001; confirmation bias, p=.017)

Table X shows the inter-correlation matrix of the 15 cognitive biases, the five decision styles, age, and gender. The composite blind spot result shows a significant positive correlation with the rational, dependent, and spontaneous decision style. Thus, indicating an overall stronger blind spot for biases for these three decision styles. The intuitive decision style correlates negatively with the blind spot composite, showing that intuitive decision makers tend to have a significant negative blind spot for cognitive biases in their decision behavior (i.e., they see themselves as more affected by biases than others).

Variable	Bias Blind Spot (BBS)															BBS composite, decision style measures (DS), and control variables (CV)							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1. BBS1	—																						
2. BBS2	-.018	—																					
3. BBS3	.025	-.035	—																				
4. BBS4	-.129**	-.093*	-.056	—																			
5. BBS5	.082	-.054	-.139**	-.077	—																		
6. BBS6	.048	-.148***	-.094*	-.103*	-.027	—																	
7. BBS7	.070	-.035	-.083	-.107*	-.021	-.176***	—																
8. BBS8	.046	-.085	-.132**	-.066	-.151***	-.003	-.028	—															
9. BBS9	.032	-.051	-.056	-.027	-.075	-.045	-.064	-.053	—														
10. BBS10	.044	-.130**	-.125	.006	-.051	-.058	-.012	-.089*	-.063	—													
11. BBS11	.040	-.041	-.091*	-.127**	-.045	-.088*	-.047	-.065	.005	-.071	—												
12. BBS12	.052	-.032	.055	.034	-.095*	-.036	-.105*	-.064	-.137**	-.057	-.023	—											
13. BBS13	.005	-.126**	-.056	-.067	-.053	-.034	.012	-.010	-.024	-.078	-.057	-.088*	—										
14. BBS14	.044	-.104*	-.027	-.059	.004	-.081	-.061	-.030	-.059	.030	-.043	-.059	-.070	—									
15. BBS15	.087	-.033	.005	.086	-.045	-.112*	-.002	-.079	-.125**	-.028	-.112*	-.110*	-.060	-.126**	—								
16. BBSC	.156***	.078	.101*	.162***	.053	-.006	.135**	.141**	.083	.130**	.093*	.116**	.073	.155*	.155***	—							
17. DS1	.035	.019	.047	.075	.006	-.008	-.015	.084	.121**	-.075	-.029	-.050	.095*	.049	.052	.246***	—						
18. DS2	.098*	-.026	-.087	.014	.070	.041	-.052	-.156***	-.156***	.068	-.051	.119**	.044	.014	-.038	-.234***	-.245***	—					
19. DS3	.042	.049	-.045	.054	.068	.028	.013	-.027	-.089*	.044	.046	.048	.020	.025	-.065	.127**	-.312***	.178***	—				
20. DS4	.024	-.025	-.102*	.017	.065	-.046	.068	-.010	-.043	.050	.013	.008	-.008	.063	-.021	.028	-.351***	.278***	.473**	—			
21. DS5	.094*	-.047	.074	.069	.081	-.021	.061	.069	-.017	-.064	.029	-.032	.098*	.057	.094	.327***	.110*	-.080	.225***	.371***	—		
22. CV1	.040	.028	-.017	-.039	.024	-.033	-.045	-.069	-.046	-.043	.082	.041	.114*	.056	.003	.043	-.081	-.002	.218***	.124**	.073	—	
23. CV2	.005	-.031	.019	-.031	.012	.046	.006	.005	.104**	.005	.015	-.042	-.083	.074	.005	.072	-.029	-.111**	-.026	.022	.046	-.163	—

* = p < 0.05, ** = p < 0.01, *** = p < 0.001

Table X: Inter-correlations Among the Key Variables – Bias Blind Spots

BBS1: Stereotyping; BBS2: Availability; BBS3: Problem-solving Set; BBS4: Imaginability; BBS5: Curse of Knowledge; BBS6: Confirmation Bias; BBS7: Illusion of Explanatory Depth; BBS8: In-Group Bias; BBS9 : Anchoring Bias; BBS10: Planning Fallacy; BBS11 : Framing Bias; BBS12: Bandwagon Effect,;

A closer look at the correlations between decision styles and the individual bias blind spots shows a positive correlation between the rational decision style and blind spots for the anchoring bias and the sunk cost neglect, as well as a positive correlation between the spontaneous decision style and blind spots for stereotyping and sunk cost neglect. The intuitive decision style correlated negatively with an in-group bias and the anchoring bias (smaller blind spot) and positively for stereotyping and the bandwagon effect. Dependent decision makers only correlate negatively with the anchoring bias, avoidant only with problem-solving set. These results indicate that individual differences in decision styles also lead to individual bias blind spots, but, interestingly, fewer differences between the styles than in the susceptibility to cognitive biases.

The inter-correlations between the bias blind spots showed 26 significant negative correlations, no significant positive correlations. Gender (female) correlates positive with a blind spot for the anchoring bias and age (older) positive with a blind spot for the sunk cost neglect.

4.4.5 Blind Spots per Decision Style (Top 25)

To further clarify the relationship between bias blind spots and individual decision styles, we analyzed the size and significance of the blind spots for the most pronounced participants (top 25) per decision style (see Table XI). We thus analyzed only the correlations of the top quartile with the bias blind spots.

The participants within the top 25 of the rational decision style show a significant blind spot for stereotyping, curse of knowledge, in-group bias, anchoring, sunk-cost fallacy, and illusory superiority and a negative blind spot (a higher self-reported susceptibility for oneself than for others) for the planning fallacy. The top 25 in the intuitive decision style show a significant blind spot for the confirmation bias and the curse of knowledge. The blind spots for dependent decision makers are in stereotyping, curse of knowledge, confirmation bias, framing bias and a negative blind spot for the anchoring bias. Avoidant top 25 participants show a significant blind spot for the curse of knowledge and functional fixedness, and a negative blind spot for problem-solving set. For spontaneous decision makers, the significant blind spots are problem-solving set, curse of knowledge, in-group bias, sunk cost fallacy, stereotyping, and illusory superiority.

Decision Style	Cognitive Bias	in others		in oneself	Statistic
Rational	Stereotyping	m=.0163	>	m=.058	F(1/414)=12.1176
Top 25 (n=208)		SD=.021		SD=.021	p=.0006
	Curse of knowledge	m=.260		m=.188	F(1/414)=3.1244
		SD=.029	>	SD=.029	p=.0779
					One tailed p-test p=.0389
	In-Group Bias	m=.270		m=.144	F(1/414)=10.1019
		SD =.028	>	SD=.028	p=.0016
	Anchoring Bias	m=.188	>	m=.111	F(1/414)=4.8859
		SD=.025		SD=.025	p=.0276
	Planning Fallacy	m=.115	<	m=.197	F(1/414)=5.3115
		SD=.025		SD=.025	p=.0217
	Sunk Cost Neglect	m=.202	>	m=.063	F(1/414)=18.3115
		SD=.023		SD=.023	p<.0001
	Illusory Superiority	m=.270	>	m=.168	F(1/414)=6.2667
		SD=.029		SD=.029	p=.0127
Intuitive	Curse of Knowledge	m=.271		m=.171	F(1/256)=3.8327
Top 25 (n=129)		SD=.036	>	SD=.036	p=.0513
					One tailed p-test p=.0257
	Confirmation Bias	m=.310		m=.217	F(1/256)=2.8854
		SD=.039	>	SD=.039	p=.0906
					One tailed p-test p=.0453
Dependent	Stereotyping	m=.194	>	m=.010	F(1/328)=6.3229
Top 25 (n=165)		SD=.027		SD=.027	p=.0124
	Curse of Knowledge	m=.224	>	m=.140	F(1/328)=4.0170
		SD=.030		SD=.030	p=.0459
	Confirmation Bias	m=.267		m=.188	F(1/328)=2.9242
		SD=.033	>	SD=.033	p=.0882
					One tailed p-test p=.0441
	Anchoring Bias	m=.133	<	m=.224	F(1/328)=4.6816
		SD=.030		SD=.030	p=.0312
	Framing	m=.236		m=.163	F(1/328)=2.7333
		SD=.031	>	SD=.031	p=.0992
					One tailed p-test p=.0496

Avoidant Top 25 (n=146)	Problem-solving Set	m=.123 SD=.031	<	m=.226 SD=.031	F(1/290)=5.4078 p=.0207
	Curse of Knowledge	m=.247 SD=.032	>	m=.130 SD=.032	F(1/290)=6.5754 p=.0108
	Functional Fixedness	m=.267 SD=.035	>	m=.185 SD=.035	F(1/290)=2.8270 p=.0938 One tailed p-test p=.0469
Spontaneous Top 25 (n=148)	Stereotyping	m=.209 SD=.026	>	m=.041 SD=.026	F(1/294)=20.5124 p<.0001
	Problem-solving Set	m=.264 SD=.034	>	m=.182 SD=.034	F(1/294)=2.8156 p=.0944 One tailed p-test p=.0472
	Curse of Knowledge	m=.243 SD=.033	>	m=.149 SD=.033	F(1/294)=4.2346 p=.0405
	In-group Bias	m=.257 SD=.033	>	m=.149 SD=.033	F(1/294)=5.4131 p=.0207
	Sunk Cost Neglect	m=.209 SD=.029	>	m=.081 SD=.029	F(1/294)=10.0907 p=.0016
	Illusory Superiority	m=.257 SD=.033	>	m=.135 SD=.033	F(1/294)=7.0665 p=.0083

Table XI: Significant Self-reported Bias Blind Spots for the Top 25 Quartile per Decision Style for the Cognitive Biases

These results show individual differences in the susceptibility to bias blind spots and thus answer the second research question. The understanding of one's own decision style can be used to identify individual bias blind spots.

4.5 Discussion

For the discussion we summarize the results following the structure of the General Decision Style Inventory (GDSMI) (Scott & Bruce, 1995) to show the vulnerability to specific cognitive biases for each decision style.

4.5.1 Rational Decision Style

The rational decision style is defined as "comprehensive search for information, inventory of alternatives and logical evaluation of alternatives" (Thunholm, 2004, p. 933), behaviors which are associated with "good decision making" (Parker, Bruine, Fischhoff, 2007). Rational decision makers show a positive correlation to attributing the control over one's destiny to factors within rather than outside oneself (Thunholm,

2004). Therefore, the results showing an overall lower self-reported susceptibility to cognitive biases are in line with research on rational decision styles.

The analysis of the blind spots for the rational decision styles on the other hand, lead to a surprising result: Participants with a strong rational decision style show more bias blind spots than the other decision styles. Research provides us with three potential explanations for this phenomenon:

A) Rational decision makers do have larger bias blind spots, as they understand themselves as more rational and having better decision-making skills and thus expect themselves to perform fewer of the presented (negative) decision behaviors. They are simply more confident in their decision-making capabilities (Hamilton, Shih, & Mohammed, 2016). West et al. (2012) reported that indeed subjects that are more cognitively sophisticated showed larger bias blind spots.
B) The blind spots can be explained by the type of cognitive biases and the degree of social desirability. Thunholm (2004) shows a significant correlation of the rational decision style with a self-perception of being hard working and independent. Consequently, rational decision makers see themselves unaffected by biases like stereotyping, in-group bias, curse of knowledge, illusory superiority and the sunk cost neglect (the blind spot in anchoring may be a different case).
C) Subjects with a strong rational decision style report to have a lower susceptibility to cognitive biases. Perhaps their perception is not a blind spot at all, but an accurate self-assessment, as they really are less prone to fall into cognitive traps. Thus, "it is possible that if people high in openness to experience have both superior cognitive ability and some awareness of that ability, they might accurately report that they are less susceptible to bias than their peers" (Scopelliti et al., 2015, p. 2477). This would contradict the finding that individuals with larger blind spots do *not* show smaller cognitive biases (West et al., 2012; West, Toplak, & Stanovich, 2008). But an interesting finding of our study may support the explanation with an accurate self-assessment: our question on the use debiasing techniques resulted in a positive correlation between a rational decision style and the number of debiasing techniques used ($r=.3185$, $p<.0001$). Rational decision makers in fact use more debiasing techniques than the other decision styles (m(rat)=4.11, m(int)=3.93, m(dep)=3.81, m(avo)=3.86, m(spo)=3.84).

There is no clear picture yet on the quality of self-assessments of the rational decision makers group, as the mere indication of using more debiasing techniques is not a proof thereof. More research is thus needed to understand the individual susceptibility of

rational decision makers to cognitive biases and the reason behind their individual bias blind spots (and if they can be even called such for this group). The perspectives of individual motivational backgrounds of cognitive biases (Oreg & Bayazit, 2009) or inter-causalities of cognitive biases (social desirability as potential moderator or amplifier for other cognitive biases or bias blind spots) may help find more insights about this phenomenon. Still, the combination of self-reported susceptibility and blind spots for cognitive biases for the rational decision styles leads to an overview of potential "bias risks" for self-assessed rational managers in their decisions (Table XII).

Top 25 Rational	Significant Blind Spot	Without Blind Spot
Significant Higher Susceptibility (top vs. bottom)		
No Significantly Different Susceptibility (top vs. bottom)	Curse of Knowledge Planning Fallacy (negative blind spot) Illusory Superiority	Problem-solving Set Imaginability Confirmation Bias Illusion of Explanatory Depth Framing Bias Bandwagon Effect Functional Fixedness
Significant Lower Susceptibility (top vs. bottom)	Stereotyping In-Group Bias Anchoring Bias Sunk Cost Neglect	Availability Bias

Table XII: Individual "Bias Risks" for Biased Decision Behavior and Blind Spots – Rational Decision Style

4.5.2 Intuitive Decision Style

Thunholm (2004) describes the intuitive decision style as characterized by a less systematic search for information and a tendency to premonitions, feelings and attention to (at times irrelevant) details in the flow of information. Intuitive decisions are a combination of one's experience and the feelings and emotions in a decision-making situation (Burke & Miller, 1999). Our results (see Tables VII, X, and XIII) show a high bias awareness of subjects with a strong intuitive decision style and surprisingly small bias blind spots. This points, one can stipulate, to a smaller introspect illusion for these subjects. There was no correlation with the number of debiasing techniques used compared to the intensity of an intuitive decision style ($r=-.0389$, $p=.3852$). These results indicate that intuitive decision makers seem to be more (accurately) aware of their decision flaws but do *not* follow through on that insight by using more debiasing techniques than others (in fact they use slightly less $m(int)=3.93$ compared to rational decision makers ($m(rat)=4.11$)).

Top 25 Intuitive	Significant Blind Spot	Without Blind Spot
Significant Higher Susceptibility (top vs. bottom)		Stereotyping Problem-solving Set Imaginability Anchoring Bias Sunk Cost Neglect Functional Fixedness
No Significantly Different Susceptibility (top vs. bottom)	Curse of Knowledge Confirmation Bias	Availability Bias Illusion of Explanatory Depth In-Group Bias Planning Fallacy Framing Bias Illusory Superiority
Significant Lower Susceptibility (top vs. bottom)		Bandwagon Effect

Table XIII: Individual "Bias Risks" for Biased Decision Behavior and Blind Spots – Intuitive Decision Style

4.5.3 Dependent Decision Style

Subjects with a strong dependent decision style tend to search for advice and direction from others in their decisions (Scott & Bruce, 1995; Thunholm, 2004). The measures of this decision style do not show any correlations with the overall susceptibility to cognitive biases or bias blind spots. A closer look to the top 25 subjects for the dependent decision style shows an average to high self-reported susceptibility and some bias blind spots (Table XIV). Interestingly, this decision style correlates significantly and negatively with the number of debiasing techniques used ($r=-.5340$, $p<.0001$). So, this decision style does depend on others, but unfortunately not on debiasing techniques.

Top 25 Dependent	Significant Blind Spot	Without Blind Spot
Significant Higher Susceptibility (top vs. bottom)		In-Group Bias
No Significantly Different Susceptibility (top vs. bottom)	Stereotyping Curse of Knowledge Confirmation Bias Framing Bias	Availability Bias Problem-solving Set Imaginability Illusion of Explanatory Depth Planning Fallacy Bandwagon Effect Sunk Cost Neglect Functional Fixedness Illusory Superiority
Significant Lower Susceptibility (top vs. bottom)	Anchoring Bias (negative blind spot)	

Table XIV: Individual "Bias Risks" for Biased Decision Behavior and Blind Spots – Dependent Decision Style

4.5.4 Avoidant Decision Style

The avoidant decision style is characterized by “attempts to avoid decision making whenever possible” (Thunholm, 2004, p. 933). The tendency to avoid decisions did not show a significant correlation with the self-reported susceptibility to cognitive biases in general. This is confirmed by the top 25 analysis, where most biases show an average susceptibility with only few bias blind spots (see Table XV). Like the dependent decision style top 25, the top quartile of the avoidant decision style correlates significantly and negatively with number of debiasing techniques used (r=-.4026, p<.0001). There is thus ample potential for this kind of managers to nudge themselves to timely and sound decisions by starting to use debiasing techniques.

Top 25 Avoidant	**Significant Blind Spot**	**Without Blind Spot**
Significant Higher Susceptibility (top vs. bottom)		In-Group Bias
No Significantly Different Susceptibility (top vs. bottom)	Problem-solving Set (negative blind spot) Curse of Knowledge Functional Fixedness	Stereotyping Availability Bias Imaginability Confirmation Bias Illusion of Explanatory Depth Anchoring Bias Framing Bias Bandwagon Effect Sunk Cost Neglect Illusory Superiority
Significant Lower Susceptibility (top vs. bottom)		Planning Fallacy

Table XV: Individual "Bias Risks" for Biased Decision Behavior and Blind Spots – Avoidant Decision Style

4.5.5 Spontaneous Decision Style

Spontaneous decision makers have “a sense of immediacy and a desire to get through the decision-making process as soon as possible” (Scott & Bruce, 1995, p. 823). A high score on the spontaneous decision style items correlated negatively with the overall self-reported susceptibility to cognitive biases and strongly positively with bias blind spots. As the spontaneous decision style also correlated negatively with the number of debiasing techniques used (r=-.2382, p<.0001), one can assume that managers with this decision style are indeed prone to more bias blind spots than the other decision-making styles. This is also represented in the “bias risk map” of the top 25 (Table XVI).

Top 25 Spontaneous	Significant Blind Spot	Without Blind Spot
Significant Higher Susceptibility (top vs. bottom)		
No Significantly Different susceptibility (top vs. bottom)	Problem-solving Set Curse of Knowledge In-Group Bias Sunk Cost Neglect	Availability Bias Imaginability Confirmation Bias Anchoring Bias Planning Fallacy Framing Bias Bandwagon Effect Functional Fixedness
Significant Lower Susceptibility (top vs. bottom)	Stereotyping Illusory Superiority	Illusion of Explanatory Depth

Table XVI: Individual "Bias Risks" for Biased Decision Behavior and Blind Spots – Spontaneous Decision Style

4.5.6 Explorative Factor Analysis GDMSI

A detailed analysis of the 25 items of the GDMSI inventory for face and content validity showed surprising inconsistencies. From a content perspective, we registered the indication that not all items in the dimensions are representative for the domain they aim to measure (rational, intuitive, and avoidant decision styles). For two decision styles (dependent, spontaneous), the items may even measure two different dimensions instead of one.

In our factor analysis, it was not possible to reproduce the dimensional structure of the GDMSI inventory. We, therefore, conducted an explorative factor analysis for each dimension to check whether the items measuring a certain dimension load high and if the items have substantively meaningful factor loadings. Table XVII shows the results of the five explorative factor analyses. Applying the two items with the highest factor loadings as representative items for the three decision styles rational (items DS01, DS05), intuitive (items DS06, DS07), and avoidant (items DS16, DS17), the analyses did not reveal a significant difference for the bias susceptibility and blind spots compared to the original five items.

Dimension in Decision Style Scale	Item	Factor loadings in Principal Axis Factor Analysis, Varimax Rotation with Kaiser Normalization, number of factors determined by Kaiser Criterion		Factor loadings in Principal Axis Factor Analysis, Varimax Rotation with Kaiser Normalization, number of factors set to 1	Comment
		Factor 1	Factor 2		
Rational	DS01	0.638		0.638	Two variables with highest factor loadings will be used for further analysis. Good comprehensibility because a clear behavior is described.
	DS02				
	DS03				
	DS04	0.344		0.344	
	DS05	0.601		0.601	
Intuitive	DS06	0.842		0.834	Two variables with highest factor loadings will be used for further analysis. Good comprehensibility.
	DS07	0.851		0.869	
	DS08		0.68		
	DS09	0.342		0.325	
	DS10	-0.359		-0.342	
Dependent	DS11		0.708	0.387	Formation of 2 index values: DS13 and DS15: Openness to support. DS11 and DS12: Dependence on others
	DS12		0.709	0.376	
	DS13	0.788		0.533	
	DS14	0.453	0.398	0.681	
	DS15	0.706		0.588	
Avoidant	DS16	0.701		0.501	Two variables with highest factor loadings will be used for further analysis. Best comprehensibility. No added value from DS18 (too concrete due to "because") and DS20 (procrastinate has too negative connotations and is a technical word that should be avoided)
	DS17	0.509		0.507	
	DS18		0.404		
	DS19		0.320	0.369	
	DS20		0.607	0.349	
Spontaneous	DS21		0.670		Formation of 2 index values: DS23 und DS25: Spontaneuous DS21 und DS24: Impulsiveness
	DS22		0.603		
	DS23	0.831		0.941	
	DS24		0.644		
	DS25	0.772		0.671	

Factor loadings below 0.3 are not displayed.

Table XVII: Factor Loading Analysis of GDSMI Factors

For the dependent decision style, the items loaded on two clearly distinct factors when we applied the Kaiser criterion: The openness for support (items DS13, DS15) and the

dependence on others (items DS11, DS12). From our perspective, forcing the items into one factor, clearly leads to a loss of differentiation. We, therefore, decided to generate the two dimensions mentioned above for further analyses. The same applies to the spontaneous decision style: the items measure two distinct dimensions that we named spontaneous decision style (items DS23, DS25) and impulsive decision style (items DS21, DS24). The general pattern of bias susceptibility of the two split decision styles is significantly different than the one of the original decision styles for the top 25 of each of these styles:

Generally, the top 25 of dependent decision makers do not show a significant difference to the bottom 25 regarding bias susceptibility. When split up into "openness for support" and "dependence on others", however, they both show a significant difference. The top 25 of "openness for support" report a significant lower susceptibility to cognitive biases than the bottom 25 ($m(top25)=2.30709$, $m(bottom25)=2.97895$, $F(1/220)=94.7156$, $p<.00001$), and the top 25 of "dependence on others" a significant higher one ($m(top25)=2.90431$, $m(bottom25)=2.42195$, $F(1/245)=17.4629$, $p<.0001$).Thus, "openness for support" may reduce one's susceptibility to cognitive biases.

Different patterns can also be recognized for specific biases: The analyses of stereotyping and in-group bias provide a lower reported susceptibility for "openness for support" and a higher reported susceptibility for "dependence on others". For the curse of knowledge, the planning fallacy, and the bandwagon effect we observed a lower reported susceptibility for the top25 "dependence on others" (no difference for "openness for support"). And, for the sunk cost fallacy and functional fixedness we observed a lower reported susceptibility for the top 25 "openness for support" (no difference for "dependence on others").

Comparing the two splits of the spontaneous decision style, the top 25 of the "spontaneous" style show – similar to the original spontaneous top 25 – a lower susceptibility than the bottom 25 to cognitive biases ($m(top25)=2.224719$, $m(bottom25)=2.96154$, $F(1/280)=135.9949$, $p<.0001$). The top 25 "impulsiveness" on the other hand report a significant higher susceptibility to cognitive biases than the bottom 25 of the same decision style ($m(top25)=2.84848$, $m(bottom25)=2.51064$, $F(1/304)=24.7836$, $p>.0001$).

A closer look at specific biases shows the following significant differences between the two "sub decision styles": A lower susceptibility for the top 25 of "spontaneous" and a higher susceptibility of "impulsiveness" can be observed for stereotyping. For the

availability bias, the framing bias, the sunk cost neglect, and functional fixedness a higher susceptibility for the top 25 "impulsiveness" is reported (with a lower reported susceptibility to the sunk cost neglect and functional fixedness for "spontaneous"). The top 25 of "spontaneous" style also show a significant lower susceptibility to the in-group bias and illusory superiority (no difference for "impulsiveness").

Regarding the bias blind spots, the general perspective does not change: The top 25 of all decision styles show a significant bias blind spot. Differences are again in between the sub decision styles. In contrast to the top 25 of "dependence on others", the top 25 of "openness for support" show a significant bias blind spot for stereotyping, in-group bias, the framing bias, the sunk cost neglect, and functional fixedness and a negative bias blind spot for the planning fallacy. The top 25 of "spontaneous" show a significant bias blind spot for stereotyping, problem-solving set, in-group bias, anchoring bias, framing bias, and functional fixedness, and a negative bias blind spot for planning fallacy – where the top 25 "impulsiveness" do not show a significant bias blind spot for these biases. As a difference to the other sub decision style, the top 25 of "impulsiveness" only show a slightly significant bigger blind spot for confirmation bias.

These results show that the splitting of the two decision styles "dependent" and "spontaneous" can lead to a more differentiated picture about bias susceptibility and bias blind spot awareness than the original 5 decision styles. But for more reliable information the 7 vs. 5 item decision style index needs to be further validated in different settings.

4.6 Conclusion

In this article we explored the awareness of bias susceptibility and the bias blind spots of experienced international managers from the C-1 level. The results show that the individual awareness of bias susceptibility and the bias blind spots differ between the individual decision styles of managers. Decision makers with a strong tendency towards a rational or spontaneous decision style see themselves less vulnerable to cognitive biases, but also show a much stronger bias blind spot than those with the tendency towards other decision styles. On the other hand, decision makers with a strong tendency towards an intuitive decision style tend to recognize their own vulnerability to cognitive biases and show even a negative blind spot – thus seeing themselves more flawed by cognitive biases than others.

As a result, the individual decision style may serve as a predictor for one's own susceptibility to cognitive biases and bias blind spots. By understanding one's own

tendencies in decision style, managers can raise their own awareness for the danger of (specific) cognitive biases in their decision and take debiasing measures (a practice that is not yet very popular, as our study shows).

4.6.1 Implications for Research

By exploring the two research questions (RQ1: the influence of decision styles on bias susceptibility; RQ2: the influence of decision styles on bias blind spots) this study provided insights for further approaches to analyze the phenomenon of cognitive biases in decision making from an individual perspective, as requested by various scholars (Aczel et al., 2015; Berthet, 2021; Bruine de Bruin et al., 2020; Hutzschenreuter & Kleindienst, 2006). The decision styles (GDSMI) proved as a valuable lens to explore individual differences in awareness for one's own susceptibility to cognitive biases and bias blind spots. Nevertheless, the results highlighted two important questions and issues for future research, namely: a) Are the 5 items of the original GDSMI sufficient to show and potentially explain individual differences in decision-making behavior? b) Are bias blind spots always bias blind spots or do rational decision makers have an accurate self-assessment concerning their vulnerability to cognitive biases? Or does this depend on the specific bias that is examined and on the cognitive background and motivation behind that bias (as the introspect illusion and naïve realism have different interactions with different cognitive biases)? To shed light on these issues further studies are necessary which will need to be combined with follow-up interviews, focus groups, and ultimately experiments (to compare self-reported measures to actual behavior).

4.6.2 Implication for Practice

The ranking of bias prevalence and the five "bias risk maps" help decision makers to identify their individual vulnerability to certain biased decision behaviors and to signal the risk of underestimating these behaviors because of an individual bias blind spot. This can serve as a starting point for an executive's pro-active debiasing actions.

Considering the obtained results regarding rational decision styles, there is a word of warning to self-proclaimed rational managers: They should consider that they are overly confident and optimistic in their self-assessment and apply debiasing measures like a devil's advocate or "consider the opposite". For the other decision styles, a similar practical implication seems clear: Use more debiasing techniques, especially when you identify yourself as an intuitive decision maker.

4.6.3 Limitations

This study exhibits the typical weakness of any survey-based research. The results are based on a self-assessment and self-observations of individual decision-making behaviors. A complementary approach could be, as noted above, to compare the self-observations with actual decision-making behaviors in an observational or experimental study and contrast these findings with the data from this survey. This would provide deeper insights in the actual bias proneness, awareness, and bias blind spots of executives.

A second limitation (that resulted in a minor methodological contribution) regards the quality of the GDSMI score and its predictive value for decision-making behavior, as the five original decision style may not provide enough accuracy in grasping the differences in decision making. Here the distinction introduced in our study (i.e., openness for support and dependence on others) should be further tested in different research settings to show its usefulness.

5. Debiasing Management Decisions: Overcoming the Practice/Theory Gap within the Strategy Decision Process

Christian Muntwiler

5.1 Introduction

Managerial decisions are influenced by the psychological context of decision makers (Bateman & Zeithaml, 1989) and are prone to cognitive biases (Barnes, 1984; Das & Teng, 1999; Lovallo & Kahneman, 2003; Powell, Lovallo, & Fox, 2011; Schwenk, 1984; Simon, 1987). The need to reduce the impact of these biases in strategy workshops and episodes has been recognized by strategy scholars (Hodgkinson, Whittington, Johnson, & Schwarz, 2006; Hodgkinson & Clarke, 2007; Jarzabkowski & Kaplan, 2015). Debiasing a managerial decision-making process and improving decision quality (at least in terms of process quality) both require corrective interventions (Bazerman & Moore, 2009): interventions that prevent, recognize and reduce the impact of biases.

A recent survey with German companies showed that less than 40% of the managers are aware of cognitive biases and according debiasing techniques and that 75% of the companies have no institutionalized debiasing processes in their decision making (Kreilkamp et al., 2021). This result from practice contrasts the long tradition of recognizing cognitive biases and research on debiasing in psychology and management literature (Fischhoff, 1982; Schwenk, 1984; Tversky & Kahneman, 1974). Such a gap between knowledge in theory and practice shows that theoretical known knowledge about debiasing has still a long way to go to be recognized in managerial practice.

And the influence of cognitive biases is not reduced to managerial decisions, but all decisions under uncertainty, as the COVID-19 induced policy making shows: “A pandemic of cognitive bias” (Landucci & Lamperti, 2021). Cognitive biases like identifiable victim effect, optimism bias, present bias, omission bias (Halpern, Truog, & Miller, 2020), confirmation bias (Garcia-Alamino, 2020), information bias and action bias (Ramnath, McSharry, & Malhotra, 2020), premature closure, availability, framing (DiMaria, Lee, Fischer, & Eiger, 2020) influence effective policy making. Overconfidence biases like miscalibration, better-than-average effect, illusion of control, optimism bias, representation bias, risk aversion, herding behavior (bandwagon) effect individual financial behavior during the COVID-19 crisis (Bansal, 2020). Cognitive biases affect clinical treatments (Zagury-Orly & Schwartzstein, 2020) with the need to recognize and address bias in COVID-data interpretation (Berenbaum,

2021). And, “biased media coverage, incomplete and asymmetric information, personal experiences, fears, inability to understand and interpret statistics, and other cognitive biases lead to distorted risk judgments” (Bagus, Peña-Ramos, & Sánchez-Bayón, 2021).

Thus, the impact of the COVID-19 crisis, its volatility, uncertainty, complexity and ambiguity, raises the need to mitigate this effect (Halpern et al., 2020) in all kind of decisions similar to classical managerial decisions.

As a consequence of the little awareness of debiasing techniques in managerial practice, the goal of this article is to add the practitioner’s perspective on debiasing. It aims to identify those debiasing techniques which are experimentally explored and support decision makers, practitioners and strategists and develop a pragmatic and practice-oriented framework for debiasing (management) decisions.

In a first step we develop an overview on existing debiasing literature, approaches, and techniques. In a second step we confront practitioners with the identified debiasing techniques and – by using a card sorting experiment – analyze how they structure these and link them to ideal types of cognitive biases. This leads to a third step, the synthesis, the development of a practice-oriented framework of homogenous – and thus easier to understand and implement – clusters of debiasing techniques for decision practice.

5.2 Debiasing: Theoretical Background

The idea of debiasing managerial decisions follows a long research tradition. Reducing the influence of cognitive biases on decision making has been of interest for scholars from various research backgrounds. In the area of cognitive psychology, Fischhoff (1982) provided a first framework of debiasing methods based on three assumptions responsible for cognitive biases: faulty tasks, faulty judges, and a mismatch between judges and tasks. Further insights into the influence of cognitive biases and overviews of debiasing approaches have been developed, among others, by Keren (1990), Arkes (1991), Larrick (2004), and Soll, Milkma, and Payne (2015). Management scholars emphasized the impact of debiasing on the quality of management decisions (Bazerman & Moore, 2009; Kaufmann et al., 2010; Schwenk, 1995) and the impact of debiasing on returns (Kahneman, Lovallo, & Sibony, 2011; Lovallo & Sibony, 2010).

The concept of debiasing combines the acceptance of “a normative – descriptive gap” in decision behavior (Larrick, 2004, p. 316) and the “decision-aiding techniques that help to debias decision making through the elimination or at least mitigation of judgement and decision biases” (Kaufmann et al., 2010, p. 793). A bias is a “systematic

deviation from normative reasoning" (Stanovich, 1999, p. 33) and, following the Meliorist position, shows a gap between the normative decision behavior ("objective standard" (Soll et al., 2015, p. 925) or "ideal standard" (Baron, 2000, p. 33)) and the actual descriptive behavior in decisions. Debiasing thus helps to make decision making more predictive (Larrick, 2004, p. 317).

Debiasing techniques exist in a wide range: from training interventions (Morewedge et al., 2015), to a change in the choice architecture (Thaler & Sunstein, 2008), or cognitive strategies like consider alternatives (Fischhoff, 1982). A common attribute is "debiasing requires intervention" (Larrick, 2004, p. 318). Thus, what interventions (internal, on oneself, and external) are theoretically recognized as debiasing techniques?

5.2.1 Decision Readiness

A precondition for successful decision making is decision readiness. Soll, Milkman, and Payne (2015, pp. 930–931) describe decision readiness as the capability of type 2 processing to perform the deliberate functions in judgement and decisions. Type 2 processing «monitors the quality» of type 1 decisions and judgements (Kahneman & Frederick, 2002, p. 51). This follows the dual-process theory which is highly recognized by scholars in cognitive psychology (Evans, 2008; Evans & Stanovich, 2013; Gilovich, Griffin, & Kahnemann, 2002; Kahneman, 2003; Kahneman & Frederick, 2002; Stanovich, 2009; Stanovich et al., 2016).

Three factors determine the decision readiness and the basic capability of deliberately switching from type 1 to type 2 processing: a) the degree of fatigue and distraction, b) emotions and visceral influences, and c) individual differences in intelligence, training and thinking styles (Soll et al., 2015, pp. 929–930). As a consequence, first interventions to debias focus on the establishment of decision readiness in two ways: 1) by addressing the aspects of fatigue and distractions on the decision-making process and 2) by addressing (and choosing) the mindware of the decision maker(s). The mindware is defined as "the knowledge, rules, procedures, and strategies that can be retrieved and used to transform decoupled representations" (Stanovich et al., 2016, p. 34), thus determined by intelligence, training and thinking styles and affecting the impact of emotions and visceral influences (see Figure 8).

5.2.2 Decision Process

Further challenges of debiasing involve the override detection and the sustained cognitive decoupling (Stanovich et al., 2016). The success of type 1 processing heuristics depends on an environment providing valid and available cues for the decision (Kahneman & Klein, 2009), a "benign environment" (Stanovich et al., 2016, p. 18). To override a type 1 decision the decision maker needs to recognize the bias (activate override) and be able to initiate the cognitive decoupling with the simulation of alternatives, thus successfully activating type 2 processing. This leads to a third and a fourth intervention point for debiasing: 3) enabling the override of type 1 processing, and 4) supporting the cognitive decoupling. Figure 8 shows an overview of the four intervention points of successful debiasing approaches. As the first two interventions focus mainly on preconditions and prerequisites of decision making, this article will focus on *interventions during the decision-making process itself*. Existing debiasing approaches to address basic decision readiness (interventions points 1 and 2) are: workplace and environment (Croskerry, Singhal, & Mamede, 2013), training and education (Bazerman & Moore, 2009; Fischhoff, 1982; Larrick, 2004; Montibeller & Winterfeldt, 2015; Soll et al., 2015), creating a general bias awareness (Arkes, 1991; Kaufmann et al., 2010) or simply by replacing the decision makers (Fischhoff, 1982).

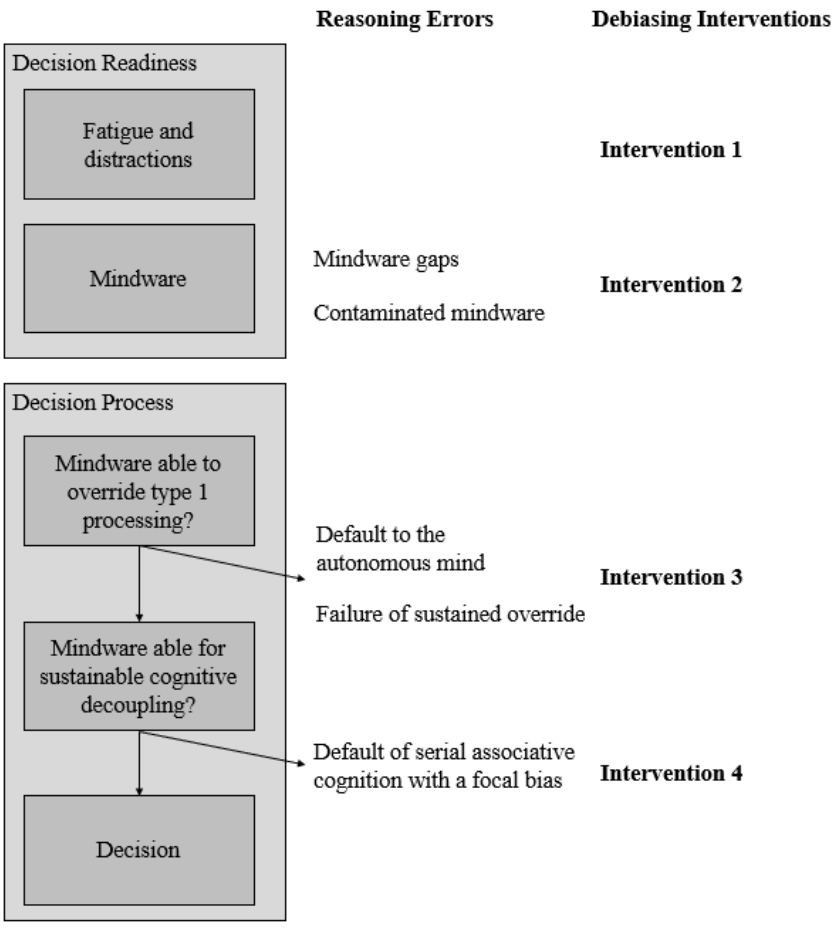


Figure 8: Debiasing Interventions

own representation based on Stanovich et al (2016, p. 56)

5.3 Debiasing Approaches and Techniques During the Decision Process

Based on Fischhoffs (1982) emphasize on faulty judges and faulty tasks, Soll, Milkman, and Payne (2015) structured debiasing techniques into two types of debasing modes during the decision process: modify the person (decision maker), and modify the environment (decision frame). Larrick (2004) structured debiasing techniques into four main approaches: motivational, cognitive, structural, and technological.

A semi-systematic literature analysis following existing overviews of debiasing techniques (Bazerman & Moore, 2009; Fischhoff, 1982; Kaufmann et al., 2010; Larrick, 2004; Montibeller & Winterfeldt, 2015; Soll et al., 2015) led to the identification of 20 different debiasing techniques recognized by literature. By adapting and combining the classification logics of Larrick (2004) and Soll et al. (2015) we clustered the theoretically acknowledged debiasing techniques during managerial decision-making processes (see Figure 9):

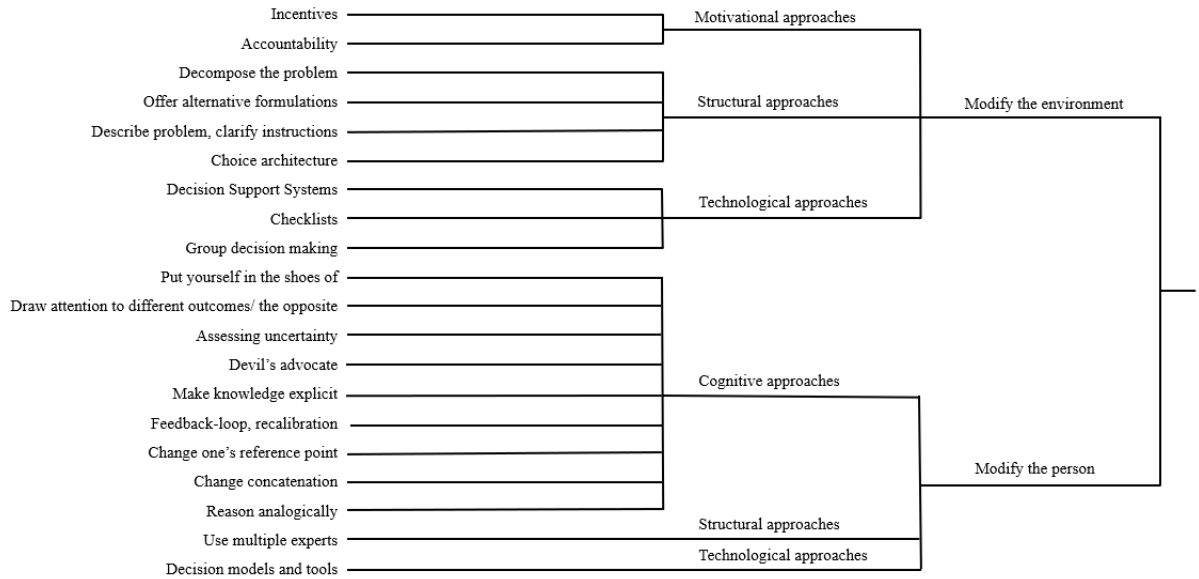


Figure 9: Theoretically Developed Clustering of Debiasing Techniques

(structured as a dendrogram)

5.3.1 Modify the Environment

Motivational Approaches

Incentives for the decision makers, as for example having higher stakes or involvement in the decision (Arkes, 1991; Harkness et al., 1985; Petty & Cacioppo, 1984), or performance-contingent incentives (Stone & Ziebart, 1995), support the debiasing for cognitive biases which are promoted by the lack of thinking motivation or thinking effort. Incentives influence the "amount, sequence, and variability of information

processing" (Stone & Ziebart, 1995, p. 251). As a consequence, this technique works for strategy-based errors where (too) simple heuristics are applied (Arkes, 1991; Harkness et al., 1985). But for biases which are not caused by insufficient attention like verification biases (overconfidence) or attribution-based errors incentives seem not work and can even have a negative backfire effect (Soll et al., 2015; Stone & Ziebart, 1995).

The *accountability* of a decision maker for her decisions in front of a third party is another way to increase the motivation to invest more cognitive capacity in decision making (Soll et al., 2015). Accountability reduces biases promoted by hasty thinking, attributional biases, overprecision, anchoring, sunk costs, order effects, but does not seem to work for ambiguity bias, loss aversion, base rate neglect, insensitivity to sample size which are even amplified by outcome accountability (Lerner & Tetlock, 1999). A strong difference is recognized between the effect of outcome accountability vs. process accountability. Lerner and Tetlock (1999) suggest process accountability to be favored as outcome accountability may promote the need for self-justification and increases escalation of commitment and the reliance on salient and easy justified dimensions of the decision (Soll et al., 2015).

Structural Approaches

Decomposing a problem by restructuring the components of a decision into smaller/simpler problems or changing the sequence of the problems has a "significant effect on the selection and use of heuristics" (Coupey, 1994, p. 96). The decomposition of the elements of a decision can reduce overconfidence, control illusion, anchoring effects, order effects and attenuate availability biases (Ashton & Kennedy, 2002; Kaufmann et al., 2010; Montibeller & Winterfeldt, 2015).

The debiasing techniques of *offer alternative formulations* (for the problem) and *describe problem, clarify instructions* were both first mentioned by Fischhoff (1982). Until now there is little research on those two approaches showing how and where they may work to debias decisions. Fischhoff (1982) suggested that the technique of describing the problem and clarify instructions may mitigate the influence of faulty tasks. For the technique "offer alternative formulations", Payne, Bettman, and Schkade (1999) suggest to ask a question in multiple different ways to identify inconsistencies in or missing pieces of information (availability) or scale effects.

A *choice architecture* like setting a default, choosing in advance, partitioning resources or planned interruptions is helpful to support the override of intuitive and impulsive type

1 decisions (Soll et al., 2015). These techniques, nudges, help against status quo bias, inertia in decisions (Thaler & Sunstein, 2008), loss aversion, and present bias/empathy gaps (Soll et al., 2015).

Technological Approaches

Decision Support Systems (DSS), computerized aids like the use of different information displays (graphs, feedback, data visualizations, display of different patterns) help to reduce biases like framing, representativeness biases, and ambiguity in information acquisition (Bhandari, Hassanein, & Deaves, 2008; Larrick, 2004; Lim & Benbasat, 1997). But it seems as anchoring/adjustment effects are robust in the context of a DSS (George, Duffy, & Ahuja, 2000).

The use of *checklists* to debias decisions is recommended for overly simplistic or hasty thinking (Soll et al., 2015), recall errors (Hales & Pronovost, 2006), as checklists enhance the recognition of overlooked details and alternatives (Shimizu, Matsumoto, & Tokuda, 2013).

The benefit of *group interaction* during the decision-making process like brainstorming, the integration of different perspectives (also supporting other debiasing approaches like "consider alternatives") or the stimulation of creativity by combining different actors helps to overcome omission and availability biases and to deal with anchoring and gain-loss biases (Montibeller & Winterfeldt, 2015). The recursive social influence within the group supports active error checking, synergies in thinking, and has a statistical effect: to raise the sample size of decision makers. This combination of the possibility of averaged forecasting, different mindsets and experiences help to reduce confirmation biases, availability, too hasty option generation and evaluation (Larrick, 2004).

5.3.2 Modify the Person

Cognitive Approaches

A deliberate perspective shift by *putting oneself in the shoes of*, taking an outsiders view or making predictions what other will do, reduces control illusions (Faro & Rottenstreich, 2006; Kaufmann et al., 2010), decreases stereotype views and prejudices and other social thought like ingroup bias or attributional biases (Galinsky & Moskowitz, 2000b; Kaufmann et al., 2010), loss aversion (Białek & Sawicki, 2014; Li, Rohde, & Wakker, 2017), and self-serving biases (Kaufmann et al., 2010).

The strongest theoretical evidence for all debiasing techniques exists for the approach of *drawing attention to different outcomes*. By considering and generating alternative situations, considering the opposite or using a pre-mortem analysis for one's own decisions and its consequences and potential outcomes, decision makers can actively reduce verification biases like overconfidence, confirmation bias, anchoring, hindsight, and control illusion (Adame, 2016; Arkes, 1991; Babcock et al., 1997; Epley & Gilovich, 2005; Hirt et al., 2004; Kaufmann et al., 2010; Koriat et al., 1980; Kray & Galinsky, 2003; Lord et al., 1984; Mussweiler et al., 2000; Slovic & Fischhoff, 1977; Soll et al., 2015; Veinott et al., 2010). This technique further helps to enhance likelihood assessments and judgmental biases (Heiman, 1990; Kaufmann et al., 2010; Koonce, 1992), mitigate the influence of opportunity cost neglect (Frederick, Novemsky, Wang, Dhar, & Nowlis, 2009), and functional fixedness (Galinsky & Moskowitz, 2000a). It is also seen to support the generation of alternatives and options (Keeney, 2012; Montibeller & Winterfeldt, 2015) and reduces the effect of framing, an attitude-decision gap, and recall biases (Payne et al., 1999).

Assessing one's own uncertainty on decision-relevant matters calibrates individual knowledge and thus helps to reduce overconfidence (Soll et al., 2015). This calibration improves the awareness of an overly confident self-view on one's knowledge and leads to a better judgement accuracy (Welsh, Begg, & Bratvold, 2007).

The application of the *devil's advocate* technique, the active, non-emotional representation of formal dissent in decision making by one party, has been demonstrated to mitigate biases of information acquisition and verification biases. Information biases like attentional biases, availability, biased information search, shared information bias or information neglect (Herbert & Estes, 1977; Schulz-Hardt, Jochims, & Frey, 2002) can be reduced as a devil's advocate helps to balance information seeking (Schulz-Hardt et al., 2002). This characteristic also supports the reduction of a confirmation bias, overconfidence, bandwagon effects and planning fallacies (Cosier, 1978; Herbert & Estes, 1977; Schulz-Hardt et al., 2002; Schweiger et al., 1989; Schwenk & Cosier, 1993; Schwenk & Valacich, 1994). A side effect of the application of a devil's advocate is a potential lower satisfaction with the outcome of a (group's) decision making and the outlook of a future collaboration (Schwenk & Cosier, 1993).

To correct a mismatch between judges and tasks, Fischhoff recommends "respondents to express what they know explicitly, rather than letting it remain "in the head"" (Fischhoff, 1982, p. 427). Until yet, this *make knowledge explicit* approach has seen few research attempts to show if and how it really helps to improve decision making.

Another cognitive approach are quick *feedback loops* to recalibrate responses during the decision-making process. Decision aids like frequent and continuous feedback lead to a "greater understanding, performance and application" of knowledge in decisions (van Brussel, Timmermans, Verkoeijen, & Paas, 2020) and thus helps to mitigate association based errors like framing, representativeness, and ambiguity (Arkes, 1991; Bhandari et al., 2008).

The deliberate *change and addition of reference points* for the decision, reframing information concerning gains and losses, is recognize to decrease the influence of gain/loss biases like loss aversion (Arkes, 1991; Soll et al., 2015). The active framing of information (negatively or positively) also influences recency and primacy effects (Rutledge, 1995).

A second technique which helps to reduce gain/loss biases is *changing the concatenation* of the decision items. The rearrangement of related items of a decision changes the gain/loss perspective (Arkes, 1991; Thaler & Sunstein, 2008). For example, instead of "we raise the market share, then, as a consequence, we decrease the production costs" a change of concatenation would lead to "we decrease the production costs, then, as a consequence, we raise the market share".

Adapting analogies from previous cases and situations supports the mitigation of simplified or narrow option generation and the evaluation of options in decision making (Bazerman & Moore, 2009; Schwenk, 1984). The *analogical reasoning*, comparing the decision situation to other, analog, situations, simulations or cases facilitates learning and transfer effects to extend the range of possible alternatives (Loewenstein et al., 1999).

Structural Approaches

The consultation of third parties during the decision process, like *multiple experts* or external advice, debiases decision making and especially mitigates confirmation bias, illusion of control and availability biases (Meissner & Wulf, 2016; Montibeller & Winterfeldt, 2015). Graf et al. (2012) recommend external advice with people not personally involved as involved consultants may increase the impact of social comparison and irrationality of decision makers.

Technological Approaches

Decision models and tools like simple pro and con tables, writing a list, linear models, causal maps, decision trees, multiattribute analyses, or decision instructions like

warnings are often easy to apply and help to switch from type 1 reasoning to type 2 reasoning. These tools help to mitigate the use of oversimplified decision heuristics in information acquisition, option generation and evaluation (Larrick, 2004; Payne et al., 1999; Soll et al., 2015), myopic problem representation biases (Montibeller & Winterfeldt, 2015), and the effects of sunk costs and escalating commitment (Ohlert & Weißenberger, 2020).

5.4 Applying a Practice Perspective on Debiasing

5.4.1 Research Questions and Hypothesis

From these 20 debiasing techniques explored in research over the last 40 years surprisingly few have had an impact on contemporary decision processes in companies. As Kreilkamp et al. (2021) showed, 75% of the companies do not have an institutionalized debiasing process and over 63% of the companies do not use debiasing countermeasures in their decision-making processes. This leads to two major questions:

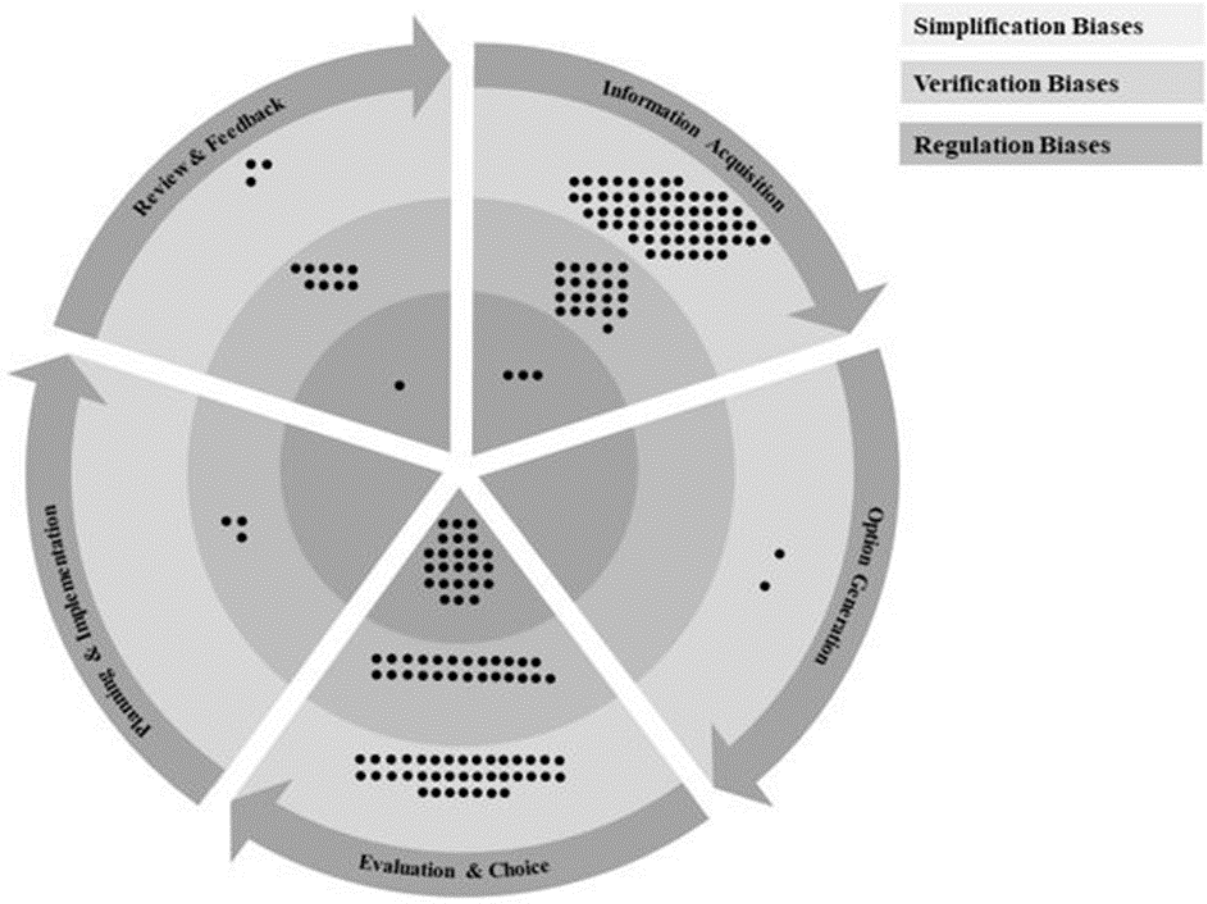
1. How would practitioners structure debiasing techniques when they connect these techniques with potential flaws in their decision-making process? Is it the same as the theoretical research-based literature or do they use a different, maybe more natural, and practice-oriented structure which can help to better implement the understanding of debiasing in practice? This leads to our hypothesis:

H1: Managers structure debiasing techniques similar to the suggestion of the theoretical literature (modify person/environment, cognitive, motivational, technological, and structural approaches).

2. Which debiasing techniques are applied in practice and with what results?

To answer these questions, we conducted a card-sorting experiment to test the hypothesis H1 (and used the Rand index to compare the similarity of the theoretical derived and the practice-oriented knowledge structure) combined with a survey on managers. Card-sorting is a variation of the q-methodology which "combines the strengths of both qualitative and quantitative methods" (Brown, 1996, p. 561). Thus, it can help to elicit the perceived (subjective) connection between the different debiasing techniques, and 15 ideal types of cognitive biases and debiasing methods. These ideal types of biases derive from a classification scheme using and combining two dimensions, the managerial perspective (the phases of a managerial decision-making process) and the psychological perspective (the motivational background of a cognitive bias; simplification, verification, and regulation biases (Oreg & Bayazit, 2009)) to

provide a framework to arrange potential flaws of managerial and strategic decision making (Eppler & Muntwiler, 2021, see Figure 10).



1. Simplified information acquisition (57/187); Nr. 1.1 – 1.57; Example: Availability bias
2. Simplified option generation (2/187); Nr. 2.1 – 2.2.; Example: Functional fixedness
3. Simplified evaluation and choice (37/187); Nr. 3.1 – 3.37; Example: Hot-hand fallacy
4. Simplified planning and implementation (0/187)
5. Simplified review and feedback (3/187); Nr. 5.1 – 5.3; Example: Outcome bias
6. Self-confirmatory information acquisition (21/187); Nr. 6.1 – 6.21; Example: Confirmation bias
7. Self-confirmatory option generation (0/187)
8. Self-confirmatory evaluation and choice (25/187); Nr. 8.1 – 8.25; Example: Illusion of control
9. Self-confirmatory planning and implementation ((3/187); Nr. 9.1 – 9.3; Example: Planning fallacy
10. Self-confirmatory review and feedback (9/187); Nr. 10.1 – 10.9; Example: Hindsight bias
11. Loss/Gain lens in information acquisition (3/187); Nr. 11.1 – 11.3; Example: Framing effect
12. Loss/Gain lens in option generation (0/187)
13. Loss/Gain lens in evaluation and choice (24/187); Nr. 13.1 – 13.24; Example: Loss aversion
14. Loss/Gain lens in planning and implementation (0/187)
15. Loss/Gain lens in review and feedback (1/187); Nr. 15.1; Choice-supportive bias

Figure 10: Overview Typology of Cognitive Biases

(Eppler & Muntwiler, 2021)

5.4.2 Experimental Design

Card sorting is a "relative simple, inexpensive method of gaining insight into user preference for the organization of information" (Hannah, 2005, p. 13). This research uses the methodology of closed card sorting. Open (or free) card sorting is sorting "p objects into a subject chosen number (c) of groups/categories" (Coxon, 1999, p. 3), analyzed with a hierarchical cluster analysis to elicit how the participants organize the items (Nawaz, 2012). Closed card sorting refers to the pre-grouping of categories by the researcher and the participants putting the items into the pre-defined groups (Fincher & Tenenberg, 2005; Hannah, 2005). In this case the analysis of correlation is used to show topic agreement (Paul, 2014).

The participants were asked to allocate the 20 debiasing techniques to the 15 ideal types of cognitive biases (from Figure 10) – according to their understanding how good these techniques work to mitigate a specific ideal type (hindsight from experience). Additionally, all participants were asked if and how successful the 20 debiasing techniques are applied in their companies.

5.5 Results

5.5.1 Card Sorting

To reach a correlation of 0.90 a minimum of 15 users is needed (Tullis & Wood, 2004). Our experiment included 16 managers (with a median of 10 – 15 years of experience) from 10 countries, 14 different industries. Five of the participants were females, 11 males. As post experimental talks exposed, the understanding of cognitive biases and debiasing techniques was very heterogenous among the participants which is in line with the findings of the study by Kreilkamp et al. (2021).

The principle of card sorting is "(1) that all objects in the same category are considered to have a higher similarity to each other than they do to other objects and (2) that the categories themselves are considered to be maximally distinct and separated" (Coxon, 1999, p. 56).

To measure the proximity between the debiasing approaches based on the sorting by the participants a co-occurrence or similarity matrix is recommended, as it provides a "useful graduation of similarity compared with the dichotomous "belonging/ not belonging" characteristic of a single sorting" (Coxon, 1999, p. 43). Table XVIII shows the co-occurrences of all 20 debiasing techniques.

(Incentives)																										
Accountability	0.0563																									
Decompose the problem	0.1605	-0.0525																								
Offer alternative formulations	0.0216	-0.2139	0.2252																							
Describe problem, clarify instructions	0.1021	-0.1638	0.6396	-0.1458																						
Choice architecture	-0.0999	-0.4128	0.1297	0.5436	-0.024																					
Put yourself in the shoes of	0.267	-0.0461	-0.2161	-0.2196	0.1331	-0.4419																				
Decision Support Systems	0.0037	0.1848	0.6886	-0.0675	0.484	0.0361	-0.0095																			
Checklists	0.0621	-0.1887	0.5254	-0.0449	0.2525	0.0485	-0.4569	0.0882																		
Group decision making	-0.3708	0.2916	-0.3315	-0.1425	-0.2518	0.1553	-0.4752	-0.4975	0.007																	
Draw attention to different outcomes opposite	-0.2804	-0.4284	0.0901	-0.2148	0.2744	0.086	-0.1575	0.1382	0.2116	-0.147																
Assessing uncertainty	-0.0569	0.1433	0.0919	0.0723	-0.1942	0.187	-0.1228	0.0968	-0.0573	0.181	0.3715															
Devil's advocate	-0.568	0.4254	-0.3924	-0.5762	-0.1734	-0.2183	-0.2199	-0.032	-0.0429	0.4761	-0.0086	-0.243														
Make knowledge explicit	0.247	-0.2884	0.0342	0.2256	-0.1227	0.5305	-0.1452	0.0342	-0.1325	0.0186	0.0143	0.2339	-0.2736													
Feedback-loop, recalibration	0.4134	0.3039	-0.3447	-0.014	-0.1773	-0.057	0.2106	-0.1453	-0.2934	-0.1097	-0.4733	-0.5438	0.2152	0.1088												
Change one's reference point	-0.2352	-0.2625	-0.2949	-0.2702	-0.415	0.1597	-0.2	0.0048	-0.2729	0.0688	0.2455	0.1849	0.2026	0.1914	-0.2241											
Change concatenation	0.0512	-0.3965	-0.0114	0.2706	0.3778	0.2437	0.1607	-0.3483	-0.0792	0.1281	0.0524	-0.0254	-0.3602	0.3704	-0.1096	-0.4114										
Reason analogically	0.0916	0.1354	-0.3695	0.0841	0.0494	0.155	-0.0066	-0.2048	-0.1169	0.0754	-0.1188	-0.2236	0.0697	-0.2618	0.304	-0.2879	0.1975									
Use multiple experts	-0.1246	-0.2736	0.0304	-0.2264	0.1244	0.0929	0.0459	0.2167	-0.304	-0.0636	-0.0634	-0.3491	0.1363	0.0047	-0.0971	0.5812	-0.0968	-0.1811								
Decision models and tools	-0.0509	-0.5421	-0.0883	0.4019	-0.2375	0.637	-0.2385	0.3016	-0.0516	0.189	0.1131	0.2195	-0.392	0.2463	-0.2114	0.3946	0.09	0.0379	0.0842							
	Incentives	Accountability	Decompose the problem	Offer alternative formulations	Describe problem, clarify instructions	Choice architecture	Put yourself in the shoes of	Decision Support Systems	Checklists	Group decision making	Draw attention to different outcomes opposite	Assessing uncertainty	Devil's advocate	Make knowledge explicit	Feedback-loop, recalibration	Change one's reference point	Change concatenation	Reason analogically	Use multiple experts	(Decision models and tools)						

Table XVIII: Co-occurrences (Similarities) of the 20 Debiasing Techniques

In a second step the data was hierarchical clustered following Ward's linkage method (Ward, 1963). Hierarchical clustering uses pairwise proximities (Coxon, 1999) to develop a "binary tree-based data structure called the dendrogram" (Aggarwal & Reddy, 2014, p. 88), which then helps to analyze the data by splitting the tree at different levels.

Ward's linkage method "is based on a classical sum-of-squares criterion, producing groups that minimize within-group dispersion at each binary fusion" (Murtagh & Legendre, 2014, p. 275). This method is recommended by Ferreira and Hitchcock (2009) as it shows the highest Rand index in most situations, and because of its "highest accuracy and coverage" (Hirano, Sun, & Tsumoto, 2004, p. 164). The outperformance of Ward's linkage method is also shown by Punj and Stewart (1983).

The application of this linkage method resulted in the dendrogram in Figure 11:

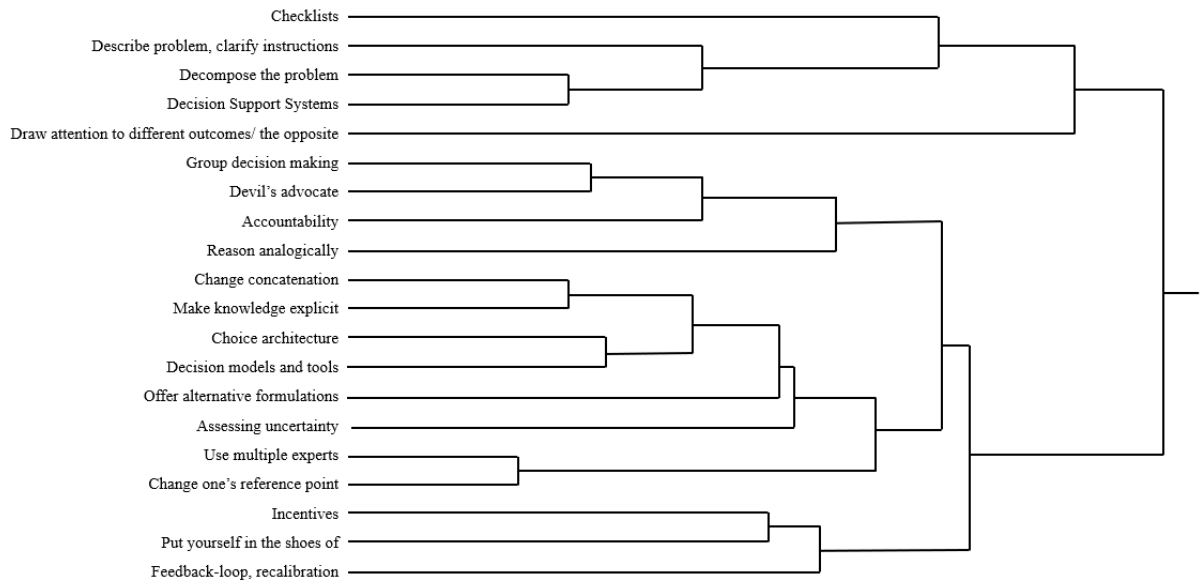


Figure 11: Dendrogram of the Card-sorting Results (Ward's Linkage Method)

The comparison with the clustering of the theoretical developed structure of debiasing approaches (Figure 9) shows a distinguishable difference of clusters (proximities and distances of the objects). The Rand index of similarity (Rand, 1971) comparing both clusterings (each with 6 main clusters; 114 pairs are in both clusterings in different clusters, 11 pairs are in both in the same cluster, and 65 pairs differ between the clusterings) results in 0.66 (with 1.0 for identical clusters), and thus rejecting hypothesis H1. Managers *do not follow the theoretical structure* of debiasing approaches when linking them to different ideal types of biases. This finding confirms a theory/practice gap in debiasing and may be one explication why debiasing in practice finds less support than could be expected (Kreilkamp et al., 2021).

5.5.2 Survey

The results of the survey mirror those of the study of Kreilkamp et al. (2021). According to it the most used debiasing techniques are risk analysis, critical discussion, accountability, and change of perspective (more than 50 % of the companies). Post-hoc decision analysis (feedback loop), decision support systems (DSS) and decision models are the least used debiasing techniques. These results are mainly confirmed by the results of our survey (see Figure 12).

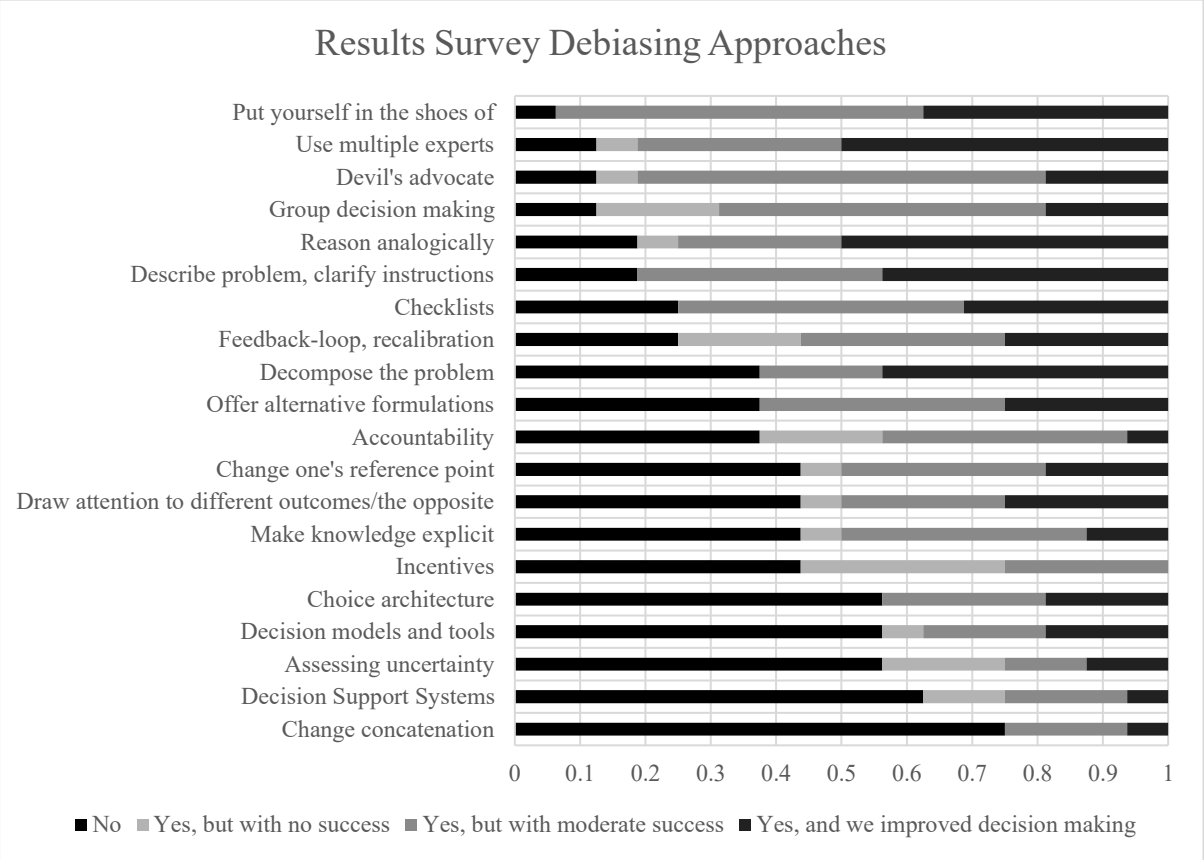


Figure 12: Debiasing Approaches Used in Managerial Practice

The debiasing techniques mostly used and recommendable by practitioners are put yourself in the shoes of, describe problem/clarify instruction, use multiple experts, devil's advocate, checklists, reason analogically, group decision making, decompose the problem, and offer alternative formulations.

5.6 Practice-oriented Framework of Debiasing Techniques – Towards a Practice Oriented Debiasing Procedure

5.6.1 Finding Clusters

As the clustering of debiasing techniques from the practitioner's view led to a different result than the theoretical clustering, the resulting dendrogram from the experiment needs a more detailed analysis with the goal of identifying homogenous and identifiable clusters. Clusters that lead practitioners towards a better understanding and knowledge of debiasing techniques and when to use them in managerial decision processes.

The elaboration and definition of cluster from an experimental-based dendrogram is considered to be "fuzzy" and arbitrary as there are few guidelines how to cluster a dendrogram (Punj & Stewart, 1983) and "interpretation is dependent on the underlying context of the problem" (Milligan & Cooper, 1987, p. 349). Harrigan states that the "researcher must decide how many clusters provide the most meaningful portrayal of the data" (Harrigan, 1985, p. 62) based on a process starting with a first approximation using the Ward's method (Figure 11) followed by an iterative partitioning process with an external validation: "a demonstration that the clusters are useful in some larger sense" (Punj & Stewart, 1983, p. 145).

The analysis and interpretation of the resulting dendrogram leads to 6 potential "cuts", 1) leading to no clustering at all (as each technique represents its own cluster), 2) resulting in 15 clusters, 3) in 12 clusters, 4) in 9, 5) in 6 clusters, and 6) in 3 clusters. As cuts 1 – 3 do not lead to a useful sum of clusters (to many for practical use) and cut 6 leads to a very heterogenous and big cluster versus two small ones, cuts 4 and 5 both show homogenous and not too many different clusters (see Figure 13) thus applicable for managerial practice.

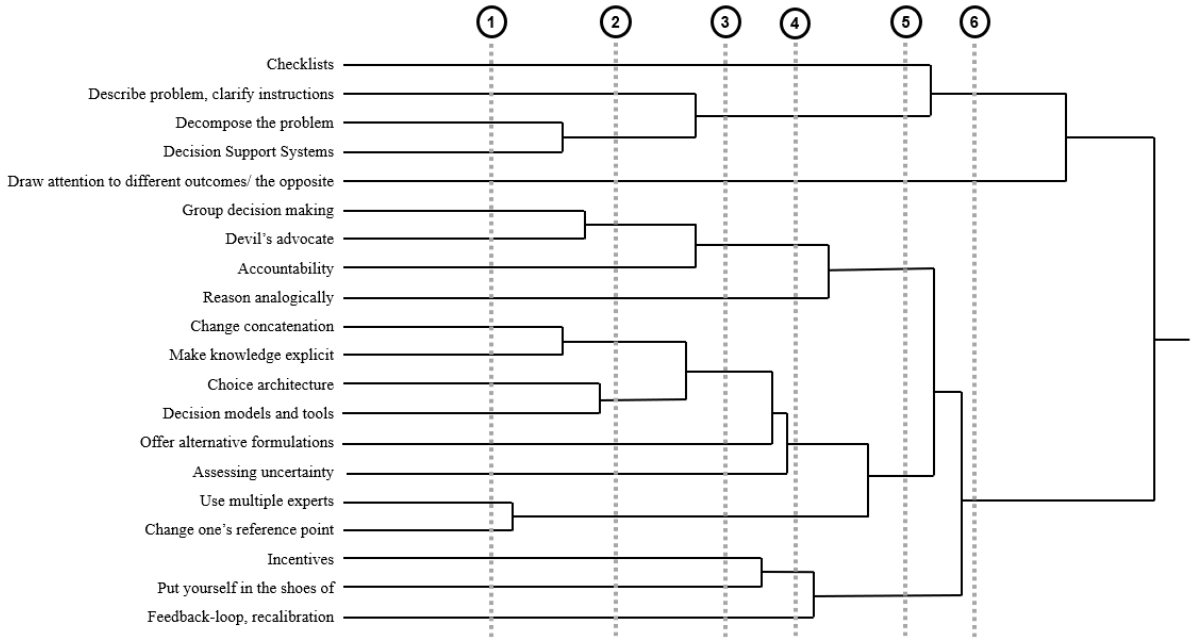


Figure 13: Cuts to Cluster the Dendrogram of Debiasing Techniques

The main difference between 9 or 6 clusters is whether the techniques of "reason analogically" should be part of the cluster with "group decision making", and the technique of "multiple experts"/change of reference point" is part of the bigger cluster with "choice architecture" etc. and if the "feedback-loop" technique is placed in the cluster with "incentives". The consideration of the differences in the practical application of these debiasing techniques indicates towards 9 clusters of debiasing techniques from a practitioner's view (see Figure 14).

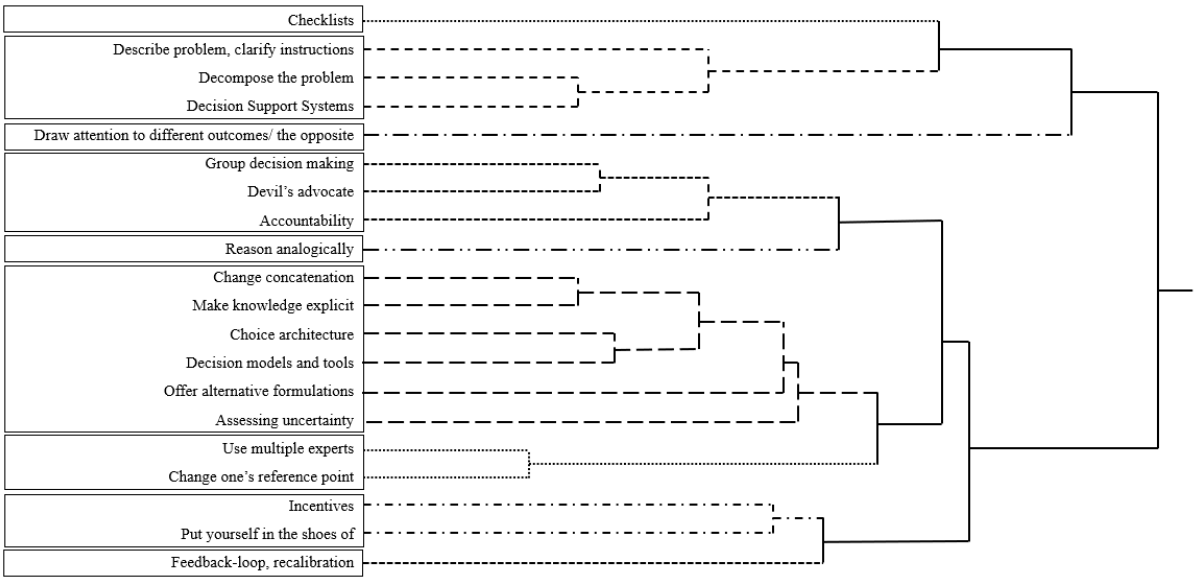


Figure 14: 9 Clusters of Debiasing Techniques

5.6.2 Towards a New Structure to Understand Debiasing Management Decisions

To develop a more practice-oriented framework of debiasing techniques we use these 9 clusters as a basis to link theoretical knowledge concerning the applicability of these techniques for certain biases with the perspective and experience of practitioners – based on the ranking of the mean cluster values from the card-sorting experiment for each of the 9 clusters (checklists, preparation, what if?, group debiasing, reason analogically, in-process debiasing, starting viewpoints, involvement, and calibration – see Table XIX). This leads to two major insights: a) when which debiasing technique may make sense in a decision process, and b) potential gaps in research and communication of research results versus practice.

Cluster	Technique	Works for - Theory	Works for - Practice	Theory-/practice Gap
Checklists	Checklists	• Simplified thinking processes (Soll et al., 2015) • Recall biases (Hales & Pronovost, 2006) • Problem-solving set, identify alternatives (Shimizu et al., 2013)	• Simplified evaluation & choice biases • Simplified planning & implementation biases • Risk-averse implementation biases	None
Preparation	Describe problem, clarify instructions	• Faulty tasks (Fischhoff, 1982)	• Simplified information acquisition biases • Simplified planning & implementation biases • Simplified evaluation & choice biases • Self-confirmatory evaluation & choice biases	None
	Decompose the problem	• Recency/primacy (Ashton & Kennedy, 2002) • Selection and use of heuristics (Coupey, 1994) • Overconfidence, availability, anchoring (Montibeller & Winterfeldt, 2015) • Control illusion, availability, framing, sunk cost effects (Kaufmann et al., 2010)		
	Decision support systems	• Framing, representativeness, ambiguity (Bhandari et al., 2008) • Biases information acquisition (Larrick, 2004) • Representativeness (Lim & Benbasat, 1997) Works NOT for Anchoring/adjustment (George et al., 2000)		

What if?	Draw attention to different outcomes, consider the opposite, consider alternative situations, generating alternatives, pre-mortem analysis	• Anchoring (Adame, 2016; Epley & Gilovich, 2005) • Explanation bias, hindsight, overconfidence, likelihood judgements (Hirt et al., 2004) • Confidence judgments, confirmation bias (Koriat et al., 1980) • Hindsight, logical problem solving, social judgement, availability, salience (Lord et al., 1984) • Anchoring (Mussweiler et al., 2000) • Hindsight (Slovic & Fischhoff, 1977; Soll et al., 2015) • Narrow option generation (Keeney, 2012) • Opportunity cost neglect (Frederick et al., 2009) • Likelihood assessments (Heiman, 1990; Koonce, 1992) • Confirmation bias (Kray & Galinsky, 2003) • Functional fixedness (Galinsky & Moskowitz, 2000a) • Framing, problematic valuation effects, attitude-decision gap, memory/recall biases (Payne et al., 1999) • Narrow option generation (Montibeller & Winterfeldt, 2015) • Confirmation bias, availability, self-serving biases (Babcock et al., 1997) • Overconfidence, planning illusion, illusion of control (Veinott et al., 2010) • Judgmental biases, control illusion, hindsight, anxiety based biases, planning fallacy (Kaufmann et al., 2010) • Association-based biases (Arkes, 1991)	• Risk-averse planning & implementation biases • Self-confirmatory evaluation biases • Loss/gain lens in information acquisition biases • Simplified evaluation & choice biases • Simplified information acquisition biases • Loss/gain lens in review & feedback biases • Simplified planning & implementation biases • Self-confirmatory option generation biases • Self-confirmatory information acquisition biases	Use for debiasing self-confirmatory planning & implementation biases in practice not recognized
Group debiasing	Group decision making	• Omission, overconfidence, availability bias, anchoring, gain-loss biases (Montibeller & Winterfeldt, 2015) • Confirmation bias, availability, simplified option generation, simplified evaluation & choice (Larrick, 2004)	• Self-confirmatory planning & implementation biases • Loss/gain lens in review and feedback biases • Self-confirmatory information acquisition biases	None
	Devil's advocate, formal dissent, search for discrepant information	• Biased information search, confirmation bias, attentional bias, shared information bias, narrow option generation, bandwagon effect, overconfidence (Schulz-Hardt et al., 2002)		

		• Confirmation bias, congruence bias (Schwenk & Cosier, 1993; Schwenk & Valacich, 1994) • Confirmation bias, narrow option generation (Schweiger et al., 1989) • Availability, confirmation bias, planning fallacy, information neglect (Herbert & Estes, 1977) • Judgmental biases, planning biases (Cosier, 1978)		
	Accountability, second-order judgement	• Sunk cost effects (Soll et al., 2015) • Attributional biases, anchoring, conjunction fallacy, overprecision (Lerner & Tetlock, 1999) • Process accountability decreases the need for self-justification ((Lerner & Tetlock, 1999) Works NOT for • "Accountability is likely to strengthen reliance on salient or easily justified dimensions, such as outcome probabilities in choice" (Larrick, 2004, p. 323) • Base rate neglect, insensitivity to sample size, preference reversals, ambiguity, attraction effect, loss aversion (Lerner & Tetlock, 1999) • "Accountability is unlikely to help when cognitive laziness is not the root source of bias" (Soll et al., 2015, p. 935)		
Reason analogically	Reason analogically	• Simplified option generation, simplified evaluation of options (Bazerman & Moore, 2009; Loewenstein et al., 1999) • Narrow option generation (Schwenk, 1984)	• Loss/gain lens in review and feedback biases • Self-confirmatory planning & implementation biases • Simplified evaluation & choice biases • Simplified information acquisition biases • Simplified review & feedback biases • Loss/gain lens in option generation biases • Self-confirmatory evaluation & choice biases	Research on implication for regulation biases (loss/gain lens) and verification biases (self-confirmatory planning & implementation, evaluation & choice), review & feedback biases
In-process debiasing	Change concatenation	• Psychophysically based errors, gain/loss biases (Arkes, 1991)	• Simplified option generation biases	Use for debiasing

		• Gain/loss biases (Thaler & Sunstein, 2008)	• Loss/gain lens in planning & implementation biases • Loss/gain lens in option generation biases • Simplified information acquisition biases	verification biases (variations of overconfidence) and regulation biases (loss/gain lens in evaluation & choice) in practice not recognized
	Make knowledge explicit	• Mismatch between judges and tasks (Fischhoff, 1982)		
	Choice architecture (nudges)	• Inertia, status quo (Thaler & Sunstein, 2008) • Reference point/loss aversion, present bias (choosing in advance, precommitment) (Soll et al., 2015)		
	Decision models and tools (e.g. linear)	• Use of simplified heuristics, memory/recall biases, availability, narrow option generation (Larrick, 2004) • Information acquisition biases, attentional bias, scaling effects (Payne et al., 1999) • Simplified heuristics, cluster illusion (Soll et al., 2015) • Myopic problem representation biases (Montibeller & Winterfeldt, 2015) • Sunk costs, escalation of commitment (Ohlert & Weißenberger, 2020)		
	Offer alternative formulations	• Influences of scale compatibility, inconsistencies in information (availability) (Payne et al., 1999)		
	Assessing uncertainty, improving judgement accuracy	• Overconfidence (Soll et al., 2015; Welsh et al., 2007)		
Starting Viewpoints	Use multiple experts	• Confirmation bias, overconfidence, availability (Montibeller & Winterfeldt, 2015) • Illusion of control, overconfidence (Meissner & Wulf, 2016)	• Self-confirmatory information acquisition biases • Self-confirmatory option generation biases • Simplified information acquisition biases • Loss/gain lens in option generation biases • Loss/gain lens in information acquisition biases • Loss/gain lens in evaluation & choice biases • Loss/gain lens in planning & implementation biases • Loss/gain lens in review & feedback biases	None
	Change one's reference point, add new gains and losses, reframe gains and losses	• Psychophysically based errors, gain/loss biases (Arkes, 1991) • Loss aversion (Soll et al., 2015) • Recency/primacy (Rutledge, 1995)		

Involvement	Incentives (raising the cost of using the suboptimal decision strategy, strong involvement with results of decision)	• Strategy-based errors (Arkes, 1991) • Too strong reliance on heuristics (Harkness et al., 1985) • Number of arguments (attentional bias), (Petty & Cacioppo, 1984) • Clerical and memorization tasks (Larrick, 2004) • Frequency assessments, anchoring/adjustment, (Stone & Ziebart, 1995) Works NOT for: • Overconfidence, prevent preference reversals, decrease the frequency of conjunction fallacy" (Stone & Ziebart, 1995) • Association-based errors (Arkes, 1991) • "Biases that are not primarily caused by lack of effort or insufficient attention. Monetary incentives can even backfire in some instances by leading people to "think harder but not smarter"" (Soll et al., 2015, p. 935)	• Loss/gain lens in option generation biases • Simplified review & feedback biases • Self-confirmatory review & feedback biases • Loss/gain lens in evaluation & choice biases • Loss/gain lens in information acquisition biases • Loss/gain lens in review & feedback biases	Use for debiasing simplification biases (information acquisition, evaluation & choice) in practice not recognized
	Put yourself in the shoes of, take an outsider's view	• Simplified evaluation and choice biases, prejudice/stereotyping, self-serving bias, anchor bias, control illusion (Kaufmann et al., 2010) • Control illusion (Faro & Rottenstreich, 2006) • Stereotyping, social thought, ingroup bias, attribution biases (Galinsky & Moskowitz, 2000b) • Loss aversion (Białek & Sawicki, 2014; Li et al., 2017)		
Calibration	Feedback-loop on decisions, provide personalized feedback, recalibrate their responses	• Framing, representativeness, ambiguity (Bhandari et al., 2008) • Association-based biases (Arkes, 1991) • Confirmation bias (van Brussel et al., 2020) • Faulty judges (Fischhoff, 1982)	• Simplified feedback & review biases • Self-confirmatory feedback & review biases • Loss/gain lens in feedback & review biases • Self-confirmatory option generation	None

Table XIX: Clustered Debiasing Techniques and Where They Work

By following the suggestion of Soll et al. (2015) to structure debiasing into "decision readiness" and "decision process", the combination of the concept of debiasing interventions from Stanovich et al. (2016) and the results of the card-sorting experiment

allows a more practice-oriented framework for debiasing interventions in managerial decision processes (Figure 15):

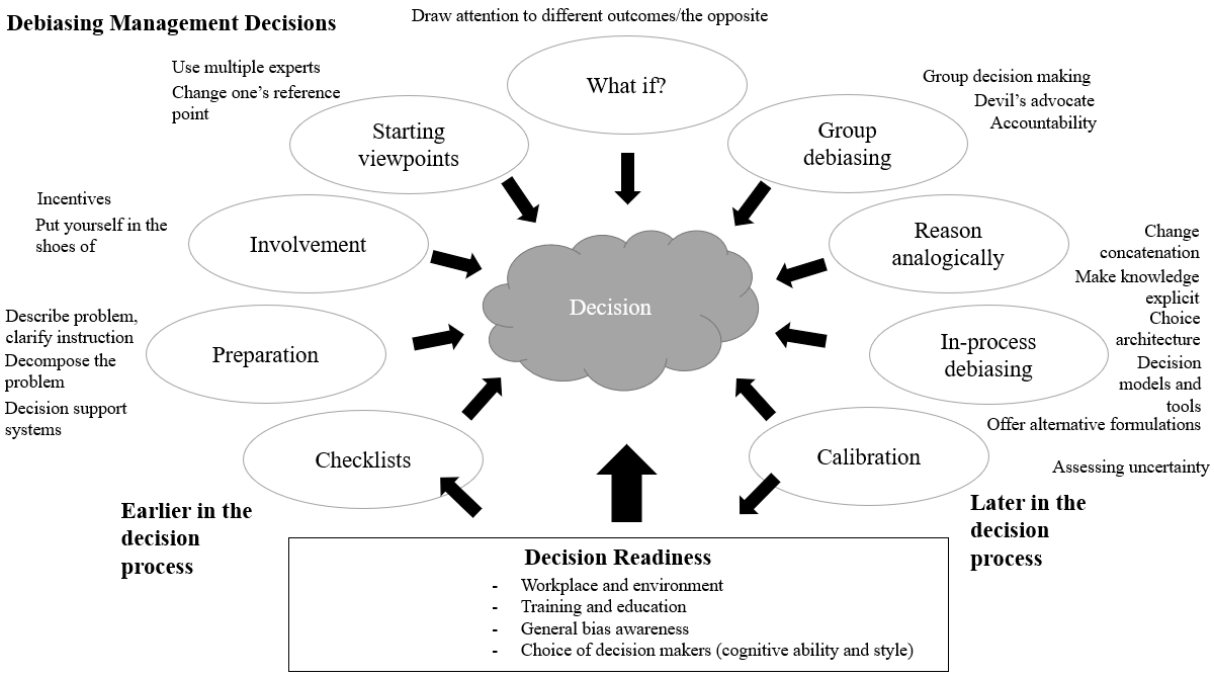


Figure 15: Overview Debiasing Management Decisions - a Practitioners' View

5.7 Conclusion and Limitations

The integration of a practice-oriented – or problem-oriented – perspective in debiasing research showed a different structure to understand debiasing techniques than the theoretical literature would provide. This new structure allows a debiasing framework closer to the managerial practice, easier to understand. Thus, it offers a chance that this way of understanding and structuring debiasing techniques may help to make managers aware of the flaws of decision biases and to show them what they can do before and during a decision process to mitigate the influence of these biases on managerial decisions, to improve the communication and implementation of debiasing techniques in (managerial) decision-making practice.

The results also show gaps in the "theory-practice relationship": The debiasing power of "involvement" techniques are not recognized in practice for the debiasing of simplification biases, same for the "what if?"-technique for self-confirmatory planning and implementation biases and the impact of "in-process debiasing" techniques on verification and regulation biases. This calls for a better transfer of research results towards the managerial practice.

On the other hand, the practitioner's view recommends more research on the debiasing technique of "reason analogically" as they see debiasing potential on regulation and verification biases.

Further research could also provide more insights about how facilitation techniques like visualization support the application of the debiasing techniques in practice and lead to a stronger and institutionalized implementation of debiasing processes in managerial decision making.

One background reason for this research is also a limitation: The managers show limited understanding of both biases and debiasing techniques and overall, a very heterogenous knowledge of these matters. Some techniques were well known but others like "change concatenation" needed explanation and were probably not fully understood by all participants. This depended on the personal expertise and individual background of the participants.

A second limitation is the number of participants, especially for the survey. Even if the findings are in line with the study of Kreilkamp et al. (2021) extending the scope of participants will help to get more insights about the real knowledge on debiasing techniques in managerial practice.

Nevertheless, the integration of the "victim's perspective" on debiasing techniques allows a new and more natural, practice-oriented understanding of debiasing. The resulting debiasing framework and overview may help for the communication and implementation in future projects to reduce the impact of cognitive biases in managerial decisions and thus making decisions better.

6. When Ignorance isn't Bliss: Managers' Illusion of Explanatory Depth for Emerging Digital Technologies and the Promise of Visualization

Martin J. Eppler, Christian Muntwiler

6.1 Introduction

Following the demand "to gain deeper insights into the cognitive and emotional significance of strategy practitioners' behaviors" (Hodgkinson & Clarke, 2007, p. 244), our studies look at one crucial factor of managerial strategizing: the knowledge about one's own knowledge, its impact on strategic decisions, and how managers can make these knowledge gaps explicit to improve strategic decision making. To do so, we apply a seminal concept from cognitive psychology to the strategy realm, namely the illusion of explanatory depth (IOED) (Rozenblit & Keil, 2002). This article combines three angles: A deeper understanding of the size of this cognitive limitation of strategy practitioners when it comes to emerging digital technologies, the impact of these limitations on strategic decisions, and an analysis how self-sketched visualizations may help to calibrate one's own knowledge and thus reduce one's overestimation of knowledge. As a consequence, the article provides scholars and managers with insights of how an IOED about emerging digital technologies may flaw the outcome of strategizing and how and why self-sketched visualizations may help to mitigate this effect. In the first part of this article, we focus on the importance of understanding emerging digital technologies from a strategic decision-making perspective, the challenge of an incorrect calibration of this knowledge which leads to overestimation, and the promise of visualizations in strategic decision making to correct this overestimation or knowledge illusion. In a second part, we develop two hypotheses concerning the influence of the IOED in strategic decision making and the potential calibration effect of self-sketched visualizations. This leads to the design of two experiments testing both hypotheses, the results, and the final discussion and conclusion.

6.1.1 Understanding Emerging Digital Technologies

The understanding of emerging digital technologies (such as blockchain, the internet of things, or artificial intelligence) is a prerequisite for successful digital business transformation (Berghaus & Back, 2016; Helmi Ismail Abdelaal, Khater, & Zaki, 2017; Rachinger, Müller, Rauter, Vorraber, & Schirgi, 2018; Westerman, Calméjane, Bonnet, Ferraris, & McAfee, 2011) or as Yoo et al. write: "digital technology is an integral part

of strategy formulations" (Yoo, Henfridsson, & Lyytinen, 2010, p. 730). The lack of understanding for novel, emerging technologies feeds uncertainties in regard of their economic potential and value creation (Kapoor & Klueter, 2021) as such an understanding and a potential adoption requires significant knowledge and experience (Shih, 2020). The digital maturity of a company (Gill & VanBoskirk, 2016; Remane, Hanelt, Wiesboeck, & Kolbe, 2017; Westerman, Tannou, Bonnet, Ferraris, & McAfee, 2012) and the knowledge of managers about strategy-relevant emerging digital technologies (Brockmann & Anthony, 2002; Eisenhardt, 1989; Smith, Collins, & Clark, 2005) is hence critical for strategic decisions. The underlying challenges of uncertainty in digital maturity and knowledge about emerging digital technologies are "managerial cognitive processes that relate to attention, perception, reasoning, and problem solving" (Kapoor & Klueter, 2021, p. 69). Thus, processes like the accurate self-assessment of this knowledge (Furnham & Boo, 2011), to understand the strengths and weaknesses of emerging digital technologies like artificial intelligence (Shrestha, Ben-Menahem, & von Krogh, 2019) and their rapid adoption (von Krogh, 2018) have become crucial for the strategic decision-making process (Fitzgerald, Kruschwitz, Bonnet, & Welch, 2013; Kane, Palmer, Phillips, Kiron, & Buckley, 2015; Westerman, Calméjane, Bonnet, Ferraris, & McAfee, 2011).

A flawed understanding of emerging digital technologies, an over- or underconfidence in one's own knowledge, may be hazardous as it, among other things, may seduce managers to overly rely on their own (flawed) expertise instead of seeking advice from experts or other internal or external collaborators (Alba & Hutchinson, 2000; Radecki & Jaccard, 1995; Singh, Aggarwal, & Cojuharenco, 2015; Walters, Fernbach, Fox, & Sloman, 2017) – and as a consequence, leads to poor strategic decision making when it comes to the assessment of emerging digital technologies and their potential value creation (Kapoor & Klueter, 2021).

6.1.2 The Effect of Exceeding Confidence in One's Own Knowledge

Overconfidence in strategic decision making has been recognized as a powerful cognitive limitation or bias with an ambiguous influence on decisions (Barber & Odean, 2001; Busenitz & Barney, 1997; Camerer & Lovallo, 1999; Malmendier & Tate, 2005). It is "one of the most consistent, powerful, and widespread" (Johnson & Fowler, 2011, p. 317) cognitive biases: "No problem in judgment and decision making is more prevalent and more potentially catastrophic than overconfidence" (Plous, 1993, p. 217).

The impact of overconfidence on managerial decision has been shown in various contexts: Overconfidence in one's own abilities leads to business entry mistakes (Camerer & Lovallo, 1999) and influences risk taking (Schumacher, Keck, & Tang, 2020). It leads "to conclude that a situation is less risky" (Busenitz & Barney, 1997, p. 25), and the overestimation of investment returns results in an overpay for target companies (Lee, Hwang, & Chen, 2017; Malmendier & Tate, 2005), and excessive trading (Barber & Odean, 2001). Overconfidence in strategic decisions is ambiguous as it "may be particularly beneficial in implementing a specific decision and persuading others to be enthusiastic about it as well" (Busenitz & Barney, 1997, p. 10), but it also threatens the quality of decision making as it crowds out decision aids, ignores the base rate, fosters groupthink and induces a failure to consider alternative perspectives (Arkes, 2001, p. 496–497). The phenomenon of overconfidence increases in "unfamiliar or poorly understood strategic contexts" (Johnson & Fowler, 2011, p. 319), and "when organizations undertake novel tasks and when top managers, who do not face strong social feedback from peers, are the ones taking action" (Dunning, Heath, & Suls, 2004, p. 93). Thus, overconfidence increases in "precisely the most dangerous of situations" (Johnson & Fowler, 2011, p. 320) – and, precisely, the situation strategists find themselves when being confronted with novel, emerging digital technologies.

Overconfidence is known as a "positive illusion" (Haselton, Nettle, & Andrews, 2015; Taylor & Brown, 1988) consisting of different phenomena: a) an unrealistic positive view of the self (Taylor & Brown, 1988, p. 195) or exaggerated personal qualities and capabilities (Johnson & Fowler, 2011, p. 317), b) the illusion of control (Johnson & Fowler, 2011, p. 317; Taylor & Brown, 1988, p. 196), and c) unrealistic optimism (Taylor & Brown, 1988, p. 196) or negligence to risk (Johnson & Fowler, 2011, p. 317). Moore and Healy (2008, p. 502) summarize these phenomena as "overestimation" and add overplacement (people believe to be better than others) and overprecision (an excessive certainty about the accuracy of one's believes) to the concept of general overconfidence.

In this article we focus on one specific aspect of overconfidence: the overestimation of managers' own explanatory knowledge in the context of strategic decision making, or in other words "the mismatch between what they think they already know and what they really know" (Rozenblit & Keil, 2002, p. 524), the illusion of explanatory depth (IOED). In contrast to the overestimation of factual, procedural, or narrative knowledge, the specific IOED shows an overestimation of one's understanding of complex causal relations, the explanatory knowledge of how things and particularly technologies work.

We have chosen to explore this specific perspective of overconfidence and overestimation as the lack of understanding emerging digital technologies (NOT being able to explain these technologies to oneself and to others involved in a decision-making process and NOT being aware of this lack) feeds uncertainties (Kapoor & Klueter, 2021) and a (re-)calibration may support an accurate self-assessment of this knowledge (Furnham & Boo, 2011). This also follows the call for more research on the effects of calibration of different kinds of knowledge in strategy research (Pillai, 2010).

6.1.3 Calibration of Knowledge and the Promise of Visualizations

A miscalibration is a deviation from the accuracy of the decision (Tang, Hess, Valacich, & Sweeney, 2014). Thus, calibration helps to close the gap between the expressed confidence (subjective confidence) and the accuracy of a decision (objective quality) (Koriat, 2012; Sniezek & Henry, 1989; Tang et al., 2014). Calibration raises the degree of certainty (Alba & Hutchinson, 2000), reduces the tendency to take inappropriate actions (Maule & Hodgkinson, 2003) based on inaccurate managerial perceptions (Pillai, 2010), and improves information search in consumer decisions (Pillai & Hofacker, 2020).

"Perfect calibration exists when one's belief in the veracity of the knowledge (confidence) matches the correctness of that knowledge (accuracy)" (Pillai, 2010, p. 301).

The calibration of knowledge can be achieved by training (Gutierrez de Blume, 2017; Moore et al., 2017) or by feedback on the accuracy of one's judgement or decision (Tang et al., 2014). The findings on feedback as calibration method show an hard-easy effect: feedback for difficult tasks provide a better calibration than for easy tasks (Keren, 1988; Petrusic & Baranski, 1997). This hard-easy effect is a result of the fluency effect, the subjective impression of how hard or easy a decision is (Zwaan & Hautz, 2019).

Another way of calibration is the deliberate reflection, "to go back to the case" (Costa Filho, Moura, Brandão, Schmidt, & Mamede, 2019, p. 231), which facilitates a disfluency effect by lowering the confidence (Sniezek & Henry, 1989) and retrieving the unknowns (Walters et al., 2017) and thus supports the calibration of knowledge. In contrast, the ease that is facilitated by fluency leads to greater use of heuristic reasoning, and sometimes more errors in judgment" (Hernandez & Preston, 2013, p. 178), thus "processing fluency may be one important factor that determines when people will overcome their intuitive responses to engage more systematic reasoning" (Alter et al., 2007, p. 575).

Following the dual coding theory by Paivio (1986), a deliberate reflection bases on two forms of mental representations: verbal and visual (imagery). Affordances of visualizations such as tangibility (making knowledge visible and concrete) and associability (relating different issues or perspectives to each other) (Paroutis et al., 2015), or the provisionality or small degree of perceived finishedness (Bresciani & Eppler, 2018; Hundhausen, 2005) give images the potential to improve "communication, comprehension, recall and motivation compared to text or discourse alone" (Paroutis & Knight, 2019, p. 207). Visualizations such as diagrams, maps, sketches, or metaphors (Eppler & Burkhard, 2007) can improve reasoning (Bauer & Johnson-Laird, 1993) and comprehension (Tversky & Kessell, 2014) by visualizing thought (Tversky, 2011) and help to mitigate the attraction or decoy effect in decisions (Dimara, Bailly, Bezerianos, & Franconeri, 2019).

Over the last years, the use of visualizations in strategizing episodes and strategic decision making has received more and more attention. Graphic representations support the strategic planning process (Eppler & Platts, 2009), help to map strategic consensus (Tarakci et al., 2014), and support transparency and inclusion in open strategy contexts (Paroutis & Knight, 2019). The use of visualizations enhances strategy tools in their interactive role to facilitate creativity, meaning, discourse and knowledge creation and sharing in strategizing (Jarzabkowski & Kaplan, 2015; Knight et al., 2018; Paroutis et al., 2015; Pfister & Eppler, 2012). It also supports the subsequent communication and hence implementation of strategies (Kernbach, Eppler, & Bresciani, 2015). Hodgkinson et al (1999, 2004) showed that drawing cause maps before a decision attenuates a framing bias.

Compared to other ways of visualizing mental representations like diagrams, maps, or images, sketching has several strengths (Eppler & Burkhard, 2007). Sketches are fast and no artistic skills are necessary which provides a low entry barrier for its use in strategizing (Walny, Huron, & Carpendale, 2015). Sketches are imprecise, unfinished with a careful fuzziness and thus "non-threating" as they make abstract principles and knowledge easier handleable and bring unconscious nuances to consciousness (Platts, 2001). Their vagueness and amorphousness allows to display and accept uncertainties (Swedberg, 2016). External visual representations like sketches help to coordinate external and internal perspectives and allow people to compute more deeply, broadly, and more precisely, to "communicate with themselves" (Kirsh, 2010, p. 444) through the incremental and "step-by-step" process of sketching knowledge.

Given these benefits of visualization and especially self-drawn sketches, we ask the following explorative question: Can self-sketched visualizations help to (re-) calibrate one's knowledge of emerging digital technologies to uncover and even correct the illusion of explanatory depth as miscalibration of knowledge?

6.2 Hypotheses

6.2.1 The Impact of an IOED and its Calibration in Strategic Decision Making

The specific phenomenon of an illusion of explanatory depth emerges because of "people's limited knowledge and their misleading intuitive epistemology" (Rozenblit & Keil, 2002, p. 522) in the self-assessment of the understanding of complex causal patterns. It leads to an inaccurate self-assessment of one's own knowledge (Fisher & Keil, 2016). Rozenblit and Keil (2002) define four features of knowledge prone to an IOED: the confusion of the internal representation and the environmental support, the confusion between the different levels of analysis, the complexity of hierarchies of explanation, and the rarity of reproduction of an explanation. The understanding of emerging digital technologies and their complex causal patterns fits this definition of "explanatory, theory-like knowledge that may converge to convince people they have vivid, blueprint-like senses of how things work, even when their actual knowledge is skeletal and incomplete" (Rozenblit & Keil, 2002, p. 522). Emerging digital technologies are characterized by layers of contents, services, networks, devices, and the combination of hardware and software (Henfriedsson, Mathiassen, & Svahn, 2014; Yoo et al., 2010). Therefore, they exhibit the "problem of unbounded causal complexity" (Keil, 2007, p. 1036) with complex hierarchical structures of the mechanisms behind the phenomenon and – consequentially – indeterminate end states of explanation (Rozenblit & Keil, 2002).

As the IOED represents an overestimation of one's abilities to understand a certain technology, we assume that managers who recognize their initial overestimation correct their intention to invest to a greater degree than managers who are not aware of their initial bias. This follows the finding that "the price a person is willing to pay for a financial option is a function of risk" (Frijns, Gilbert, Lehnert, & Tourani-Rad, 2013, p. 2458). The amount a person is willing to invest measures risky behavior (Weber & Hsee, 1998), as a higher investment indicates greater (intended) strategic risk taking (Chng & Wang, 2016).

We acknowledge that this not measure the actual risk behavior (Reypens & Levine, 2018) as there are often gaps in willingness to pay and actual behavior (Nelson, Pei-Jou,

Melissa, & Raymond, 2012). But to measure a change in intention due to the awareness of one's own limited knowledge, a different mindset before and after the re-calibration of knowledge, serves as the closest proxy to come by in an experiment without actual spending the money and buying real companies.

As overestimation of one's knowledge leads to the perception that a specific "situation is less risky" (Busenitz & Barney, 1997, p. 25), we analyze the size of correction in the intention to pay between managers who were aware of an IOED and those who were not. The corresponding hypothesis reads as follows:

> *H1: The recognition of an IOED leads to a stronger correction (reduction) in the intention to invest.*

6.2.2 The Visual Self-Calibration of Explanatory Knowledge

Rozenblit and Keil (2002) have already shown that a written (verbal) self-explanation of a phenomenon reduces the IOED and revealed in their study 5 that this was in fact the effect of accurate recalibration and not "a result of feeling "challenged"" (Rozenblit & Keil, 2002, p. 533). Mental representations like a self-explanation enable managers "to see things they were not aware of, and this insight helps them to define new questions, hypotheses, and models of their data" (Van Wijk, 2005, p. 3). The benefit of self-explanations is also supported by research on learning: "by generating inferences to fill in missing information, integrating new information with prior knowledge, and monitoring and repairing faulty knowledge, learners who self-explain develop more accurate internal representations of a concept" (Kim, Reinecke, & Hullman, 2017, p. 1376). An actively constructed visual representation of knowledge enhances the understanding of one's own uncertainty (Hullman, Kay, Kim, & Shrestha, 2018).

Visualizations structure and externalize original internal or implicit knowledge (Brockmann & Anthony, 2002; Mengis & Eppler, 2006). Visual representations are in fact "more effective than verbal explanations in representing sequential and hierarchical relations" (Guri-Rozenblit, 1988, p. 219). Visual (graphical) support for representations of knowledge leads to a higher accuracy in the understanding of probability distributions (Goldstein & Rothschild, 2014). Illustrations allow to show the major components of complex causal patterns and the interaction of these components (Mayer & Gallini, 1990) which supports building mental models or mental imagery (Paivio, 1969). The provisionality of sketching (Bresciani & Eppler, 2018; Hundhausen, 2005) creates a "disfluency", an "interruption of the smooth flow of thought" (Ellis, 2018, p. 123). Disfluency makes "people more critical and analytical of that information, allowing for

greater consideration of counter-attitudinal arguments, and more skepticism toward attitude-consistent information" (Hernandez & Preston, 2013, p. 179). A more critical analysis of one's own understanding, a deliberate reflection, a deeper computing (Kirsh, 2010) should consequentially lead to a better calibration of knowledge, which provides us with the explorative hypothesis 2.

> *H2: A visual (sketched) self-explanation leads to a more accurate calibration of knowledge (and reduction of the IOED) than a textual self-explanation.*

6.3 Methods

To test the two hypotheses, we developed two experiments and a coding scheme to analyze the written and sketched (visual) self-explanations of the participants. For the analysis of a potential impact on decisions when people do recognize their IOED, their knowledge limitations in a certain area, we conducted a first experiment to analyze differences between IOED-calibrated and non-IOED-calibrated participants and their differences in the willingness to invest in a business.

The second experiment consisted of a pre-survey testing for active-open-minded-thinking and 4 experimental steps mainly replicating the original IOED-experiment by Rozenblit and Keil (2002) with the aim of sticking as close as possible to the original setting. To test hypothesis 2, we introduced two randomly assigned modes of self-explanation, a written one and a sketched (visual) one.

6.3.1 Experiment 1

Sample

The participants of the first experiment consisted of 117 managers which participated in international strategy and communication workshops and trainings. They were from 23 different countries (average age 36.98 years, 13.35 years of working experience and 5.72 years of management experience).

Procedure

We let participants watch a video sequence from the Canadian TV show "Dragon's Den" where a start-up called Phazon (focusing on an easy-to-known digital technology topic: wireless earbuds) was presented and one of the investors closed with a concrete offer for the whole company (4 million dollars - the external investment anchor in our experiment). Thus, after watching the video, all experiment participants had to complete

an online survey with the following procedure, using a part of Rozenblit and Keil's experiment on the IOED (2002):

1. Question 1: "After having watched the Phazon/Dragon's Den video: How much would you invest in the company? (Answer within a range from 0 – 5 mio $: invest T1)
2. Random assignment to IOED or control group (CG)
3. Question 2 IOED group only: "How well do you understand how wireless earbuds work, please express your understanding on a scale of 1 (no idea at all) to 7 (excellent understanding)." (IOED T1)
4. Question 3 IOED group only: "Explain how wireless earphones work: Now, we'd like to probe your knowledge in a little more detail. Please describe all the details you know about wireless earphones and how they work." (Self-explanation)
5. Question 4 IOED group only: "Now, please rate again how well you feel you understand how wireless earphones work on a scale of 1 (no idea at all) to 7 (excellent understanding)." (IOED T2)
6. Question 5 IOED group only: "After assessing your knowledge about wireless earphones: How much would you invest in the company now?" (Answer within a range from 0 – 5 mio $: invest T2)
7. New information for both groups (IOED and control group – to give the control group a reason for the second time question about the investment proposal): "Now a Phazon manager informs you that the battery life of Phazon's wireless earbuds is equal to the one in competing producers."
8. Question 6, both groups (IOED and CG): "After this new information: How much would you invest in the company now?" (Answer within a range from 0 – 5 mio $: invest T3)

At the end, this led, for the control group, to two investment statements (invest T1, and invest T3, after the newly acquired, but not really relevant, information), and for the IOED group to three investment statements (invest T1, invest T2 after the IOED test, and invest T3, after the newly acquired information) and the measure of the IOED (IOED T1 and IOED T2, after the written self-explanation). This procedure allowed us to compare invest 1 and 3 for the group without an IOED intervention, the group with an intervention but no correction (correct self-evaluation or stable overestimation) and the group with intervention and correction, to both check for the influence of an IOED on the correction and a potential order effect.

6.3.2 Experiment 2

Sample

For the second experiment, we have enlisted a total of 78 participants, of which 59 were experienced managers (age 30+) who had enrolled in management seminars and workshops as well as experienced professionals enrolled in different MBA programs (age 25+, 19 participants). Regarding participant demographics, the mean age of all 78 participants was 38.3 years, with 15.0 years of work experience and 8.1 years of management experience. 56 were males, while 22 were females. They came from 11 different countries (a majority from European countries) and covered more than 15 different industries.

Procedure

Pre-Survey: As indicated by Alter et. al. (2010) and Silk-Eglit and Kurtz (2011) cognitive dispositions may have an influence on the degree of an IOED adjustment and one's ability to self-calibrate. Thus, we have integrated a test for the "active-open-minded-thinking" (AOT) as a pre-survey before the experiment to check for variations in the IOED based on the AOT results. To optimize the duration of the experiment and keep it under 30 minutes (as we did the experiments during time-critical seminars and workshop with managers), the AOT-version of Svendholm-Häkkinen and Lindeman (2017) was used. The research of Czerwonka (2017) and Toplak, West and Stanovich (2014) both show that cognitive abilities predict the impact of an anchor bias and therefore a high AOT-rating should lead to a more accurate first self-assessment in explanatory knowledge.

Step 1 – Calibration: To indicate their level of understanding, the participants learned to use a 7-point scale to rate their understanding (deep, partial, shallow) of complex causal patterns on two training examples (the understanding of the concepts of ROI and GPS – the second example was taken from the original experiment).

Step 2 – Measure T1: The participants rated their *level of understanding* (T1) of seven digital technologies. We have chosen these seven key digital technologies as they were mentioned by Forbes as key digital trends (https://www.forbes.com/sites/danielnewman/ 2017/09/26/top-10-trends-for-digital-transformation-in-2018/#42fc2926293a). These seven technologies are generally considered to have a major impact on strategic decisions for a company. In fact, they are consistently cited in various publicly accessible management publications and

websites as the key technologies relevant for business today. They are: artificial intelligence, blockchain, internet of things, 5G mobile communication, virtual reality, augmented reality, and big data analysis. Thus, it could be expected that today's managers are aware and have a certain understanding of these technologies and how they affect their business model.

Step 3 – Measure T2: For three of these technologies (following the design of the original experiment by Rosenblit and Keil), each of the participants was asked to deliver a self-developed explanation (how does this technology work?). The participants were randomly assigned to one of the two mode conditions: 50% of the participants had to deliver a written explanation, while the other 50% of the participants had to create a sketched explanation. After the explanation, the participants re-rated their understanding of all seven items (T2).

Step 4 – Measure T3: For each of the three technologies where a self-explanation was requested, the participants were asked a detailed "diagnostic question" (e.g., how is a crypto currency built and what makes it work?) which they had to answer in writing (for both conditions). Then all participants re-rated their level of understanding for all items one final time (T3).

At the end of the experiment, all participants had to complete a short questionnaire about their background (age, gender, work experience, managerial experience, industry, country of origin).

Thus, every participant rated his or her understanding of the seven digital technologies three times: T1 (the original self-rating), T2 (the self-rating after a visual or written explanation of the phenomenon given by them), and T3 (the self-rating after a diagnostic question concerning the phenomenon and their own written answer).

6.3.3 The Coding of the Self-Explanations (Textual and Visual)

To check for the accuracy of the correction after visual self-explanation, we had to analyze and code the quality of the self-explanations (both textual and visual and both experiments). To do so, we have developed an averaged reference for the self-explanations for the item in experiment 1 and for the three selected items in experiment 2 based on publicly available and easily accessible sources. This reference shows what a manager (rather than an expert in this area) could reasonably be expected to know about wireless earbuds (experiment 1) and blockchain, internet of things, augmented reality (experiment 2). This allowed us to rate all self-explanations in both experiments

for completeness of the self-explanation in comparison to an (authoritative/validated) averaged reference for visual and textual explanations of the technologies.

Coding the Textual Self-Explanations

For an objective analysis of the textual self-explanations ("short free-text answers") a semantic analysis based on the matching of patterns (concept, key words and terms for the item) was applied (Roy, Narahari, & Deshmukh, 2015). Semantic text similarity (Dijkman, Dumas, van Dongen, Käärik, & Mendling, 2011) provides a reliable measure of knowledge (Rehder et al., 1998). The correct, item-related key words or terms included in the textual self-explanation (ranging from short essays to even shorter lists of keywords) were counted and compared to an averaged reference (pattern matching). This leads to the following metric for the textual self-explanations:

C(t) = completeness of the textual self-explanation in comparison to an (expert-based/authoritative/validated) averaged reference

T(t) = number of correct, item-related terms/concepts/key words in the text in comparison to an averaged reference

$$C(t) = T(t)$$

Coding the Visual Self-Explanations

For an objective analysis of the visualizations, a metric to quantify the quality of the sketches is a necessity. Literature on metrics for sketches provides different approaches. Ways to code sketches are based on the perceived skills and quality (Booth, Taborda, Ramani, & Reid, 2016; Camba, Kimbrough, & Kwon, 2018; Yang & Cham, 2007), complexity and size (McGown, Green, & Rodgers, 1998), the medium used (McGown et al., 1998; Song & Agogino, 2004), representation and annotations (Lau, Oehlberg, & Agogino, 2009). Joshi and Summers (2012) and Dinar et al (2016) both provide an overview on different metrics to evaluate sketches. For our research, we needed a metric that allows a conclusion for the degree of knowledge revealed about a specific item. In this context, the metric completeness, representing the relevant content via number of data elements (Freitas et al., 2002) is the most useful one. For the visual self-explanations there are two major data elements to code: (correct, item-related) annotations ("type of support notation including labels, lists, narratives, dimensions, and calculation" (Song and Agogino, 2004, p. 352)), and number of (correct, item-related) elements or artifacts of the item (variety of description) (Grenier, 2008; Shah, Smith, & Vargas-Hernandez, 2003; Westmoreland, Schmidt, & Ruocco, 2011). The use of

annotations (labels) and structure (elements) to measure similarity (or difference) to analyze visual models is also supported by Dijkman et. al. (2011). This leads to the following metric for the visual self-explanations (the visual representations of knowledge) in our experiments:

C(v) = completeness of the visual self-explanation in comparison to an (expert-based/authoritative/validated) averaged reference

A(v) = number of correct, item-related annotations in the sketch in comparison to an averaged reference

E(v) = number of correct, item-related visual elements (boxes, symbols, connections, etc.) in the sketch in comparison to an averaged reference

$$C(v) = \text{Mean}\,(A(v), E(v))$$

Both dimensions (A(v), E(v)) can be counted and then compared to the averaged reference value for both. This leads to an objective, explicit, quantitative and manual coding of the visualizations (Dinar et al., 2016; Joshi & Summers, 2012).

Authoritative Averaged Reference

For the comparison of the results with what could be expected to know from a manager we developed an authoritative averaged reference. How good were the participants really, what do they know compared to what could be known? The closest proxy to come by for the expected knowledge of average managers in all kinds of companies. This served as the averaged reference of completeness (C(v or t) = 1.0). This served as the basis to measure similarity (or difference) and thus the degree of completeness for each self-explanation (visual and textual). For this averaged reference we took three short textual explanations for experiment 1 and three visual and short textual explanations for each of the three items tested from public online sources (experiment 2), easily accessible for managers around the world. These show what a manager (and not an expert in this area) could easily know about blockchain, the internet of things, augmented reality, and wireless earbuds with a short Google search. The nine visual explanations were then coded for correct, item-related annotations/labels (A(v)) and correct, item-related visual elements (E)(v), leading to an averaged A(v) and E(v) resulting in the averaged reference completeness C(v). Same procedure, but with the semantic analysis leading to T(t), for the textual self-explanations, providing the averaged reference C(t) (see details and sources of the authoritative averaged references in Appendix C).

Coded Groups

The self-explanations and the self-assessments of all participants for both experiments were then coded and categorized. This helped us to compare the initial estimations of knowledge with the "real" knowledge of the participants and the result of their self-calibration after the self-explanations, as testing the real knowledge of the participants in advance would have flawed the experiment. The resulting groups are different combinations of accuracy and confidence levels, pre- and post-experimental. We coded the self-explanations and the self-assessments of all participants according to the scheme below:

Completeness (of self-explanation): < .33 = Low, .33 - .66 = Medium, > .66 = High.

Self-Estimation (of one's knowledge) T1: 1, 2 = Low, 3, 4, 5 = Medium, 6, 7 = High

Self-Estimation (of one's knowledge) T2: 1, 2 = Low, 3, 4,5 = Medium, 6,7 = High

Correction T1T2 (between the two self-assessments): negative, 0, positive.

This led to following ex post grouping of the quality of self-assessments in relation to the completeness of the self-explanations, reflecting Pillai's calibration/miscalibration matrix and its combinations of accuracy and confidence (Pillai, 2010):

- OE (stable overestimation – consistent miscalibration): T1 (low, medium, high) > C (low, medium, high), T1T2 = 0, negative, T2 > C
- Still OE (light correction, but still OE – corrected, but still miscalibration): T1 > C, T1T2 = positive, T2 > C
- Overcorrected OE (corrected, but still miscalibration): T1 ≥ C, T1T2 = positive, T2 < C
- OE corr (OE corrected – corrected calibration): T1 ≥ C, T1T2 = positive, T2 = C
- UE (Underestimation – consistent miscalibration): T1 < C, T1T2 = 0, positive, T2 < C
- UE corr (UE corrected – corrected calibration): T1 ≤ C, T1T2 = negative, T2 = C
- Overcorrected UE (corrected, but still miscalibration): T1 ≤ C, T1T2 = negative, T2 > C
- Still UE (light correction, but still UE – corrected, but miscalibration) : T1 < C, T1T2 = negative, T2 < C
- No C (no correction – consistent calibration): T1 = C, T1T2 = 0, T2 = C, correct self-assessment

6.4 Results

6.4.1 Experiment 1

As can be expected, the *initial* investment proposal from both groups (with and without an IOED check) in the first experiment (IOED (n=56): 1'946'429$, control group (n=61): 1'850'000$) did not show a significant difference. To analyze the *effect of a recognized IOED on the intention to invest,* we coded the results according to the textual coding scheme. Of all 117 participants, 61 were in the first (control) group without an IOED check, therefore no coding was applied. In the second group, with the IOED check questions, 32 participants made no correction after their self-explanation (due to a correct self-evaluation from the beginning or a stable overestimation), while 24 participants corrected their self-evaluation of knowledge. The repeated-measures ANOVA showed a *significant difference between the adjustments of the intention to invest* ($F(6/110) = 4.28$, $p = .006$). The correction of the group "Overestimation corrected" (n=9, correction = 1'572'222) was significantly different than the other corrections, confirming hypothesis 1 (differences of adjustments per group, see Figure 16).

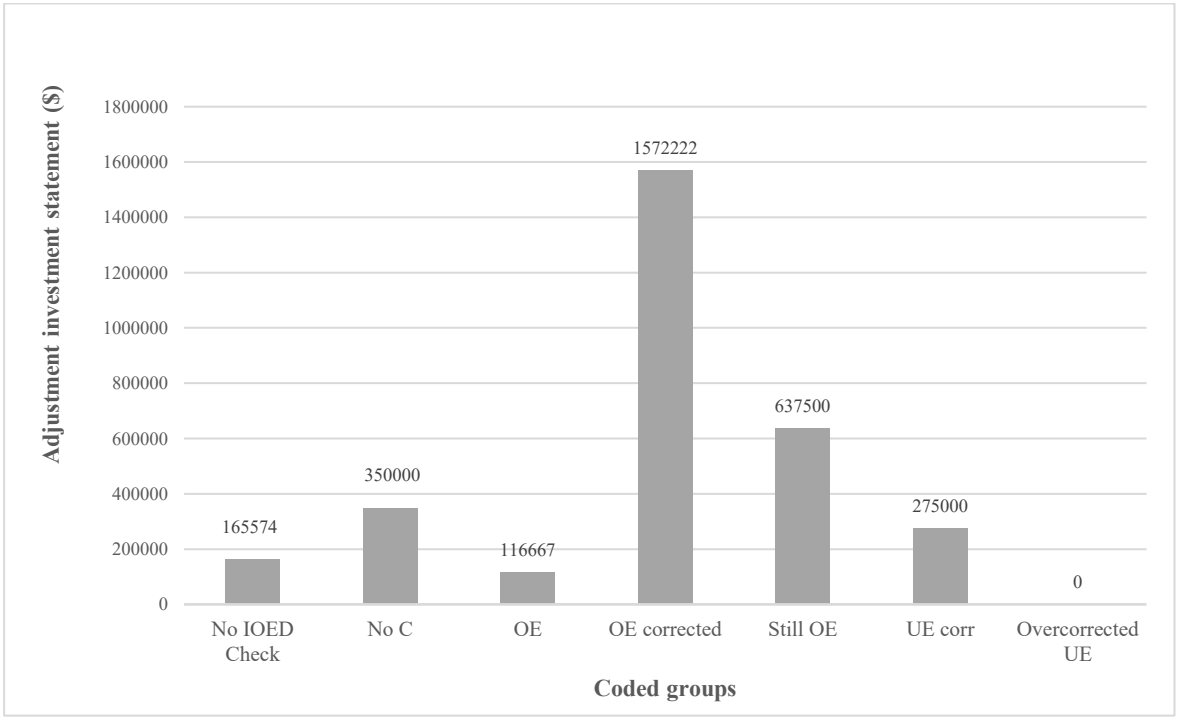


Figure 16: Coding of the Groups After the Self-explanation

No C: no correction; OE: still overestimation after self-explanation; OE corrected: successful recalibration after self-explanation; Still OE: correction after self-explanation but still overestimating one's knowledge; UE corr: successful calibration of an underestimation; Overcorrected UE: an overcorrected underestimation; No IOED Check: Control group without self-explanation

Existing research has already emphasized and shown order effects (recency and primacy effects) in belief-updating (Hajaj, Hazon, & Sarne, 2014; Hogarth & Einhorn, 1992; Jasper, Kunzler, Prichard, & Christman, 2014; Johnson, 1995; Kwak & Huettel, 2018; Tubbs, Gaeth, Levin, & Van Osdol, 1993; Wang, 1998; Yankova, 2015). We thus checked whether the change in strategic intentions is due to an order effect based on the experimental procedure or indeed provoked by the re-calibration of knowledge. In other words: Do managers with a recognized IOED reduce their intended investment because of the IOED effect or just because of an "simple" order effect by being repeatedly asked the same question?

If the correction of the investment intention for the IOED group is due to an order effect and not because of the recognition of an IOED, then there should be no significant difference in the adjustment of the investment intention between those who corrected their initial rating and those who did not. And there should be a significant difference between the IOED group and the control group, as the IOED group was asked an additional time for their willingness to invest, the repetition of the same question. To check for such an order effect, we split the IOED group in those who recalibrated their knowledge and those who did not (due to correct self-evaluation or a stable overestimation) and compared their final investment propositions (I3) with those from the control group. The repeated measures ANOVA showed a *significant difference* between the results of the three groups ($F(2/114) = 7.69$, $p = .0007$) – see Figure 17. The comparison within the IOED groups (corrected vs. no correction of IOED) showed a significant difference in I3 between the two groups (ANOVA, $F(1/54) = 7.46$, $p = .0085$), again indicating a strong IOED effect differing from an order effect.

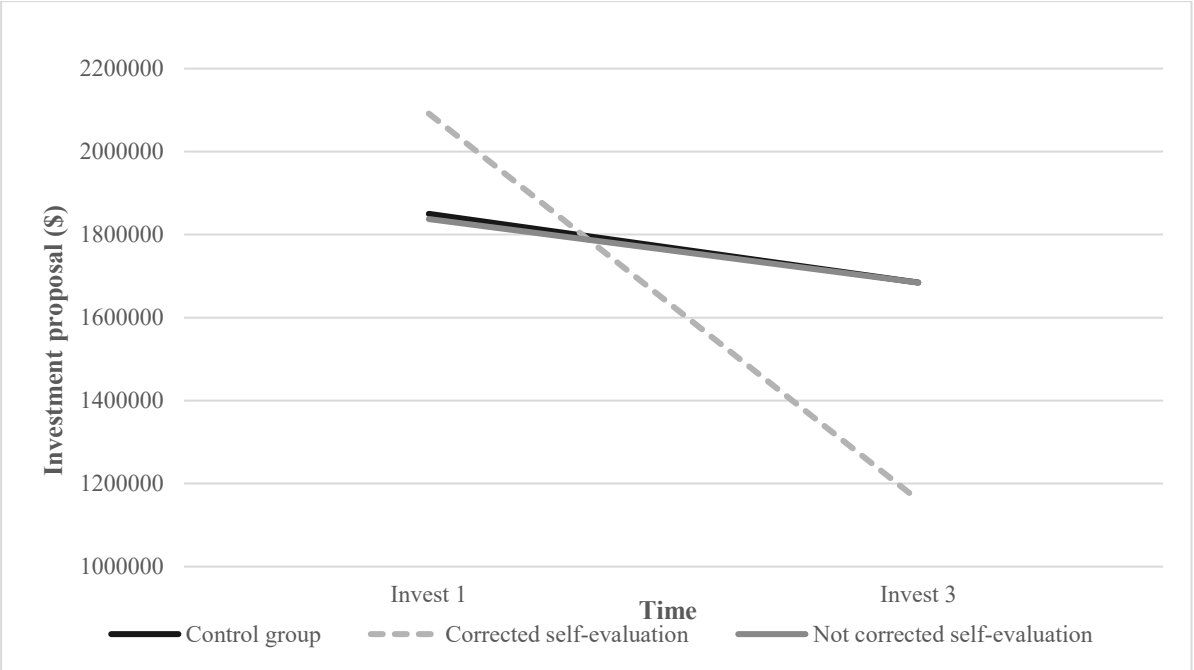


Figure 17: Investment Proposals per Group

Control group: invest 1 = 1'850'000, invest 3 = 1'684'426; corrected self-evaluation: invest 1 = 2'091'666, invest 3 = 1'160416; Not corrected self-evaluation: invest 1 = 1'837'500, invest 3 = 1'684'375

The analysis of the IOED correction (adjustment T1T2) and the adjustment of the investment proposal (invest 1 to 2) even showed a significant correlation. The size of the IOED correction predicts the adjustment of the investment proposal in invest 2 (ANOVA: F (1/54) = 5.67, p < .0208). *Thus, the bigger the recalibration of knowledge (self-evaluation) is, the greater the reduction of the intended investment towards a smaller strategic risk.* Recognizing one's illusion of understanding thus clearly has the potential to impact decision making.

6.4.2 Experiment 2

General Findings

The results of experiment 2 are aligned with the predictions of the established theory of IOED in other domains. They are also in line with the argument by Gaviria, Corredor, and Zuluage-Rendón (2016) that the high social desirability of specific knowledge like digital technologies contributes to an IOED (i.e., the fact that managers are supposed to understand digital technologies today). The participants showed a *significant drop in the self-ratings from measure T1 to T3* (means T1=3.38, T2=2.79, T3=2.54, repeated measures ANOVA: F (2/1611) = 31.37, p < .0001) thus confirming that *managers originally overestimated their understanding of emerging digital technologies*.

There was the overall observation that a higher rating in the active-open-minded-thinking-test (AOT) lead to a smaller adjustment in the re-rating, as predicted by Czerwonka (2017) and Toplak, West and Stanovich (2014), but this effect is not statistically significant with the exception of the tendency for underestimation for managers with a high AOT. There were no observed variations in the impact of an IOED based on management experience and work experience. The relation between the "actively-open-thinking-test" results and the self-assessment groups showed a significant difference depending on the AOT-results, a stronger active-open-minded-thinking (AOT above 5, on a scale from 1 - 6) leads to a stronger tendency of underestimation (ANOVA: F (9/224) = 2.98, p = .0023). The result of the likelihood test (multinominal logistic regression) (AOT $\chi^2(9) = 33.09$, $p < .0001$; result of the other factors: age $\chi^2(9) = 11.41$, $p = .2485$; work experience $\chi^2(9) = 6.28$, $p = .7118$; management experience $\chi^2(9) = 11.95$, $p = .2159$) indicates that it is more likely to underestimate one's own knowledge when you have a high AOT-ratio.

The Promise of Visualizations

The result of experiment 2 showed that a sketched self-explanation (n=40) leads to a significantly *higher* adjustment of the self-rating from T1 to T2 than a written self-explanation (n=38). The pooled t-test for the comparison between the visual and the textual self-explanation showed a p-value of .0324 (mean adjustment: text condition = .49, visual condition= .70). *Managers who visualize their current knowledge are hence more aware of its limitations than those who merely provide a written explanation.*

The contingency analysis for experiment 2 relating the two conditions (text and visual) and the coded groups of self-assessments showed a significant difference ($\chi^2(8, N = 234) = 25.08$, $p = .0015$) of the calibration effect (see Table XX). To analyze whether the visual self-explanation indeed led to a more accurate calibration, we used two categories of calibration: correct calibration (those results which were correct from the beginning and those which were calibrated correctly), and incorrect calibration (all other results, still over- or underestimating one's knowledge). The result of the one-tailed t-test comparing the effect of the visual or textual condition on the correct or incorrect calibration *showed a significant more accurate calibration for those with a visual self-explanation* (t(232)= -1.66, p-value= .0493).

Thus, the visual self-explanation led to a more accurate calibration of knowledge and to a reduction of overestimation compared to the textual one.

	No correc-tion (No C)	Over-estima-tion (OE) corrected	Under-estima-tion (UE) corrected	Over-correc-ted OE	Over-correc-ted UE	OE	UE	Correc-ted but still OE	Correc-ted but still UE	Total
Text	31	30	5	1	1	28	1	17	0	114
Visual	38	42	2	2	1	15	11	7	2	120
Total	69	72	7	3	2	43	12	24	2	234

Table XX: Contingency Analysis Experiment 2

Moderation Effect of Informational Complexity

A deeper analysis and comparison of the results of all three items revealed an interesting insight. The contingency analyses of blockchain and augmented reality, showed no significant difference in the calibration effect between the textual and the visual condition. For the internet of things, it showed a significant difference between the conditions ($\chi^2(7, N = 78) = 35.51, p < .0001$).

By analyzing the interaction of the two conditions (text/visual) and the three items (blockchain, augmented reality, and internet of things) in relation to the outcome of the self-calibration (correct vs. incorrect) we found a significant influence of item ($F(2)=5.95$, $p= .0030$) and the combination item x condition ($F(2)=3.60$, $p= .0289$). *This shows a moderation effect of the item on the visual condition*.

An explanation for this moderation effect is the difference in informational complexity of the three items. Informational complexity is defined by the degree of element interactivity of domain-specific knowledge, the elements that have to be considered simultaneously (Sweller, 2020). Complex knowledge is specified by "the number of [information] chunks and their intensity of interaction" (Sorenson, 2005, p. 84) as in technologies with an open network structure without a clearly defined beginning and an end (versus the elements of sequential, procedural, process-oriented technologies with fewer and less complex interactions). Due to these interactions the replication of complex knowledge is harder (Sorenson, 2005). As a consequence, the transformation of verbal information into pictorial information of knowledge with a higher informational complexity requires more cognitive resources and as a result facilitates the process of an "external quality control" of one's mental model of understanding a certain technology (Leutner, Leopold, & Sumfleth, 2009, p. 285). The items blockchain and augmented reality are both process-oriented technologies that can be explained with sequential and procedural elements. In contrast, internet of things is more an open network structure with many "chunks" and a high intensity of interaction between. Thus,

the higher informational complexity of the item internet of things may impede the visual replication and thus lead to a higher impact of visualization for the calibration.

This means, among other things, that whenever managers are discussing issues with a high informational complexity, they should make a special effort (beyond PowerPoint bullet points) to use interactive, live visualization in their deliberation to avoid an illusion of understanding.

Further Findings

The self-assessment of managers' understanding of digital technologies and the comparison of their knowledge externalized in visual and textual self-explanations with a publicly available averaged reference provided further interesting results (all based on the second experiment):

a) For all three explained technologies the completeness (C) was low (< .33), with an overall mean of C = .24 (blockchain, C = .24; internet of things, C = .31; augmented reality, C = .16) showing a surprisingly modest knowledge of digital technology by our sampled managers.
b) A regression analysis for experiment 1 comparing "completeness" of the self-explanations with the age of the participants showed that *younger managers have significant more knowledge about these technologies* than older ones (ANOVA: $F(1/232) = 9.13$, $p = .0028$).
c) A contingency analysis relating gender and the self-evaluation groups showed a significant distinction between *male and female self-evaluation and re-calibration* ($\chi^2(8, N = 234) = 26.05$, $p = .0010$): *Men tend to keep their overestimation of understanding digital technologies and correct their initial view less than women,* confirming the gender gap in overconfidence (Barber & Odean, 2001; Bengtsson, Persson, & Willenhag, 2005; Buser, Grimalda, Putterman, & van der Weele, 2020) (see Table XXI):

	No correc-tion (No C)	Over-estima-tion (OE) corrected	Under-estima-tion (UE) corrected	Over-correc-ted OE	Over-correc-ted UE	OE	UE	Correc-ted but still OE	Correc-ted but still UE	Total
Female	31	17	0	1	0	5	6	5	1	66
Male	38	55	7	2	2	38	6	19	1	168
Total	69	72	7	3	2	43	12	24	2	234

Table XXI: Contingency Analysis Experiment 2 for Male/Female Overestimation

6.5 Discussion, Conclusion, and Limitations

6.5.1 Discussion

Overall, both experiments have shown the existence of an IOED concerning managers' understanding of emerging digital technologies. The participating managers significantly overestimated their understanding of complex causal patterns, creating a "positive illusion" about their own knowledge. This can lead to flawed decision making in the strategy process.

Thus, the features of explanatory knowledge identified by Rozenblit and Keil mentioned above (such as confusing levels of analysis) seem to be useful predictors for the occurrence of IOED in strategic related topics. Our findings also gives support to the hypothesis by Fisher and Keil that especially intermediary familiar items lead to an IOED; "perhaps items like these are particularly difficult to accurately assess because they are neither familiar, which would lead to frequent recalibration, nor are they totally unfamiliar, which would lead to appropriate caution." (Fisher & Keil, 2016, p. 1265).

How can managers overcome this "positive illusion" which biases strategic decisions in their practice? The results of our studies show that the externalization of knowledge, the visual representation of one's understanding of complex causal patterns in the form of sketches, can help to uncover the IOED and (re-)calibrate this knowledge, even stronger and more accurate calibration than a textual self-explanation.

Generally, the use of external representations (both textual and visual) for mental images supports the reinterpretation and the discovery of omissions of internal representations by an examination (and development) of one's own mental images (Reisberg, 1987, p. 281). "The refinement of patterns" (Anderson & Helstrup, 1993, p. 292), the support of solution-solving by self-explanation (Chi, Bassok, Lewis, Reimann, & Glaser, 1989), "the process of externalization helps to refine and disambiguate ambiguous mental images" (Cox, 1999, p. 353) – to show unknown evidence (Walters, Fernbach, Fox, & Sloman, 2016). Additionally, external representations serve as external memory (Hegarty & Steinhoff, 1997; Reisberg, 1987) or cognitive offloading (Liu & Stasko, 2010).

An explanation for this debiasing and calibration effect of sketches combines three characteristics of self-drawn visualizations: first, the affordances "system topology" and "component behavior" through illustrations (Mayer & Gallini, 1990) – which helps to detect gaps in one's knowledge of complex causal patterns. The advantage of

visualization is that "one discovers in the process of drawing some aspects were simply absent from the image" (Reisberg, 1987, p. 289), that "the weak expressiveness of graphics makes inference more tractable" (Cox, 1999, p. 350), even generates and reinforces inferences (Glenberg & Langston, 1992). The second characteristic is the mental disfluency (Ellis, 2018) provided by the provisionality, fuzziness, vagueness or small degree of perceived finishedness of self-sketched visualizations (Bresciani, Blackwell, & Eppler, 2008; Hundhausen, 2005; Platts, 2001; Swedberg, 2016). The creation of a disfluency promotes metacognitive difficulty and thus leads "to deeper processing of the information and less reliance on heuristic modes of processing. The third characteristic explaining a potential debiasing and calibration effect of sketches is the cost structure of computation: sketching as fast method to produce an external representation of one's own knowledge reduces the "cognitive cost" of calibration (Kirsh, 2010). "Graphical representations such as diagrams limit abstraction and thereby aid processability" (Stenning & Oberlander, 1997, p. 98). This is also supported by research from Larkin and Simon (1987) that in visualizations information is organized by location and needs less computational power to be extracted. These findings contribute to the already mentioned aspects of the higher effectiveness in representing relations (Guri-Rozenblit, 1988) and the improvement of reasoning (Bauer & Johnson-Laird, 1993).

6.5.2 Conclusion

The sequence of experiments on the illusion of explanatory depth and visualization adds another perspective to the use of visualizations in strategizing, complementing the "visual turn" in strategy research: Visualizing one's own technology understanding does not only reveal an illusion of explanatory depth as effectively as a textual externalization, but even calibrates the individual knowledge more accurately than a textual one. Visualization thus supports *debiasing* in strategizing, especially for knowledge with a higher informational complexity (as it is often the case in strategic decisions).

Additionally, our research also shows that recalibrated knowledge leads to lower strategic risk taking. Uncovering one's overestimation of understanding digital technologies with sketches or textual self-explanations does not only facilitate a better calibration of this knowledge, but also reduces the intention to take riskier decisions (in domains that one does not understand well). In this context, however, we have to be aware that overconfidence is ambiguous in decision making and "not bad per se" (Thomas, 2018, p. 119) and can even be beneficial (Busenitz & Barney, 1997; Grichnik,

2008; Koellinger, Minniti, & Schade, 2007; Rose, 2008; Tang, Li, & Yang, 2012) with positive implications. Thus, the application of this finding in strategy practice may depend on the specific situation and decision.

Our further findings section revealed another interesting implication for the current practice of strategizing: it indicated that at times managers' knowledge of emerging digital technologies is quite modest, and that the inclusion of *female and younger managers* combined with *visual* externalization of knowledge may help to have a more accurately calibrated knowledge as a basis for strategic decisions (and thus increase a management team's propensity to seek advice on such technology by experts).

6.5.3 Limitations

The experiments presented in this study face several limitations. First, they focused on the mode variations text/visual. The form of an oral self-explanation was not examined, neither was the effect of disillusioning (revealing overconfidence in knowledge) in groups in contrast to individual disillusioning. Thus, further research could focus on other techniques and tools of disillusioning than the individual visualization of one's knowledge, as could be an in-depth analysis under which conditions visual methods are more or less effective in adjusting an inaccurate anchor or which kind of visualizations support debiasing knowledge illusions best, as "visualization designs affect decisions" (Xiong, Shapiro, Hullman, and Franconeri, 2020, p. 853).

Second, actual in-situ managerial behavior was not analyzed in our research. Experiment 1 focused on the change in *intention*. We acknowledge that this does not measure the actual risk behavior (Reypens & Levine, 2018) as there are often gaps in willingness to pay and actual behavior (Nelson et al., 2012). But to measure a change in intention due to the awareness of one's own limited knowledge, a different mindset before and after the re-calibration of knowledge, serves as the closest proxy to come by in an experiment without actual spending the money and buying real companies. Thus, future research may go one step further and observe how an IOED impacts actual behavior in strategic decision making, as recommended by various scholars (Baumeister, Vohs, & Funder, 2007; Nelson et al., 2012; Reypens & Levine, 2018).

Third, as the original procedure of the IOED experiments showed the difficulty of a "traditional" control group (you cannot check for existing knowledge before the experiment without influencing the results of the self-evaluation), we used the results of the self-explanations compared with an "averaged reference" to control for actual knowledge in both experiments. The choice of this references and their coding is not

perfect, and we thus tried to minimize the influence of these subjective choices by categorizing the results broadly (low, medium, high knowledge, for example) and not use a continuous scale.

Fourth, the impact of an IOED has been measured on a simple investment example based on an individual's choice and not on complex team-based strategic decisions. This lacks the integration of a perspective on variations due to factors like cultural background, group think effects, social desirability bias etc. These issues should be integrated in future research on the phenomenon of an IOED in management.

Nevertheless, the results show that *visualizing what you think you know* is one effective way to improve strategizing that should be further explored in research and practice. In this way, managers who embark on digital strategizing can become, with a little help from visualizations, aware of the limitations of their own knowledge and hence reduce this bias in their strategic decisions.

7. Contributions, Limitations, and Future Research

Following the conceptualization as cognitive biases as both, a consequence, and a driving factor of bounded rationality in strategic decisions, the goal of this dissertation was to develop and answer research questions with the aim to provide new insights for research and practice to detect and mitigate the influence of cognitive biases in strategic decision making. Because of their characteristics such as infrequency, interdependence, and the context of a decision unfriendly environment (VUCA), strategic decisions are especially vulnerable to cognitive biases. Therefore, this dissertation followed the call for new insights to provide tools and techniques that support managers in the recognition and diagnosis of cognitive biases in their decision making and to show ways how to mitigate the influence of these biases in their decision-making practice (Barnes, 1984; Burgelman et al., 2018; Hutzschenreuter & Kleindienst, 2006; Leiblein et al., 2018).

This call resulted in four distinct research questions:

- RQ1: Which classification (or typology) of the identified 150+ cognitive biases supports strategists in the recognition and diagnosis of cognitive biases in strategic decision-making processes?
- RQ2: What are the most prevalent cognitive biases in strategic decision making and do decision styles help to anticipate one's own susceptibility ("bias risk maps") and bias blind spots concerning these biases?
- RQ3: Which interventions support strategists or facilitators of strategic decisions to mitigate or debias the influence of cognitive biases and how can they be structured?
- RQ4: How can visual techniques support decision makers and facilitators in the debiasing of cognitive biases in strategic decision making?

Overall, the research to answer these questions with a variety of applied research methods as shown in the articles above leads to four main theoretical contributions of this dissertation in regard of research on cognitive biases in managerial decisions in general (and strategic decisions in specific). Additionally, the results provide knowledge, tools, and techniques for practitioners to improve one's own decision making.

7.1 Theoretical Contributions

First, this dissertation adds a mapping of (currently) 190 known cognitive biases based on the five phases of strategic decision-making processes and the three motivational backgrounds of cognitive biases. This knowledge map of cognitive biases provides the research community with a typology to structure future research on cognitive biases in strategic decisions. The BIASMAP follows the call for mapping cognitive biases in strategic decision making (Leiblein et al., 2018) to provide more insights about the "when" and why" cognitive biases flaw decisions (Das & Teng, 1999) and support the debiasing of decisions (Bazerman & Moore, 2009).

Second, this research introduces individual decision styles as a valuable lens to analyze the individual susceptibility to cognitive biases and bias blind spots of decision makers. This supports the call for the exploration of individual differences in cognitive biases (Aczel et al., 2015). The insights showed the self-reported fewer susceptibility of rational and spontaneous decision makers for cognitive biases combined with bigger bias blind spots. And it showed that intuitive decision makers have a higher awareness of their own bias susceptibility without showing bigger bias blind spots. This opens new questions concerning the individual phenomenon of bias blind spots: are they really blind spots or are they the results of an accurate self-assessment?

Third, the card-sorting experiment provides a more practice-oriented framework of understanding and communicating debiasing techniques. A framework that helps to unveil gaps in the "theory-practice relationship" of debiasing. And it provides a clustering that gives future research an overview of known debiasing techniques and a different structure to analyze the practical impact of debiasing techniques on managerial decisions. Thus, it addresses the phenomenon that less than 40% of managers are aware of debiasing techniques (Kreilkamp et al., 2021).

And last, experiments show the specific relevance of the illusion of explanatory depth in strategic management and how self-drawn, sketched, visual, explanations can improve one's accuracy of knowledge calibration as a debiasing technique. These results contribute to the research on overconfidence, especially overestimation, and support the call for calibration methods to raise the quality of (managerial) decisions (Koriat, 2012). Additionally, these experiments add to the growing attention for visualizations in the facilitation of strategic decision making (Eppler & Platts, 2009; Hodgkinson et al., 2004; Paroutis & Knight, 2019; Tarakci et al., 2014).

7.2 Practical Contributions

The insights provided by the research endeavors for this dissertation also contribute to the *practice* of strategic decision making and provide strategists and strategy practitioners with knowledge, tools, and techniques to improve the quality of their decision processes.

The mapping of cognitive biases, by using the five generic steps of a strategic decision-making process, helps managers and other strategic decision makers to identify "what can go wrong" during their decision-making processes and allow them to recognize and anticipate these flaws, diagnose them, and take a next step towards a corrective intervention. By knowing and understanding what the problem is, a strategist can start to intervene correctively by using appropriate debiasing methods within the strategic decision-making process.

The ranking and the connection between the individual decision styles and cognitive biases helps practitioners to focus on the "tip of the iceberg" and focus their corrective interventions on the most prevalent and impactful biases. By knowing their own individual decision style, managers can use the "bias risk maps" to analyze their own decision behavior, their potential susceptibility to certain cognitive biases, and the quality of their awareness and consequential bias blind spots.

The more practice-oriented structure of debiasing techniques and the "know how" and where they might work helps managers to better understand what facilitates successful decision-making practices in strategy. This clustering makes it easier for practitioners to connect the debiasing techniques to process steps of decision-making processes in practice and supports the communication of these techniques – and, as a result, may raise the knowledge about and use of debiasing techniques in managerial practice.

And finally, the results of the experiments concerning the illusion of explanatory depth show the need for a certain humility of managers concerning their knowledge of strategy-relevant digital technologies and that the technique of self-drawn, sketched, visual, explanations might help to overcome the individual overestimation of that knowledge and lead to a better calibration of relevant knowledge for strategic decisions.

7.3 Limitations and Future Research

Due to the different motivational reasons of cognitive biases and the individual cognitive background of decision makers, the research endeavors of this dissertation face several limitations.

The typology with its 15 “ideal types” of cognitive biases and the theoretical placement is based on the current status of research on the classified 190 cognitive biases, their prevalence, their motivational and cognitive background, and external factors mitigating or intensifying their influence. As more research on these cognitive biases will provide more insights and details, the theoretical placement or even the 15 “ideal types” will be up for future amends, rearrangements and changes and the typology will become more accurate over time.

As cognitive biases are hard to observe in “real life” – their existence is mostly proved by experiments – due to the challenge of isolating the influence of cognitive biases from other influence factors of decisions (personal background, experience, state of mood etc.), the prevalence and susceptibility is based on self-reports and self-assessment of one’s own decision behavior. Future research can take this into account by linking self-awareness, real behavior, the influence of isolated cognitive biases and combining different research approaches to deal with these challenges and provide more insights about the individual vulnerability to cognitive biases.

The same issue is a limitation for research on debiasing. As in practice often several debiasing techniques are (more or less thoroughly) applied by many different personalities and their cognitive background, it is hard to isolate single decisive factors. Future research may connect the results of this dissertation with a more individualistic approach on how debiasing works for different cognitive biases (or sets/groups of related cognitive biases).

Generally, a stronger individual approach, linking actual in-situ decision-making behavior of managers or groups of managers with the influence of one or more cognitive biases, potential debiasing and calibration techniques would provide more and deeper knowledge about the real influence of the phenomenon of cognitive biases on managerial decisions.

The theoretical and practical contributions of this dissertation provided additional knowledge for these future research endeavors to further explore the role of cognitive biases in strategic management decisions and how to debias them and mitigate their influence on such decisions.

References

Acciarini, C., Brunetta, F., & Boccardelli, P. (2020). Cognitive biases and decision-making strategies in times of change: a systematic literature review. *Management Decision*, *59*(3), 638–652. https://doi.org/10.1108/MD-07-2019-1006

Aczel, B., Bago, B., Szollosi, A., Foldes, A., & Lukacs, B. (2015). Measuring individual differences in decision biases: Methodological considerations. *Frontiers in Psychology*, *6*, 1770. https://doi.org/10.3389/fpsyg.2015.01770

Adame, B. J. (2016). Training in the mitigation of anchoring bias: A test of the consider-the-opposite strategy. *Learning and Motivation*, *53*, 36–48. https://doi.org/10.1016/j.lmot.2015.11.002

Adams, G. S., Converse, B. A., Hales, A. H., & Klotz, L. E. (2021). People systematically overlook subtractive changes. *Nature*, *592*(7853), 258–261. https://doi.org/10.1038/s41586-021-03380-y

Aggarwal, C., & Reddy, C. (2014). *Data clustering: Algorithms and applications*. (C. Aggarwal & C. Reddy, Eds.). New York: Chapman and Hall/CRC. https://doi.org/10.1201/9781315373515

Ahmad, F. (2020). Personality traits as predictor of cognitive biases: moderating role of risk-attitude. *Qualitative Research in Financial Markets*, *12*(4), 465–484. https://doi.org/10.1108/QRFM-10-2019-0123

Alba, J. W., & Hutchinson, J. W. (2000). Knowledge calibration: What consumers know and what they think they know. *Journal of Consumer Research*, *27*(2), 123–156. https://doi.org/10.1086/314317

Allison, S. T., & Messick, D. M. (1985). The group attribution error. *Journal of Experimental Social Psychology*, *21*(6), 563–579. https://doi.org/10.1016/0022-1031(85)90025-3

Alloy, L. B., Albright, J. S., & Clements, C. M. (1987). Depression, nondepression, and social comparison biases. In J. E. Maddux, C. D. Stoltenberg, & R. Rosenwein (Eds.), *Social processes in clinical and counseling psychology* (pp. 94–112). New York: Springer. https://doi.org/10.1007/978-1-4613-8728-2_8

Alter, A. L., Oppenheimer, D. M., Epley, N., & Eyre, R. N. (2007). Overcoming intuition: Metacognitive difficulty activates analytic reasoning. *Journal of Experimental Psychology*, *136*(4), 569–576. https://doi.org/10.1037/0096-3445.136.4.569

Alter, A. L., Oppenheimer, D. M., & Zemla, J. C. (2010). Missing the trees for the forest: a construal level account of the illusion of explanatory depth. *Journal of Personality and Social Psychology*, *99*(3), 436–451. https://doi.org/10.1037/a0020218

Anderson, C. R., & Paine, F. T. (1975). Managerial perceptions and strategic behavior. *Academy of Management Journal*, *18*(4), 811–823. https://doi.org/10.2307/255380

Anderson, J. R., & Paulson, R. (1977). Representation and retention of verbatim information. *Journal of Verbal Learning and Verbal Behavior*, *16*(4), 439–451. https://doi.org/10.1016/S0022-5371(77)80038-8

Anderson, P. (1999). Complexity theory and organization science. *Organization Science*, *10*(3), 216–232. https://doi.org/10.1287/orsc.10.3.216

Anderson, R. E., & Helstrup, T. (1993). Visual discovery in mind and on paper. *Memory & Cognition*, *21*(3), 283–293. https://doi.org/10.3758/BF03208261

Andrews, K. R. (1971). *The concept of corporate strategy*. Homewood: Dow Jones-Irwin.

Ansoff, H. I. (1965). *Corporate strategy*. New York: McGraw-Hill.

Antons, D., & Piller, F. T. (2015). Opening the black box of "not invented here": Attitudes, decision biases, and behavioral consequences. *Academy of Management Perspectives*, *29*(2), 193–217. https://doi.org/10.5465/amp.2013.0091

Arkes, H. R. (1991). Costs and benefits of judgment errors: Implications for debiasing. *Psychological Bulletin*, *110*(3), 486–498. https://doi.org/10.1037/0033-2909.110.3.486

Arkes, H. R. (2001). Overconfidence in judgmental forecasting. In J.S. Armstrong (Ed.), *Principles of forecasting. international series in operations research and Mmnagement science* (pp. 495–515). Boston, MA: Springer.

Arkes, H. R., & Blumer, C. (1985). The psychology of sunk cost. *Organizational Behavior and Human Decision Processes*, *35*(1), 124–140. https://doi.org/10.1016/0749-5978(85)90049-4

Armstrong, J. Scott. (1982). The value of formal planning for strategic decisions: A comment. *Strategic Management Journal*, *3*(3), 197–211. https://doi.org/10.1002/smj.4250070206

Arnott, D. (2006). Cognitive biases and decision support systems development: a design science approach. *Information Systems Journal*, *16*(1), 55–78. https://doi.org/10.1111/j.1365-2575.2006.00208.x

Artinger, F., Petersen, M., Gigerenzer, G., & Weibler, J. (2015). Heuristics as adaptive decision strategies in management. *Journal of Organizational Behavior*, *36*(S1), S33–S52. https://doi.org/10.1002/job.1950

Ashton, R. H., & Kennedy, J. (2002). Eliminating recency with self-review: the case of auditors' 'going concern' judgments. *Journal of Behavioral Decision Making*, *15*(3), 221–231. https://doi.org/10.1002/bdm.412

Astley, W. G., Axelsson, R., Butler, R. J., Hickson, D. J., & Wilson, D. C. (1982). Complexity and cleavage: Dual explanations of strategic decision-making. *Journal of Management Studies*, *19*(4), 357–375. https://doi.org/10.1111/j.1467-6486.1982.tb00114.x

Attneave, F. (1953). Psychological probability as a function of experienced frequency. *Journal of Experimental Psychology*, *46*(2), 81–86. https://doi.org/10.1037/h0057955

Avichai, Y. (1979). Equity in politics: Name placement on ballots. *Law & Social Inquiry*, *4*(1), 141–178. https://doi.org/10.1111/j.1747-4469.1979.tb00852.x

Axelsson, R., & Rosenberg, L. (1979). Decision-making and organizational turbulence. *Acta Sociologica*, *22*(1), 45–62. https://doi.org/10.1177/000169937902200104

Babcock, L., Loewenstein, G., & Issacharoff, S. (1997). Creating convergence: Debiasing biased litigants. *Law & Social Inquiry*, *22*(4), 913–925. https://doi.org/10.1111/j.1747-4469.1997.tb01092.x

Bagus, P., Peña-Ramos, J. A., & Sánchez-Bayón, A. (2021). COVID-19 and the political economy of mass hysteria. *International Journal of Environmental Research and Public Health*, *18*(4), 1376. https://doi.org/10.3390/ijerph18041376

Baker, D. F. (2010). Enhancing group decision making: An exercise to reduce shared information bias. *Journal of Management Education*, *34*(2), 249–279. https://doi.org/10.1177/1052562909343553

Bansal, T. (2020). Behavioral finance and COVID-19: Cognitive errors that determine the financial future. *SSRN*, accessed 3.3.2021. https://doi.org/10.2139/ssrn.3595749

Bar-Hillel, M. (1974). Similarity and probability. *Organizational Behavior and Human Performance*, *11*(2), 277–282. https://doi.org/10.1016/0030-5073(74)90020-8

Bar-Hillel, M. (1982). Studies of representativeness. In D. Kahneman, P. Slovic, & A. Tversky (Eds.), *Judgment under uncertainty* (pp. 69–83). Cambridge: Cambridge University Press. https://doi.org/10.1017/cbo9780511809477.006

Barber, B. M., & Odean, T. (2001). Boys will be boys: Gender, overconfidence, and common stock investment. *The Quarterly Journal of Economics*, *116*(1), 261–292. https://doi.org/10.2139/ssrn.139415

Barbey, A. K., & Sloman, S. A. (2007). Base-rate respect: From ecological rationality to dual processes. *Behavioral and Brain Sciences*, *30*(3), 241–297. https://doi.org/10.1017/S0140525X07001653

Barnes, J. H. (1984). Cognitive biases and their impact on strategic planning. *Strategic Management Journal*, *5*(2), 129–137. https://doi.org/10.1002/smj.4250050204

Baron, J. (2000). *Thinking and deciding*. Cambridge: Cambridge University Press.

Baron, J. (2003). Value analysis of political behavior. self-interested: moralistic:: altruistic: moral. *University of Pennsylvania Law Review*, *151*(3), 1135–1167. https://doi.org/10.2307/3312887

Baron, J., Beattie, J., & Hershey, J. C. (1988). Heuristics and biases in diagnostic reasoning. II. Congruence, information, and certainty. *Organizational Behavior and Human Decision Processes*, *42*(1), 88–110. https://doi.org/10.1016/0749-5978(88)90021-0

Baron, J., Gowda, R., & Kunreuther, H. (1993). Attitudes toward managing hazardous waste: What should be cleaned up and who should pay for it? *Risk Analysis*, *13*(2), 183–192. https://doi.org/10.1111/j.1539-6924.1993.tb01068.x

Baron, J., & Hershey, J. C. (1988). Outcome bias in decision evaluation. *Journal of Personality and Social Psychology*, *54*(4), 569–579. https://doi.org/10.1037/0022-3514.54.4.569

Barr, P. S., Stimpert, J. L., Huff, A. S., Wiley, J., & Barr, S. (1992). Cognitive change, strategic action, and organizational renewal. *Strategic Management Journal*, *13*(S1), 15–36. https://doi.org/10.1002/smj.4250131004

Bateman, T. S., & Zeithaml, C. P. (1989). The psychological context of strategic decision: A model and convergent experimental findings. *Strategic Management Journal*, *10*(1), 59–74. https://doi.org/10.1002/smj.4250100106

Bauer, M. I., & Johnson-Laird, P. N. (1993). How diagrams can improve reasoning. *Psychological Science*, *4*(6), 372–378. https://doi.org/10.1111/j.1467-9280.1993.tb00584.x

Baumeister, R. F., Vohs, K. D., & Funder, D. C. (2007). Psychology as the science of self-reports and finger movements: Whatever happened to actual behavior? *Perspectives on Psychological Science*, *2*(4), 396–403. https://doi.org/10.1111/j.1745-6916.2007.00051.x

Bazerman, M. H., & Moore, D. A. (2009). *Judgment in managerial decision making*. Hoboken: Wiley.

Becker, S. W., Ronen, J., & Sorter, G. H. (1974). Opportunity costs - an experimental approach. *Journal of Accounting Research*, *12*(2), 317–329. https://doi.org/10.2307/2490379

Belli, R. F. (1989). Influences of misleading postevent information: Misinformation interference and acceptance. *Journal of Experimental Psychology*, *118*(1), 72–85. https://doi.org/10.1037/0096-3445.118.1.72

Bengtsson, C., Persson, M., & Willenhag, P. (2005). Gender and overconfidence. *Economics Letters*, *86*(2), 199–203. https://doi.org/https://doi.org/10.1016/j.econlet.2004.07.012

Bennett, N., & Lemoine, G. J. (2014). What a difference a word makes: Understanding threats to performance in a VUCA world. *Business Horizons*, *57*(3), 311–317. https://doi.org/10.2139/ssrn.2406676

Berenbaum, M. R. (2021). On COVID-19, cognitive bias, and open access. *Proceedings of the National Academy of Sciences*, *118*(2), e2026319118. https://doi.org/10.1073/pnas.2026319118

Bergers, D. (2021). Individual differences in the susceptibility of biases relevant in price management: a state-of-the-art article. *Journal of Revenue and Pricing Management*. https://doi.org/10.1057/s41272-020-00270-2

Berghaus, S., & Back, A. (2016). Stages in digital business transformation: Results of an empirical maturity study. In *MCIS Proceedings 2016* (pp. 22–38).

Berkowitz, L. (1960). The judgmental process in personality functioning. *Psychological Review*, *67*(2), 130–142. https://doi.org/10.1037/h0048565

Berthet, V. (2021). The measurement of individual differences in cognitive biases: A review and improvement. *Frontiers in Psychology*, *12*, 630177. https://doi.org/10.3389/fpsyg.2021.630177

Berthet, V. (2022). The impact of cognitive biases on professionals' decision-making: A review of four occupational areas. *Frontiers in Psychology*, *12*, 802439. https://doi.org/10.3389/fpsyg.2021.802439

Bhandari, G., Hassanein, K., & Deaves, R. (2008). Debiasing investors with decision support systems: An experimental investigation. *Decision Support Systems*, *46*(1), 399–410. https://doi.org/https://doi.org/10.1016/j.dss.2008.07.010

Bhandaria, G., & Hassanein, K. (2012). An agent-based debiasing framework for investment decision-support systems. *Behaviour & Information Technology*, *31*(5), 495–507. https://doi.org/10.1080/0144929X.2010.499477

Bhargava, S., & Fisman, R. (2014). Contrast effects in sequential decision: Evidence from speed dating. *Review of Economics & Statistics*, *96*(3), 444–457. https://doi.org/10.1162/REST_a_00416

Białek, M., & Sawicki, P. (2014). Can taking the perspective of an expert debias human decisions? The case of risky and delayed gains. *Frontiers in Psychology*, *5*, 989. https://doi.org/10.3389/fpsyg.2014.00989

Billig, M. (1973). Normative communication in a minimal intergroup situation. *European Journal of Social Psychology*, *3*(3), 339–343. https://doi.org/10.1002/ejsp.2420030312

Bingham, C. B., & Eisenhardt, K. M. (2011). Rational heuristics: the 'simple rules' that strategists learn from process experience. *Strategic Management Journal*, *32*(13), 1437–1464. https://doi.org/10.1002/smj.965

Bingham, C. B., & Eisenhardt, K. M. (2014). Response to Vuori and Vuori's commentary on "Heuristics in the strategy context." *Strategic Management Journal*, *35*(11), 1698–1702. https://doi.org/10.1002/smj.2257

Birch, S. A. J., Brosseau-Liard, P. E., Haddock, T., & Ghrear, S. E. (2017). A 'curse of knowledge' in the absence of knowledge? People misattribute fluency when judging how common knowledge is among their peers. *Cognition*, *166*, 447–458. https://doi.org/10.1016/j.cognition.2017.04.015

Blackwell, D., & Hodges, J. L. (1957). Design for the control of selection bias. *The Annals of Mathematical Statistics*, *28*(2), 449–460. https://doi.org/10.1214/aoms/1177706973

Blanco, F. (2017). Cognitive bias. In J. Vonk & T. Shackelford (Eds.), *Encyclopedia of animal cognition and behavior* (pp. 1–7). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-47829-6_1244-1

Blankenship, A. B. (1940). The case for and against the public opinion poll. *Journal of Marketing*, *5*(2), 110–113. https://doi.org/10.2307/1245435

Blumenthal-Barby, J. S. (2016). Biases and heuristics in decision making and their impact on autonomy. *American Journal of Bioethics*, *16*(5), 5–15. https://doi.org/10.1080/15265161.2016.1159750

Bondurant, B., & Donat, P. L. N. (1999). Perceptions of women's sexual interest and acquaintance rape: The role of sexual overperception and affective attitudes. *Psychology of Women Quarterly*, *23*(4), 691–705. https://doi.org/10.1111/j.1471-6402.1999.tb00392.x

Booth, J. W., Taborda, E. A., Ramani, K., & Reid, T. (2016). Interventions for teaching sketching skills and reducing inhibition for novice engineering designers. *Design Studies*, *43*, 1–23. https://doi.org/https://doi.org/10.1016/j.destud.2015.11.002

Bowker, G. C., & Star, S. L. (1999). *Sorting things out. Classification and its consequences*. Cambridge: MIT Press.

Brabazon, T. (2006). The Google effect: Googling, blogging, wikis and the flattening of expertise. *LIBRI*, *56*(3), 157–167. https://doi.org/10.1515/LIBR.2006.157

Brehm, J. W. (1966). *A theory of psychological reactance*. Oxford: Academic Press.

Brehm, S. S. (1981). Psychological reactance and the attractiveness of unobtainable objects: Sex differences in children's responses to an elimination of freedom. *Sex Roles*, *7*(9), 937–949. https://doi.org/10.1007/BF00290976

Brenner, M. (1973). The next-in-line effect. *Journal of Verbal Learning and Verbal Behavior*, *12*, 320–323. https://doi.org/10.1016/S0022-5371(73)80076-3

Bresciani, S., Blackwell, A. F., & Eppler, M. J. (2008). A collaborative dimensions framework: Understanding the mediating role of conceptual visualizations in collaborative knowledge work. In *Proceedings of the 41st Annual Hawaii International Conference on System Sciences (HICSS 2008)* (pp. 364–364). Waikoloa.

Bresciani, S., & Eppler, M. J. (2018). The collaborative dimensions of argument maps: A socio-visual approach. *Semiotica*, (220), 199–216. https://doi.org/doi.org/10.1515/sem-2015-0140

Brigham, J. C., & Malpass, R. S. (1985). The role of experience and contact in the recognition of faces of own- and other-race persons. *Journal of Social Issues*, *41*(3), 139–155. https://doi.org/10.1111/j.1540-4560.1985.tb01133.x

Brockmann, E. N., & Anthony, W. P. (2002). Tacit knowledge and strategic decision making. *Group and Organization Management*, *27*(4), 436–455. https://doi.org/10.1177/1059601102238356

Brooks, B., Curnin, S., Owen, C., & Bearman, C. (2020). Managing cognitive biases during disaster response: the development of an aide memoire. *Cognition, Technology & Work*, *22*(2), 249–261. https://doi.org/10.1007/s10111-019-00564-5

Brown, A. S. (1991). A review of the tip-of-the-tongue experience. *Psychological Bulletin*, *109*(2), 204–223. https://doi.org/10.1037/0033-2909.109.2.204

Brown, A. S., & Murphy, D. R. (1989). Cryptomnesia: Delineating inadvertent plagiarism. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *15*(3), 432–442. https://doi.org/10.1037/0278-7393.15.3.432

Brown, R., & McNeill, D. (1966). The "tip of the tongue" phenomenon. *Journal of Verbal Learning and Verbal Behavior*, *5*(4), 325–337. https://doi.org/10.1016/S0022-5371(66)80040-3

Brown, S. R. (1996). Q methodology and qualitative research. *Qualitative Health Research*, *6*(4), 561–567. https://doi.org/10.1177/104973239600600408

Bruine de Bruin, W., Parker, A. M., & Fischhoff, B. (2007). Individual differences in adult decision-making competence. *Journal of Personality and Social Psychology*, *92*(5), 938–956. https://doi.org/10.1037/0022-3514.92.5.938

Bruine de Bruin, W., Parker, A. M., & Fischhoff, B. (2020). Decision-making competence: More than intelligence? *Current Directions in Psychological Science*, *29*(2), 186–192. https://doi.org/10.1177/0963721420901592

Brundin, E., & Liu, F. (2015). The role of emotions in strategizing. In D. Golsorkhi, D. Seidl, E. Vaara, & L. Rouleau (Eds.), *Cambridge handbook of strategy as practice* (2nd ed., pp. 632–646). Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9781139681032.037

Buehler, R., Griffin, D., & Peetz, J. (2010). The planning fallacy. Cognitive, motivational, and social origins. *Advances in Experimental Social Psychology*, *43*, 1–62. https://doi.org/10.1016/S0065-2601(10)43001-4

Burgelman, R., Floyd, S., Laamanen, T., Mantere, S., Vaara, E., & Whittington, R. (2018). Strategy processes and practices: dialogues and intersections. *Strategic Management Journal*, *39*, 531–558. https://doi.org/10.1002/smj.2741

Burke, L. A., & Miller, M. K. (1999). Taking the mystery out of intuitive decision making. *Academy of Management Executive*, *13*(4), 91–99. https://doi.org/10.5465/AME.1999.2570557

Busenitz, L. W., & Barney, J. B. (1997). Differences between entrepreneurs and managers in large organizations: Biases and heuristics in strategic decision-making. *Journal of Business Venturing*, *12*(1), 9–30.

Buser, T., Grimalda, G., Putterman, L., & van der Weele, J. (2020). Overconfidence and gender gaps in redistributive preferences: Cross-Country experimental evidence. *Journal of Economic Behavior & Organization*, *178*, 267–286. https://doi.org/https://doi.org/10.1016/j.jebo.2020.07.005

Camba, J. D., Kimbrough, M., & Kwon, E. (2018). Conceptual product design in digital and traditional sketching environments: A comparative exploratory study. *Journal of Design Research*, *16*(2), 131–154. https://doi.org/10.1504/JDR.2018.092810

Camerer, C., Loewenstein, G., & Weber, M. (1989). The curse of knowledge in economic settings: An experimental analysis. *Journal of Political Economy*, *97*(5), 1232–1254. https://doi.org/10.1086/261651

Camerer, C., & Lovallo, D. (1999). Overconfidence and excess entry: an experimental approach. *The American Economic Review*, *89*(1), 306–318. https://doi.org/10.1257/aer.89.1.306

Campbell, W. K., & Sedikides, C. (1999). Self-threat magnifies the self-serving bias: A meta-analytic integration. *Review of General Psychology*, *3*(1), 23–43. https://doi.org/10.1037/1089-2680.3.1.23

Caputo, A. (2014). Relevant information, personality traits and anchoring effect. *International Journal of Management and Decision Making*, *13*(1), 62–76. https://doi.org/10.1504/IJMDM.2014.058470

Carter, C. R., Kaufmann, L., & Michel, A. (2007). Behavioral supply management: A taxonomy of judgment and decision-making biases. *International Journal of Physical Distribution and Logistics Management*, *37*(8), 631–669. https://doi.org/10.1108/09600030710825694

Cary, M., & Reder, L. M. (2003). A dual-process account of the list-length and strength-based mirror effects in recognition. *Journal of Memory and Language*, *49*(2), 231–248. https://doi.org/10.1016/S0749-596X(03)00061-5

Ceschi, A., Costantini, A., Sartori, R., Weller, J., & Di Fabio, A. (2019). Dimensions of decision-making: An evidence-based classification of heuristics and biases. *Personality and Individual Differences*, *146*, 188–200. https://doi.org/10.1016/j.paid.2018.07.033

Chapman, D. W., & Volkmann, J. (1939). A social determinant of the level of aspiration. *The Journal of Abnormal and Social Psychology*, *34*(2), 225–238. https://doi.org/10.1037/h0057115

Chapman, L. J. (1967). Illusory correlation in observational report. *Journal of Verbal Learning and Verbal Behavior*, *6*(1), 151–155. https://doi.org/10.1016/S0022-5371(67)80066-5

Chapman, L. J., & Chapman, J. P. (1969). Illusory correlation as an obstacle to the use of valid psychodiagnostic signs. *Journal of Abnormal Psychology*, *74*(3), 271–280. https://doi.org/10.1037/h0027592

Chi, M. T. H., Bassok, M., Lewis, M. W., Reimann, P., & Glaser, R. (1989). Self-explanations: How students study and use examples in learning to solve problems. *Cognitive Science*, *13*(2), 145–182. https://doi.org/10.1016/0364-0213(89)90002-5

Chng, D. H. M., & Wang, J. C. Y. (2016). An experimental study of the interaction effects of incentive compensation, career ambition, and task attention on Chinese managers' strategic risk behaviors. *Journal of Organizational Behavior*, *37*(5), 719–737. https://doi.org/10.1002/job.2062

Choi, J., Hecht, G. W., & Tayler, W. B. (2012). Lost in translation: The effects of incentive compensation on strategy surrogation. *The Accounting Review*, *87*(4), 1135–1163. https://doi.org/10.2308/accr-10273

Choi, J., Hecht, G. W., & Tayler, W. B. (2013). Strategy selection, surrogation, and strategic performance measurement systems. *Journal of Accounting Research*, *51*(1), 105–133. https://doi.org/10.1111/j.1475-679X.2012.00465.x

Choo, H., & Franconeri, S. L. (2014). Enumeration of small collections violates Weber's law. *Psychonomic Bulletin and Review*, *21*(1), 93–99. https://doi.org/10.3758/s13423-013-0474-4

Citroen, C. L. (2011). The role of information in strategic decision-making. *International Journal of Information Management*, *31*(6), 493–501. https://doi.org/https://doi.org/10.1016/j.ijinfomgt.2011.02.005

Coley, J. D., Arenson, M., Xu, Y., & Tanner, K. D. (2017). Intuitive biological thought: Developmental changes and effects of biology education in late adolescence. *Cognitive Psychology*, *92*, 1–21. https://doi.org/10.1016/J.COGPSYCH.2016.11.001

Correll, J., Park, B., Judd, C. M., & Wittenbrink, B. (2002). The police officer's dilemma: Using ethnicity to disambiguate potentially threatening individuals. *Journal of Personality and Social Psychology*, *83*(6), 1314–1329. https://doi.org/10.1037/0022-3514.83.6.1314

Cosier, R. A. (1978). The effects of three potential aids for making strategic decisions on prediction accuracy. *Organizational Behavior and Human Performance*, *22*(2), 295–306. https://doi.org/10.1016/0030-5073(78)90018-1

Costa Filho, G. B., Moura, A. S., Brandão, P. R., Schmidt, H. G., & Mamede, S. (2019). Effects of deliberate reflection on diagnostic accuracy, confidence and diagnostic calibration in dermatology. *Perspectives on Medical Education*, *8*(4), 230–236. https://doi.org/10.1007/s40037-019-0522-5

Coupey, E. (1994). Restructuring: Constructive processing of information displays in consumer choice. *Journal of Consumer Research*, *21*(1), 83–99. https://doi.org/10.1086/209384

Cox, R. (1999). Representation construction, externalised cognition and individual differences. *Learning and Instruction*, *9*(4), 343–363. https://doi.org/10.1016/S0959-4752(98)00051-6

Coxon, A. P. M. (1999). *Sorting data: Collection and analysis.* Thousand Oaks: Sage.

Craik, F. I., & Tulving, E. (1975). Depth of processing and the retention of words in episodic memory. *Journal of Experimental Psychology*, *104*(3), 268–294. https://doi.org/10.1037/0096-3445.104.3.268

Croskerry, P., Singhal, G., & Mamede, S. (2013). Cognitive debiasing 2: impediments to and strategies for change. *BMJ Quality & Safety*, *22*, ii65–ii72. https://doi.org/10.1136/bmjqs-2012-001713

Crutcher, R. J., & Healy, A. F. (1989). Cognitive operations and the generation effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *15*(4), 669–675. https://doi.org/10.1037/0278-7393.15.4.669

Curşeu, P. L., & Schruijer, S. G. L. (2012). Decision styles and rationality: An analysis of the predictive validity of the general decision-making style inventory. *Educational and Psychological Measurement*, *72*(6), 1053–1062. https://doi.org/10.1177/0013164412448066

Cushman, F. (2008). Crime and punishment: Distinguishing the roles of causal and intentional analyses in moral judgment. *Cognition*, *108*(2), 353–380. https://doi.org/10.1016/j.cognition.2008.03.006

Cyert, R. M., & March, J. G. (1963). *A behavioral theory of the firm*. Englewood Cliffs: Prentice-Hall.

Czerwonka, M. (2017). Anchoring and overconfidence: The influence of culture and cognitive abilities. *International Journal of Management and Economics*, *53*(3), 48–66. https://doi.org/10.1515/ijme-2017-0018

Das, T. K., & Teng, B. S. (1999). Cognitive biases and strategic decision processes: an integrative perspective. *Journal of Management Studies*, *36*(6), 757–778. https://doi.org/10.1111/1467-6486.00157

Davison, W. P. (1983). The third-person effect in communication. *The Public Opinion Quarterly*, *47*(1), 1–15. https://doi.org/10.1086/268763

De Leeuw, E., & Berzelak, N. (2016). Survey mode or survey modes. In C. Wolf, D. Joye, T. W. Smith, & Y. Fu (Eds.), *The SAGE handbook of survey methodology* (pp. 142–156). Thousand Oaks: Sage Publications Ltd. https://doi.org/10.4135/9781473957893.n11

Dean, J. W., & Sharfman, M. P. (1993). Procedural rationality in the strategic decision-making process. *Journal of Management Studies*, *30*(4), 587–610. https://doi.org/10.1111/j.1467-6486.1993.tb00317.x

Dewberry, C., Juanchich, M., & Narendran, S. (2013). Decision-making competence in everyday life: The roles of general cognitive styles, decision-making styles and personality. *Personality and Individual Differences*, *55*(7), 783–788. https://doi.org/https://doi.org/10.1016/j.paid.2013.06.012

Dijkman, R., Dumas, M., van Dongen, B., Käärik, R., & Mendling, J. (2011). Similarity of business process models: Metrics and evaluation. *Information Systems*, *36*(2), 498–516. https://doi.org/10.1016/j.is.2010.09.006

Dimara, E., Bailly, G., Bezerianos, A., & Franconeri, S. (2019). Mitigating the attraction effect with visualizations. *IEEE Transactions on Visualization and Computer Graphics*, *25*(1), 850–860. https://doi.org/10.1109/TVCG.2018.2865233

Dimara, E., Franconeri, S., Plaisant, C., Bezerianos, A., & Dragicevic, P. (2020). A task-based taxonomy of cognitive biases for information visualization. *IEEE Transactions on Visualization and Computer Graphics*, *26*(2), 1413–1432. https://doi.org/10.1109/TVCG.2018.2872577

DiMaria, C. N., Lee, B., Fischer, R., & Eiger, G. (2020). Cognitive bias in the COVID-19 pandemic. *Cureus*, *12*(7), e9019–e9019. https://doi.org/10.7759/cureus.9019

Dinar, M., Summers, J. D., Shah, J., & Park, Y.-S. (2016). Evaluation of empirical design studies and metrics. In P. Cash, T. Stankovic, & M. Storga (Eds.), *Experimental design research: Approaches, perspectives, applications* (pp. 13–40). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-33781-4_2

Dmitracova, O. (2020). What companies can learn from behavioural psychology. *The Independent*.

Dodge, K. A., & Coie, J. D. (1987). Social-information-processing factors in reactive and proactive aggression in children's peer groups. *Journal of Personality and Social Psychology*, *53*(6), 1146–1158. https://doi.org/10.1037/0022-3514.53.6.1146

Doty, D. H., & Glick, W. H. (1994). Typologies as a unique form of theory buildings: Toward improved understanding and modeling. *Academy of Management Review*, *19*(2), 230–251. https://doi.org/10.2307/258704

Duncan, R. B. (1972). Characteristics of organizational environments and perceived environmental uncertainty. *Administrative Science Quarterly*, *17*(3), 313–327. https://doi.org/10.2307/2392145

Duncker, K. (1945). On problem-solving. *Psychological Monographs*, *58*(5), i–113. https://doi.org/10.1037/h0093599

Dunning, D., Heath, C., & Suls, J. M. (2004). Flawed self-assessment: Implications for health, education, and the workplace. *Psychological Science in the Public Interest*, *5*(3), 69–106. https://doi.org/10.1111/j.1529-1006.2004.00018.x

Dunning, D., Meyerowitz, J. A., & Holzberg, A. D. (1989). Ambiguity and self-evaluation: The role of idiosyncratic trait definitions in self-serving assessments of ability. *Journal of Personality and Social Psychology*, *57*(6), 1082–1090. https://doi.org/10.1037/0022-3514.57.6.1082

Durand, R. B., Fung, L., & Limkriangkrai, M. (2019). Myopic loss aversion, personality, and gender. *Journal of Behavioral Finance*, *20*(3), 339–353. https://doi.org/10.1080/15427560.2018.1511562

Eagly, A. H., & Mladinic, A. (1994). Are people prejudiced against women? Some answers from research on attitudes, gender stereotypes, and judgments of competence. *European Review of Social Psychology*, *5*(1), 1–35. https://doi.org/10.1080/14792779543000002

Edwards, A. L. (1957). *The social desirability variable in personality assessment and research*. Ft Worth: Dryden Press.

Efferson, C., Lalive, R., & Fehr, E. (2008). The coevolution of cultural groups and ingroup favoritism. *Science*, *321*(5897), 1844–1849. https://doi.org/10.1126/science.1155805

Ehrlinger, J., Gilovich, T., & Ross, L. (2005). Peering into the bias blind spot: People's assessments of bias in themselves and others. *Personality and Social Psychology Bulletin*, *31*(5), 680–692. https://doi.org/10.1177/0146167204271570

Einhorn, H. J., & Hogarth, R. M. (1981). Behavioral decision theory: Processes of judgment and choice. *Journal of Accounting Research*, *19*(1), 1–31. https://doi.org/10.2307/2490959

Eisenhardt, K. M. (1989). Making fast strategic decisions in high-velocity environments. *Academy of Management Journal*, *32*(3), 543–576. https://doi.org/10.2307/256434

Eisenhardt, K. M., & Zbaracki, M. J. (1992). Strategic decision making. *Strategic Management Journal*, *13*, 17–37. https://doi.org/10.1002/smj.4250130904

Elbanna, S. (2006). Strategic decision-making: Process perspectives. *International Journal of Management Reviews*, *8*(1), 1–20. https://doi.org/10.1111/j.1468-2370.2006.00118.x

Elbanna, S., Thanos, I. C., & Jansen, R. J. G. (2020). A literature review of the strategic decision-making context: A synthesis of previous mixed findings and an agenda for the way forward. *M@n@gement*, *23*(2), 42–60. https://doi.org/10.37725/mgmt.v23i2.4621

Elenkov, D. (1997). Strategic uncertainty and environmental scanning: The case for institutional influences on scanning behavior. *Strategic Management Journal*, *18*(4), 287–302. https://doi.org/10.1002/(SICI)1097-0266(199704)18:4<287::AID-SMJ865>3.0.CO;2-B

Ellis, G. (2018). *Cognitive biases in visualizations*. Cham: Springer International Publishing.

Epley, N., & Gilovich, T. (2005). When effortful thinking influences judgmental anchoring: differential effects of forewarning and incentives on self-generated and externally provided anchors. *Journal of Behavioral Decision Making*, *18*(3), 199–212. https://doi.org/10.1002/bdm.495

Eppler, M. J. (2011). What is an effective knowledge visualization? Insights from a review of seminal concepts. In *2011 15th International Conference on Information Visualisation* (pp. 349–354). https://doi.org/10.1109/IV.2011.13

Eppler, M. J., & Burkhard, R. A. (2007). Visual representations in knowledge management: framework and cases. *Journal of Knowledge Management*, *11*(4), 112–122. https://doi.org/10.1108/13673270710762756

Eppler, M. J., & Muntwiler, C. (2021). BIASMAP – developing a visual typology and interface to explore and understand decision-making errors in management. In T. Ahram, R. Taiar, & F. Groff (Eds.), *Human Interaction, Emerging Technologies and Future Applications IV. IHIET-AI 2021. Advances in Intelligent Systems and Computing, vol 1378* (pp. 670–677). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-74009-2_85

Eppler, M. J., & Platts, K. W. (2009). Visual strategizing. The systematic use of visualization in the strategic-planning process. *Long Range Planning*, *42*(1), 42–74. https://doi.org/10.1016/j.lrp.2008.11.005

Erceg, N., Galic, Z., & Bubic, A. (2020). Individual differences in cognitive biases: Some evidence for a rationality factor and its convergent/discriminant and ecological validity. *PsyArXiv*, *November 2*. https://doi.org/10.31234/osf.io/8hx7f

Ertug, G., Gruber, M., Nyberg, A., & Steensma, H. K. (2018). From the editors - a brief primer on data visualization opportunities in management research. *Academy of Management Journal*, *61*(5), 1613–1625. https://doi.org/10.5465/amj.2018.4005

Evans, J. S. B. T. (2007). *Hypothetical thinking: Dual processes in reasoning and judgement*. Hove: Psychology Press.

Evans, J. S. B. T. (2008). Dual-processing accounts of reasoning, judgment, and social cognition. *Annual Review of Psychology*, *59*, 255–278. https://doi.org/10.1146/annurev.psych.59.103006.093629

Evans, J. S. B. T., Barston, J., & Pollard, P. (1983). On the conflict between logic and belief in syllogistic reasoning. *Memory & Cognition*, *11*(3), 295–306. https://doi.org/10.3758/BF03196976

Evans, J. S. B. T., & Stanovich, K. E. (2013). Dual-process theories of higher cognition: Advancing the debate. *Perspectives on Psychological Science*, *8*(3), 223–241. https://doi.org/10.1177/1745691612460685

Fallon, C. K., Panganiban, A. R., Wohleber, R., Matthews, G., Kustubayeva, A. M., & Roberts, R. (2014). Emotional intelligence, cognitive ability and information search in tactical decision-making. *Personality and Individual Differences*, *65*, 24–29. https://doi.org/https://doi.org/10.1016/j.paid.2014.01.029

Farjoun, M. (2002). Towards an organic perspective on strategy. *Strategic Management Journal*, *23*(7), 561–594. https://doi.org/10.1002/smj.239

Faro, D., & Rottenstreich, Y. (2006). Affect, empathy, and regressive mispredictions of others' preferences under risk. *Management Science*, *52*(4), 529–541. https://doi.org/10.1287/mnsc.1050.0490

Fechner, G. T. (1860). *Elemente der Psychophysik*. Leipzig: Breitkopf und Härtel.

Ferreira, L., & Hitchcock, D. B. (2009). A comparison of hierarchical methods for clustering functional data. *Communications in Statistics - Simulation and Computation*, *38*(9), 1925–1949. https://doi.org/10.1080/03610910903168603

Fincher, S., & Tenenberg, J. (2005). Making sense of card sorting data. *Expert Systems*, *22*(3), 89–93. https://doi.org/10.1111/j.1468-0394.2005.00299.x

Fischer, S., Soyez, K., & Gurtner, S. (2015). Adapting Scott and Bruce's General Decision-Making Style Inventory to patient decision making in provider choice. *Medical Decision Making*, *35*(4), 525–532. https://doi.org/10.1177/0272989X15575518

Fischhoff, B. (1982). Debiasing. In D. Kahnemann, P. Slovic, & A. Tversky (Eds.), *Judgment under uncertainty: Heuristics and biases* (pp. 422–444). Cambridge: Cambridge University Press.

Fischhoff, B., & Beyth, R. (1975). "I knew it would happen". Remembered probabilities of once-future things. *Organizational Behavior and Human Performance*, *13*(1), 1–16. https://doi.org/10.1016/0030-5073(75)90002-1

Fischhoff, B., Slovic, P., & Lichtenstein, S. (1978). Fault trees: Sensitivity of estimated failure probabilities to problem representation. *Journal of Experimental Psychology: Human Perception and Performance*, *4*(2), 330–344. https://doi.org/10.1037/0096-1523.4.2.330

Fisher, I. (1929). *The money illusion*. London: George Allen and Unwin, Ltd.

Fisher, M., & Keil, F. C. (2016). The curse of expertise: When more knowledge leads to miscalibrated explanatory insight. *Cognitive Science*, *40*(5), 1251–1269. https://doi.org/10.1111/cogs.12280

Fiske, S. T. (1980). Attention and weight in person perception: The impact of negative and extreme behavior. *Journal of Personality and Social Psychology*, *38*(6), 889–906. https://doi.org/10.1037/0022-3514.38.6.889

Fitzgerald, J. M. (1988). Vivid memories and the reminiscence phenomenon: The role of a self narrative. *Human Development*, *31*(5), 261–273. https://doi.org/10.1159/000275814

Fitzgerald, M., Kruschwitz, N., Bonnet, D., & Welch, M. (2013). Embracing digital technology: A new strategic imperative. *MIT Sloan Management Review*, 1–12. https://doi.org/10.1057/palgrave.ejis.3000650

Frederick, S. (2005). Cognitive reflection and decision making. *The Journal of Economic Perspectives*, *19*(4), 25. https://doi.org/10.1257/089533005775196732

Frederick, S., Novemsky, N., Wang, J., Dhar, R., & Nowlis, S. (2009). Opportunity cost neglect. *Journal of Consumer Research*, *36*(4), 553–561. https://doi.org/10.1086/599764

Fredrickson, B., & Kahneman, D. (1993). Duration neglect in retrospective evaluations of affective episodes. *Journal of Personality and Social Psychology*, *65*(1), 45–55. https://doi.org/10.1037/0022-3514.65.1.45

Fredrickson, J. W. (1984). The comprehensiveness of strategic decision processes: Extension, observations, future directions. *Academy of Manajement Journal*, *27*(3), 445–466. https://doi.org/10.2307/256039

Freitas, C. M. D. S., Luzzardi, P. R. G., Cava, R. A., Pimenta, M. S., Nedel, L. P., & Winckler, M. (2002). On evaluating information visualization techniques. In *Proceedings of the Workshop on Advanced Visual Interfaces AVI* (pp. 373–374). Rio Grande do Sul. https://doi.org/10.1145/1556262.1556326

Freud, S. (1905). *Drei Abhandlungen zur Sexualtheorie*. Leipzig und Wien: Deuticke.

Frijns, B., Gilbert, A., Lehnert, T., & Tourani-Rad, A. (2013). Uncertainty avoidance, risk tolerance and corporate takeover decisions. *Journal of Banking & Finance*, *37*(7), 2457–2471. https://doi.org/10.1016/J.JBANKFIN.2013.02.010

Frisch, D., & Baron, J. (1988). Ambiguity and rationality. *Journal of Behavioral Decision Making*, *1*(3), 149–157. https://doi.org/10.1002/bdm.3960010303

Fry, W. F. (1986). Humor, physiology, and the aging process. In L. Nahemow, P. E. McGhee, & K. A. McCluskey-Fawcett (Eds.), *Humor and aging* (pp. 81–98). Oxford: Academic Press. https://doi.org/10.1016/b978-0-12-513790-4.50011-x

Fujino, J., Fujimoto, S., Kodaka, F., Camerer, C. F., Kawada, R., Tsurumi, K., … Takahashi, H. (2016). Neural mechanisms and personality correlates of the sunk cost effect. *Scientific Reports*, *6*(1), 33171. https://doi.org/10.1038/srep33171

Furnham, A., & Boo, H. C. (2011). A literature review of the anchoring effect. *Journal of Socio-Economics*, *40*(1), 35–42. https://doi.org/10.1016/j.socec.2010.10.008

Galai, D., & Sade, O. (2006). The "ostrich effect" and the relationship between the liquidity and the yields of financial assets. *The Journal of Business*, *79*(5), 2741–2759. https://doi.org/10.1086/505250

Galinsky, A. D., & Moskowitz, G. B. (2000a). Counterfactuals as behavioral primes: Priming the simulation heuristic and consideration of alternatives. *Journal of Experimental Social Psychology*, *36*(4), 384–409. https://doi.org/https://doi.org/10.1006/jesp.1999.1409

Galinsky, A. D., & Moskowitz, G. B. (2000b). Perspective-taking: Decreasing stereotype expression, stereotype accessibility, and in-group favoritism. *Journal of Personality and Social Psychology*, *78*(4), 708–724. https://doi.org/10.1037/0022-3514.78.4.708

Galton, F. (1886). Regression towards mediocrity in hereditary stature. *The Journal of the Anthropological Institute of Great Britain and Ireland*, *15*, 246–263. https://doi.org/10.2307/2841583

Garcia-Alamino, J. M. (2020). Human biases and the SARS-CoV-2 pandemic. *Intensive & Critical Care Nursing*, *58*, 102861. https://doi.org/10.1016/j.iccn.2020.102861

Garcia, S. M., Song, H., & Tesser, A. (2010). Tainted recommendations: The social comparison bias. *Organizational Behavior and Human Decision Processes*, *113*(2), 97–101. https://doi.org/10.1016/j.obhdp.2010.06.002

Gaviria, C., Corredor, J., & Zuluaga-Rendón, Z. (2016). "If it matters , I can explain it": Social desirability of knowledge increases the illusion of explanatory depth. *Proceedings of the 38th Annual Meeting Cognitive Science Society*, 2073–2078.

Geier, A. B., Rozin, P., & Doros, G. (2006). Unit bias: A new heuristic that helps explain the effect of portion size on food intake. *Psychological Science*, *17*(6), 521–525. https://doi.org/10.1111/j.1467-9280.2006.01738.x

George, J. F., Duffy, K., & Ahuja, M. (2000). Countering the anchoring and adjustments bias with decision support systems. *Decision Support Systems*, *29*(2), 195–206. https://doi.org/10.1016/S0167-9236(00)00074-9

German, T. P., & Barrett, H. C. (2005). Functional fixedness in a technologically sparse culture. *Psychological Science*, *16*(1), 1–5. https://doi.org/10.1111/j.0956-7976.2005.00771.x

Gertner, A., Zaromb, F. M., Schneider, R., Roberts, R. D., & Matthews, G. (2016). The assessment of biases in cognition: Development and evaluation of an assessment instrument for the measurement of cognitive bias. *MITRE Technical Report, Case Number 16-0956*.

Ghemawat, P. (1991). *Commitment: The dynamic of strategy.* New York: Free Press.

Gibbons, J. A., Velkey, A. K., & Partin, K. T. (2008). Influence of recall procedures on the modality effect with numbers and enumerated stimuli. *Journal of General Psychology*, *135*(1), 84–104. https://doi.org/10.3200/GENP.135.1.84-104

Gigerenzer, G., & Gaissmaier, W. (2011). Heuristic decision making. *Annual Review of Psychology*, *62*, 451–482. https://doi.org/10.1146/annurev-psych-120709-145346

Gigerenzer, G., & Goldstein, D. G. (1996). Reasoning the fast and frugal way: Models of bounded rationality. *Psychological Review*, *103*(4), 650–669. https://doi.org/10.1037/0033-295X.103.4.650

Gilbert, D. T., Brown, R. P., Pinel, E. C., & Wilson, T. D. (2000). The illusion of external agency. *Journal of Personality and Social Psychology*, *79*(5), 690–700. https://doi.org/10.1037/0022-3514.79.5.690

Gilbert, D. T., Driver-Linn, E., & Wilson, T. D. (2002). The trouble with Vronsky: Impact bias in the forecasting of future affective states. In L. F. Barrett & P. Salovey (Eds.), *The wisdom in feeling: Psychological processes in emotional intelligence* (pp. 114–143). New York: The Guilford Press.

Gilbert, D. T., & Malone, P. S. (1995). The correspondence bias. *Psychological Bulletin*, *117*(1), 21–38. https://doi.org/10.1037/0033-2909.117.1.21

Gill, M., & VanBoskirk, S. (2016). Digital Maturity Model 4.0. *Benchmarks: Digital Transformation Playbook*.

Gilligan, S. G., & Bower, G. H. (1983). Reminding and mood-congruent memory. *Bulletin of the Psychonomic Society*, *21*(6), 431–434. https://doi.org/10.3758/BF03330000

Gilovich, T., Griffin, D., & Kahneman, D. (2002). *Heuristics and biases. The psychology of intuitive judgment*. Cambridge: Cambridge University Press.

Gilovich, T., Medvec, V. H., & Savitsky, K. (2000). The spotlight effect in social judgment: An egocentric bias in estimates of the salience of one's own actions and appearance. *Journal of Personality and Social Psychology*, *78*(2), 211–222. https://doi.org/10.1037/0022-3514.78.2.211

Gilovich, T., & Savitsky, K. (1999). The spotlight effect and the illusion of transparency: Egocentric assessments of how we are seen by others. *Current Directions in Psychological Science*, *8*(6), 165–168. https://doi.org/10.1111/1467-8721.00039

Gilovich, T., Vallone, R., & Tversky, A. (1985). The hot hand in basketball: On the misperception of random sequences. *Cognitive Psychology*, *17*(3), 295–314. https://doi.org/10.1016/0010-0285(85)90010-6

Glenberg, A. M., & Langston, W. E. (1992). Comprehension of illustrated text: Pictures help to build mental models. *Journal of Memory and Language*, *31*(2), 129–151. https://doi.org/10.1016/0749-596X(92)90008-L

Goldstein, D. G., & Rothschild, D. (2014). Lay understanding of probability distributions. *Judgment and Decision Making*, *9*(1), 1–14.

Graf, L., König, A., Enders, A., & Hungenberg, H. (2012). Debiasing competitive irrationality: How managers can be prevented from trading off absolute for relative profit. *European Management Journal*, *30*(4), 386–403. https://doi.org/https://doi.org/10.1016/j.emj.2011.12.001

Graham, S., Hudley, C., & Williams, E. (1992). Attributional and emotional determinants of aggression among African-American and Latino young adolescents. *Developmental Psychology*, *28*(4), 731–740. https://doi.org/10.1037/0012-1649.28.4.731

Grant, R. M. (2003). Strategic planning in a turbulent environment: Evidence from the oil majors. *Strategic Management Journal*, *24*(6), 491–517. https://doi.org/10.1002/smj.314

Greene, R. L. (1989). Spacing effects in memory: Evidence for a two-process account. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *15*(3), 371–377. https://doi.org/10.1037/0278-7393.15.3.371

Gregor, S. (2006). The nature of theory in information systems. *MIS Quarterly*, *30*(3), 611–642. https://doi.org/10.2307/25148742

Gregory, W. J., & Romm, N. R. A. (2001). Critical facilitation: Learning through intervention in group processes. *Management Learning*, *32*(4), 453–467. https://doi.org/10.1177/1350507601324003

Grenier, A. L. (2008). *Conceptual understanding and the use of hand-sketching in mechanical engineering design*. University of Maryland, College Park, US.

Greve, H. R. (2013). Microfoundations of management: Behavioral strategies and levels of rationality in organizational action. *Academy of Management Perspectives*, *27*(2), 103–119. https://doi.org/10.5465/amp.2012.0091

Grichnik, D. (2008). Risky choices in new venture decisions—experimental evidence from Germany and the United States. *Journal of International Entrepreneurship*, *6*(1), 22–47. https://doi.org/10.1007/s10843-008-0019-5

Guri-Rozenblit, T. S. (1988). The interrelations between diagrammatic representations and verbal explanations in learning from social science texts. *Instructional Science*, *17*(3), 219–234.

Gutierrez de Blume, A. P. (2017). The effects of strategy training and an extrinsic incentive on fourth- and fifth-grade students' performance, confidence, and calibration accuracy. *Cogent Education*, *4*(1), 1314652. https://doi.org/10.1080/2331186X.2017.1314652

Hafer, C. L., & Begue, L. (2005). Experimental research on just-world theory: Problems, developments, and future challenges. *Psychological Bulletin*, *131*(1), 128–167. https://doi.org/10.1037/0033-2909.131.1.128

Hajaj, C., Hazon, N., & Sarne, D. (2014). Ordering effects and belief adjustment in the use of comparison shopping agents. In *Proceedings of the National Conference on Artificial Intelligence* (pp. 930–936). American Association for Artificial Intelligence.

Hales, B. M., & Pronovost, P. J. (2006). The checklist - a tool for error management and performance improvement. *Journal of Critical Care*, *21*(3), 231–235. https://doi.org/10.1016/j.jcrc.2006.06.002

Halpern, S. D., Truog, R. D., & Miller, F. G. (2020). Cognitive bias and public health policy during the COVID-19 pandemic. *JAMA*, *324*(4), 337–338. https://doi.org/10.1001/jama.2020.11623

Hamilton, K., Shih, S.-I., & Mohammed, S. (2016). The development and validation of the rational and intuitive decision styles scale. *Journal of Personality Assessment*, *98*(5), 523–535. https://doi.org/10.1080/00223891.2015.1132426

Hamilton, P., & Copeman, A. (1970). The effect of alcohol and noise on components of a tracking and monitoring task. *British Journal of Psychology*, *61*(2), 149–156. https://doi.org/10.1111/j.2044-8295.1970.tb01232.x

Hammond, K. R., & Adelman, L. (1976). Science, values, and human judgment. *Science*, *194*(4263), 389–396. https://doi.org/10.1126/science.194.4263.389

Han, X. (2011). *Omission neglect and the bias blind spot: Effects of the self-other asymmetry in susceptibility to bias and responsiveness to debiasing*. ProQuest Dissertations Publishing.

Hannah, S. (2005). *Sorting out card sorting: Comparing methods for information architects, usability specialists, and other practitioners*. University of Oregon, Portland.

Harkness, A. R., DeBono, K. G., & Borgida, E. (1985). Personal involvement and strategies for making contingency judgments: A stake in the dating game makes a difference. *Journal of Personality and Social Psychology*, *49*(1), 22–32. https://doi.org/10.1037/0022-3514.49.1.22

Harrigan, K. R. (1985). An application of clustering for strategic group analysis. *Strategic Management Journal*, *6*(1), 55–73. https://doi.org/10.1002/smj.4250060105

Haselton, M. G. (2003). The sexual overperception bias: Evidence of a systematic bias in men from a survey of naturally occurring events. *Journal of Research in Personality*, *37*(1), 34–47. https://doi.org/10.1016/S0092-6566(02)00529-9

Haselton, M. G., Bryant, G. A., Wilke, A., Frederick, D. A., Galperin, A., Frankenhuis, W. E., & Moore, T. (2009). Adaptive rationality: An evolutionary perspective on cognitive bias. *Social Cognition*, *27*(5), 733–763. https://doi.org/10.1521/soco.2009.27.5.733

Haselton, M. G., Nettle, D., & Andrews, P. W. (2015). The evolution of cognitive bias. In D. M. Buss (Ed.), *The Handbook of Evolutionary Psychology* (pp. 724–746). Los Angeles: John Wiley and Sons Ltd. https://doi.org/10.1002/9781119125563.evpsych241

Hasher, L., Goldstein, D., & Toppino, T. (1977). Frequency and the conference of referential validity. *Journal of Verbal Learning and Verbal Behavior*, *16*(1), 107–112. https://doi.org/10.1016/S0022-5371(77)80012-1

Hastorf, A. H., & Cantril, H. (1954). They saw a game; a case study. *The Journal of Abnormal and Social Psychology*, *49*(1), 129–134. https://doi.org/10.1037/h0057880

Heath, C. (1999). On the social psychology of agency relationships: Lay theories of motivation overemphasize extrinsic incentives. *Organizational Behavior and Human Decision Processes*, *78*(1), 25–62. https://doi.org/10.1006/obhd.1999.2826

Heckman, J. J. (1979). Sample selection bias as a specification error. *Econometrica*, *47*(1), 153–161. https://doi.org/10.2307/1912352

Hedlund, J. (2000). Risky business: Safety regulations, risk compensation, and individual behavior. *Injury Prevention*, *6*(2), 82–89. https://doi.org/10.1136/ip.6.2.82

Hegarty, M., & Steinhoff, K. (1997). Individual differences in use of diagrams as external memory in mechanical reasoning. *Learning and Individual Differences*, *9*(1), 19–42. https://doi.org/10.1016/S1041-6080(97)90018-2

Heiman, V. B. (1990). Auditors' assessments of the likelihood of error explanations in analytical review. *The Accounting Review*, *65*(4), 875–890.

Helmi Ismail Abdelaal, M., Khater, M., & Zaki, M. (2017). *Digital business transformation and strategy: What do we know so far?* Cambridge: University of Cambridge. https://doi.org/10.13140/RG.2.2.36492.62086

Hendry, J. (2000). Strategic decision making, discourse, and strategy as social practice. *Journal of Management Studies*, *37*(7), 955–978. https://doi.org/10.1111/1467-6486.00212

Hendry, J., & Seidl, D. (2003). The structure and significance of strategic episodes: Social systems theory and the routine rractices of strategic change. *Journal of Management Studies*, *40*, 175–196. https://doi.org/10.1111/1467-6486.00008

Henkel, L. A., & Coffman, K. J. (2004). Memory distortions in coerced false confessions: a source monitoring framework analysis. *Applied Cognitive Psychology*, *18*(5), 567–588. https://doi.org/10.1002/acp.1026

Herbert, T. T., & Estes, R. W. (1977). Improving executive decisions by formalizing dissent: The corporate devil's advocate. *Academy of Management Review*, *2*(4), 662–667. https://doi.org/10.5465/amr.1977.4406749

Hernandez, I., & Preston, J. L. (2013). Disfluency disrupts the confirmation bias. *Journal of Experimental Social Psychology*, *49*(1), 178–182. https://doi.org/10.1016/j.jesp.2012.08.010

Hershey, J. C., Kunreuther, H. C., & Schoemaker, P. J. H. (1982). Sources of bias in assessment procedures for utility functions. *Management Science*, *28*(8), 936–954. https://doi.org/10.1287/mnsc.28.8.936

Highhouse, S. (1996). Context-dependent selection: The effects of decoy and phantom job candidates. *Organizational Behavior and Human Decision Processes*, *65*(1), 68–76. https://doi.org/10.1006/OBHD.1996.0006

Hirano, S., Sun, X., & Tsumoto, S. (2004). Comparison of clustering methods for clinical databases. *Information Sciences*, *159*(3), 155–165. https://doi.org/10.1016/j.ins.2003.03.011

Hirt, E. R., Kardes, F. R., & Markman, K. D. (2004). Activating a mental simulation mind-set through generation of alternatives: Implications for debiasing in related and unrelated domains. *Journal of Experimental Social Psychology*, *40*(3), 374–383. https://doi.org/10.1016/j.jesp.2003.07.009

Hodgkinson, G. P., Bown, N. J., Maule, A. J., Glaister, K. W., & Pearman, A. D. (1999). Breaking the frame: An analysis of strategic cognition and decision making under uncertainty. *Strategic Management Journal*, *20*(10), 977–985. https://doi.org/10.1002/(SICI)1097-0266(199910)20:10<977::AID-SMJ58>3.0.CO;2-X

Hodgkinson, G. P., & Clarke, I. (2007). Exploring the cognitive significance of organizational strategizing: A dual-process framework and research agenda. *Human Relations*, *60*(1), 243–255. https://doi.org/10.1177/0018726707075297

Hodgkinson, G. P., & Healey, M. P. (2008). Cognition in organizations. *Annual Review of Psychology*, *59*, 387–406. https://doi.org/10.1146/annurev.psych.59.103006.093612

Hodgkinson, G. P., Langan-Fox, J., & Sadler-Smith, E. (2008). Intuition: A fundamental bridging construct in the behavioural sciences. *British Journal of Psychology*, *99*(1), 1–27. https://doi.org/10.1348/000712607X216666

Hodgkinson, G. P., Maule, A. J., & Bown, N. J. (2004). Causal cognitive mapping in the organizational strategy field: A comparison of alternative elicitation procedures. *Organizational Research Methods*, *7*(1), 3–26. https://doi.org/10.1177/1094428103259556

Hodgkinson, G. P., Sadler-Smith, E., Burke, L. A., Claxton, G., & Sparrow, P. R. (2009). Intuition in organizations: Implications for strategic management. *Long Range Planning*, *42*(3), 277–297. https://doi.org/10.1016/j.lrp.2009.05.003

Hodgkinson, G. P., Whittington, R., Johnson, G., & Schwarz, M. (2006). The role of strategy workshops in strategy development processes: Formality, communication, co-ordination and inclusion. *Long Range Planning*, *39*(5), 479–496. https://doi.org/10.1016/j.lrp.2006.07.003

Hogarth, R. M. (1987). *Judgement and choice. The psychology of decision* (2nd ed.). Chichester: Wiley.

Hogarth, R. M., & Einhorn, H. J. (1992). Order effects in belief updating: The belief-adjustment model. *Cognitive Psychology*, *24*(1), 1–55. https://doi.org/10.1016/0010-0285(92)90002-J

Hsee, C. K. (1998). Less is better: When low-value options are valued more highly than high-value options. *Journal of Behavioral Decision Making*, *11*(2), 107–121. https://doi.org/10.1002/(SICI)1099-0771(199806)11:2<107::AID-BDM292>3.0.CO;2-Y

Hsee, C. K., & Zhang, J. (2004). Distinction bias: Misprediction and mischoice due to joint evaluation. *Journal of Personality and Social Psychology*, *86*(5), 680–695. https://doi.org/10.1037/0022-3514.86.5.680

Huber, J., Payne, J. W., & Puto, C. (1982). Adding asymmetrically dominated alternatives: Violations of regularity and the similarity hypothesis. *Journal of Consumer Research*, *9*(1), 90–98. https://doi.org/10.1086/208899

Hullman, J., Kay, M., Kim, Y., & Shrestha, S. (2018). Imagining eplications: Graphical prediction & discrete visualizations improve recall & estimation of effect uncertainty. *IEEE Transactions on Visualization and Computer Graphics*, *24*(1), 446–456. https://doi.org/10.1109/TVCG.2017.2743898

Hummer, M. K., Dember, W. N., Melton, R. S., & Schefft, B. K. (1992). On the partial independence of optimism and pessimism. *Current Psychology*, *11*(1), 37–50. https://doi.org/10.1007/BF02686826

Hundhausen, C. D. (2005). Using end-user visualization environments to mediate conversations: a 'Communicative Dimensions' framework. *Journal of Visual Languages and Computing*, *16*, 153–185. https://doi.org/10.1016/j.jvlc.2004.11.002

Hunt, R. R. (1995). The subtlety of distinctiveness: What von Restorff really did. *Psychonomic Bulletin and Review*, *2*(1), 105–112. https://doi.org/10.3758/BF03214414

Hutzschenreuter, T., & Kleindienst, I. (2006). Strategy-process research: What have we learned and what is still to be explored. *Journal of Management*, *32*(5), 673–720. https://doi.org/10.1177/0149206306291485

Huy, Q., & Zott, C. (2019). Exploring the affective underpinnings of dynamic managerial capabilities: How managers' emotion regulation behaviors mobilize resources for their firms. *Strategic Management Journal*, *40*(1), 28–54. https://doi.org/10.1002/smj.2971

Jansari, A., & Parkin, A. J. (1996). Things that go bump in your life: Explaining the reminiscence bump in autobiographical memory. *Psychology and Aging*, *11*(1), 85–91. https://doi.org/10.1037/0882-7974.11.1.85

Janssen, S. M. J., Chessa, A. G., & Murre, J. M. J. (2006). Memory for time: How people date events. *Memory & Cognition*, *34*(1), 138–147. https://doi.org/10.3758/BF03193393

Jarvik, M. E. (1951). Probability learning and a negative recency effect in the serial anticipation of alternative symbols. *Journal of Experimental Psychology*, *41*(4), 291–297. https://doi.org/10.1037/h0056878

Jarzabkowski, P., Balogun, J., & Seidl, D. (2007). Strategizing: The challenges of a practice perspective. *Human Relations*, *60*(1), 5–27. https://doi.org/10.1177/0018726707075703

Jarzabkowski, P., & Kaplan, S. (2015). Strategy tools-in-use: A framework for understanding technologies of rationality in practice. *Strategic Management Journal*, *36*(4), 537–558. https://doi.org/10.1002/smj.2270

Jasper, J. D., Kunzler, J. S., Prichard, E. C., & Christman, S. D. (2014). Individual differences in information order effects: The importance of right-hemisphere access in belief updating. *Acta Psychologica*, *148*, 115–122. https://doi.org/10.1016/j.actpsy.2014.01.004

Javidan, M. (1984). The impact of environmental uncertainty on long-range planning practices of the U.S. savings and loan industry. *Strategic Management Journal*, *5*(4), 381–392. https://doi.org/10.1002/smj.4250050407

Jecker, J., & Landy, D. (1969). Liking a person as a function of doing him a favour. *Human Relations*, *22*(4), 371–378. https://doi.org/10.1177/001872676902200407

Jenni, K. E., & Loewenstein, G. (1997). Explaining the "identifiable victim effect." *Journal of Risk and Uncertainty*, *14*(3), 235–257. https://doi.org/0.1023/A:1007740225484

Jie, J. Y., & Li, Y. (2016). Argumentum ad novitatem: Mere newness as a choice heuristic. In P. Moreau & S. Puntoni (Eds.), *Advances in Consumer Research* (Vol. 44, pp. 506–507). Duluth: Association for Consumer Research.

Johnson, D. D. P., & Fowler, J. H. (2011). The evolution of overconfidence. *Nature*, *477*(7364), 317–320. https://doi.org/10.1038/nature10384

Johnson, E. N. (1995). Effects of information order, group assistance, and experience on auditors' sequential belief revision. *Journal of Economic Psychology*, *16*(1), 137–160. https://doi.org/10.1016/0167-4870(94)00039-D

Johnson, H. M., & Seifert, C. M. (1994). Sources of the continued influence effect: When misinformation affects later inferences. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, *20*(6), 1420–1436. https://doi.org/10.1037/0278-7393.20.6.1420

Jones, E. E., & Nisbett, R. E. (1971). The actor and the observer: Divergent perceptions of the causes of behavior. In B. Jones, Edward E Kanouse, D. E. Valins, S. Kelley, H. H Nisbett, R. E. Weiner (Ed.), *Attribution: Perceiving the causes of behavior*. Morristown: General Learning Press.

Joshi, S., & Summers, J. D. (2012). Representation: Metrics for analyzing sketches: A critical survey. In *Proceedings of the ASME Design Engineering Technical Conference* (Vol. 7, pp. 773–783). Department of Mechanical Engineering, Clemson University. https://doi.org/10.1115/DETC2012-71425

Jost, J. T., Pelham, B. W., & Carvallo, M. R. (2002). Non-conscious forms of system justification: Implicit and behavioral preferences for higher status groups. *Journal of Experimental Social Psychology*, *38*(6), 586–602. https://doi.org/10.1016/S0022-1031(02)00505-X

Joyce, E. J., & Biddle, G. C. (1981). Are auditor's judgments sufficiently regressive? *Journal of Accounting Research*, *19*(2), 323–349. https://doi.org/10.2307/2490868

Jung, C. G. (1902). *Zur Psychologie und Pathologie sogenannter occulter Phänomene / eine psychiatrische Studie von Dr. med C. G. Jung, 1 Assistenzarzt der psychiatrischen Universitätsklinik in Zürich*. Leipzig: Oswald Mutze.

Kafka, G. (1936). The change in the concepts of "world" and "surrounding-world." *The Journal of General Psychology*, *14*(2), 438–460. https://doi.org/10.1080/00221309.1936.9713164

Kahlbaum, K. K. (1865). Die verschiedenen Formen der Sinnesdelirien. Ein Beitrag zur Erweiterung der psychiatrischen Symptomatologie und zur physiologischen Psychologie. *Centralblatt Für Die Medicinischen Wissenschaften*, *57*, 908ff.

Kahneman, D. (2003). A perspective on judgment and choice: Mapping bounded rationality. *American Psychologist*, *58*(9), 697–720. https://doi.org/10.1037/0003-066X.58.9.697

Kahneman, D., & Frederick, S. (2002). Representativeness revisited: Attribute substitution in intuitive judgment. In T. Gilovich, D. Griffin, D. Kahneman, T. Gilovich (Ed), D. Griffin (Ed), & D. Kahneman (Ed) (Eds.), *Heuristics and biases: The psychology of intuitive judgment.* (pp. 49–81). Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511808098.004

Kahneman, D., & Klein, G. (2009). Conditions for intuitive expertise: A failure to disagree. *American Psychologist*, *64*(6), 515–526. https://doi.org/10.1037/a0016755

Kahneman, D., Lovallo, D., & Sibony, O. (2011). Before you make that big decision... *Harvard Business Review*, *89*(6), 50–60.

Kahneman, D., Lovallo, D., & Sibony, O. (2019). A structured approach to strategic decisions. *MIT Sloan Management Review*, *60*(3), 67–73.

Kahneman, D., Slovic, P., & Tversky, A. (1982). *Judgment under uncertainty: Heuristics and biases.* Cambridge: Cambridge University Press.

Kahneman, D., & Tversky, A. (1972). Subjective probability: A judgment of representativeness. *Cognitive Psychology*, *3*(3), 430–454. https://doi.org/10.1016/0010-0285(72)90016-3

Kahneman, D., & Tversky, A. (1973). On the psychology of prediction. *Psychological Review*, *80*(4), 237–251. https://doi.org/10.1037/h0034747

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, *47*(2), 263–291. https://doi.org/10.2307/1914185

Kahneman, D., & Tversky, A. (1982). Intuitive prediction: Biases and corrective procedures. In A. Tversky, D. Kahneman, & P. Slovic (Eds.), *Judgment under uncertainty: Heuristics and biases* (pp. 414–421). Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511809477.031

Kane, G. C., Palmer, D., Phillips, A. N., Kiron, D., & Buckley, N. (2015). Strategy, not technology, drives digital transformation. *MIT Sloan Management Review and Deloitte University Press*, *14*, 1–25.

Kanouse, D. E., & Hanson, L. R. (1971). Negativity in evaluations. In Edward E Jones, D. E. Kanouse, S. Valins, H. H. Kelley, R. E. Nisbett, & B. Weiner (Eds.), *Attribution: Perceiving the causes of behavior*. Morristown: General Learning Press.

Kant, I. (1788). *Critic der practischen Vernunft*. Riga: Johann Friedrich Hartknoch.

Kapoor, R., & Klueter, T. (2021). Unbundling and managing uncertainty surrounding emerging technologies. *Strategy Science*, *6*(1), 62–74. https://doi.org/10.1287/stsc.2020.0118

Karlsson, N., Loewenstein, G., & Seppi, D. (2009). The ostrich effect: Selective attention to information. *Journal of Risk and Uncertainty*, *38*(2), 95–115. https://doi.org/10.1007/s11166-009-9060-6

Kaufmann, L., Carter, C. R., & Buhrmann, C. (2010). Debiasing the supplier selection decision: a taxonomy and conceptualization. *International Journal of Physical Distribution & Logistics Management*, *40*(10), 792–821. https://doi.org/10.1108/09600031011093214

Kearsley, G. P. (1975). Problem-solving set and functional fixedness: A contextual dependency hypothesis. *Canadian Psychological Review*, *16*(4), 261–268. https://doi.org/10.1037/h0081813

Keeney, R. L. (2012). Value-focused brainstorming. *Decision Analysis*, *9*(4), 303–313. https://doi.org/10.1287/deca.1120.0251

Kellermanns, F. W., Walter, J., Lechner, C., & Floyd, S. W. (2005). The lack of consensus about strategic consensus: Advancing theory and research. *Journal of Management*, *31*(5), 719–737. https://doi.org/10.1177/0149206305279114

Kenyon, T., & Beaulac, G. (2014). Critical thinking education and debiasing. *Informal Logic*, *34*(4), 341–363. https://doi.org/10.22329/il.v34i4.4203

Keren, Gideon. (1988). On the ability of monitoring non-veridical perceptions and uncertain knowledge: Some calibration studies. *Acta Psychologica*, *67*(2), 95–119. https://doi.org/10.1016/0001-6918(88)90007-8

Keren, Gideon. (1990). Cognitive aids and debiasing methods: Can cognitive pills cure cognitive ills? *Advances in Psychology*, *68*, 523–552. https://doi.org/10.1016/S0166-4115(08)61341-2

Kernbach, S., Eppler, M. J., & Bresciani, S. (2015). The use of visualization in the communication of business strategies. *International Journal of Business Communication*, *52*(2), 164–187. https://doi.org/10.1177/2329488414525444

Kiesler, S., & Sproull, L. (1982). Managerial response to changing environments : Perspectives on problem sensing from social cognition. *Administrative Science Quarterly*, *27*(4), 548–570. https://doi.org/10.2307/2392530

Kim, Y.-S., Reinecke, K., & Hullman, J. (2017). Explaining the gap: Visualizing one's predictions improves recall and comprehension of data. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (pp. 1375–1386). New York: Association for Computing Machinery. https://doi.org/10.1145/3025453.3025592

Kintz, B. L., Delprato, D. J., Mettee, D. R., Persons, C. E., & Schappe, R. H. (1965). The experimenter effect. *Psychological Bulletin*, *63*(4), 223–232. https://doi.org/10.1037/h0021718

Kirsh, D. (2010). Thinking with external representations. *AI & Society*, *25*(4), 441–454. https://doi.org/10.1007/s00146-010-0272-8

Klein, G. (1997). Developing expertise in decision making. *Thinking & Reasoning*, *3*(4), 337–352. https://doi.org/10.1080/135467897394329

Klingebiel, R., & De Meyer, A. (2013). Becoming aware of the unknown: Decision making during the implementation of a strategic initiative. *Organization Science*, *24*(1), 133–153. https://doi.org/10.1287/orsc.1110.0726

Klotz, L. (2011). Cognitive biases in energy decisions during the planning, design, and construction of commercial buildings in the United States: An analytical framework and research needs. *Energy Efficiency*, *4*(2), 271–284. https://doi.org/10.1007/s12053-010-9089-z

Knight, E., Paroutis, S., & Heracleous, L. (2018). The power of PowerPoint: A visual perspective on meaning making in strategy. *Strategic Management Journal*, *39*(3), 894–921. https://doi.org/10.1002/smj.2727

Knight, F. B. (1923). *Qualities related to success in teaching*. New York: Columbia University.

Koellinger, P., Minniti, M., & Schade, C. (2007). "I think I can, I think I can": Overconfidence and entrepreneurial behavior. *Journal of Economic Psychology*, *28*(4), 502–527. https://doi.org/https://doi.org/10.1016/j.joep.2006.11.002

Koonce, L. (1992). Explanation and counterexplanation during audit analytical review. *The Accounting Review*, *67*(1), 59–76.

Koriat, A. (2012). The self-consistency model of subjective confidence. *Psychological Review*, *119*(1), 80–113. https://doi.org/10.1037/a0025648

Koriat, A., Goldsmith, M., & Pansky, A. (2000). Toward a psychology of memory accuracy. *Annual Review of Psychology*, *51*(1), 481–537. https://doi.org/10.1146/annurev.psych.51.1.481

Koriat, A., Lichtenstein, S., & Fischhoff, B. (1980). Reasons for confidence. *Journal of Experimental Psychology: Human Learning and Memory*, *6*(2), 107–118. https://doi.org/10.1037/0278-7393.6.2.107

Korteling, J. E., Brouwer, A.-M., & Toet, A. (2018). A neural network framework for cognitive bias. *Frontiers in Psychology*, *9*(1561), 1–12. https://doi.org/10.3389/fpsyg.2018.01561

Kray, L. J., & Galinsky, A. D. (2003). The debiasing effect of counterfactual mind-sets: Increasing the search for disconfirmatory information in group decisions. *Organizational Behavior and Human Decision Processes*, *91*(1), 69–81. https://doi.org/10.1016/S0749-5978(02)00534-4

Kreilkamp, N., Schmidt, M., & Wöhrmann, A. (2021). Debiasing as a powerful management accounting tool? Evidence from german firms. *Journal of Accounting and Organizational Change*, *17*(4), 555–582. https://doi.org/10.1108/JAOC-12-2019-0122

Kroneisen, M., Rummel, J., & Erdfelder, E. (2016). What kind of processing is survival processing? *Memory & Cognition*, *44*(8), 1228–1243. https://doi.org/10.3758/s13421-016-0634-7

Kruger, J. (1999). Lake Wobegon be gone! The "below-average effect" and the egocentric nature of comparative ability judgments. *Journal of Personality and Social Psychology*, *77*(2), 221–232. https://doi.org/10.1037//0022-3514.77.2.221

Kruger, Justin, & Dunning, D. (1999). Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology*, *77*(6), 1121–1134. https://doi.org/10.1037/0022-3514.77.6.1121

Kruger, Justin, & Gilovich, T. (1999). "Naive cynicism" in everyday theories of responsibility assessment: On biased assumptions of bias. *Journal of Personality and Social Psychology*, *76*(5), 743–753. https://doi.org/10.1037/0022-3514.76.5.743

Krumpal, I. (2013). Determinants of social desirability bias in sensitive surveys: A literature review. *Quality and Quantity*, *47*(4), 2025–2047. https://doi.org/10.1007/s11135-011-9640-9

Kukucka, J., Kassin, S. M., Zapf, P. A., & Dror, I. E. (2017). Cognitive bias and blindness: A global survey of forensic science examiners. *Journal of Applied Research in Memory and Cognition*, *6*(4), 452–459. https://doi.org/10.1016/J.JARMAC.2017.09.001

Kwak, Y., & Huettel, S. (2018). The order of information processing alters economic gain-loss framing effects. *Acta Psychologica*, *182*, 46–54. https://doi.org/10.1016/j.actpsy.2017.11.013

Laamanen, T., & Wallin, J. (2009). Cognitive dynamics of capability development paths. *Journal of Management Studies*, *46*(6), 950–981. https://doi.org/10.1111/j.1467-6486.2009.00823.x

Lancefield, D. (2021). Practicing strategy in an uncertain world. *Strategy + Business*, Issue 103.

Landucci, F., & Lamperti, M. (2021). A pandemic of cognitive bias. *Intensive Care Medicine*, *47*(5), 636–637. https://doi.org/10.1007/s00134-020-06293-y

Langer, E. J. (1975). The illusion of control. *Journal of Personality and Social Psychology*, *32*(2), 311–328. https://doi.org/10.1037/0022-3514.32.2.311

Langer, T., & Weber, M. (2001). Prospect theory, mental accounting, and differences in aggregated and segregated evaluation of lottery portfolios. *Management Science*, *47*(5), 716. https://doi.org/10.1287/mnsc.47.5.716.10483

Lanza, C. (1881). Hypermnesia or exaltations of memory. *Science*, *2*(65), 450–453. https://doi.org/10.1126/science.os-2.66.450

Lapiere, R. T., & Farnsworth, P. R. (1936). *Social psychology*. New York: McGraw-Hill.

Larkin, J. H., & Simon, H. A. (1987). Why a diagram is (sometimes) worth ten thousand words. *Cognitive Science: Incorporating the Journal Cognition and Brain Theory: A Multidisciplinary Journal*, *11*(1), 65–99. https://doi.org/10.1111/j.1551-6708.1987.tb00863.x

Larrick, R. P. (2004). Debiasing. In D. J. Koehler & N. Harvey (Eds.), *Blackwell handbook of judgment and decision making* (pp. 316–337). Malden and Oxford: Wiley-Blackwell.

Larrick, R. P., Burson, K. A., & Soll, J. B. (2007). Social comparison and confidence: When thinking you're better than average predicts overconfidence (and when it does not). *Organizational Behavior and Human Decision Processes*, *102*(1), 76–94. https://doi.org/10.1016/J.OBHDP.2006.10.002

Lau, K., Oehlberg, L., & Agogino, A. (2009). Sketching in design journals: An analysis of visual representations in the product design process. *Engineering Design Graphics Journal*, *73*(3), 23–28.

Lee, J. M., Hwang, B. - H., & Chen, H. (2017). Are founder CEOs more overconfident than professional CEOs? Evidence from S&P 1500 companies. *Strategic Management Journal*, *38*(3), 751–769. https://doi.org/10.1002/smj.2519

Lee, S., & Feeley, T. H. (2016). The identifiable victim effect: a meta-analytic review. *Social Influence*, *11*(3), 199–215. https://doi.org/10.1080/15534510.2016.1216891

Leiblein, M. J., Reuer, J. J., & Zenger, T. (2018). What makes a decision strategic? *Strategy Science*, *3*(4), 558–573. https://doi.org/10.1287/stsc.2018.0074

Leising, D. (2011). The consistency bias in judgments of one's own interpersonal behavior: Two possible sources. *Journal of Individual Differences*, *32*(3), 137–143. https://doi.org/10.1027/1614-0001/a000046

Lenzen, V. F. (1934). The philosophical problem of the existence of the physical world. *American Journal of Physics*, *2*(4), 152–158. https://doi.org/10.1119/1.1992889

Lerner, J. S., & Tetlock, P. E. (1999). Accounting for the effects of accountability. *Psychological Bulletin*, *125*(2), 255–275. https://doi.org/10.1037/0033-2909.125.2.255

Lerner, M. J., & Simmons, C. H. (1966). Observer's reaction to the "innocent victim": Compassion or rejection? *Journal of Personality and Social Psychology*, *4*(2), 203–210. https://doi.org/10.1037/h0023562

Leutner, D., Leopold, C., & Sumfleth, E. (2009). Cognitive load and science text comprehension: Effects of drawing and mentally imagining text content. *Computers in Human Behavior*, *25*(2), 284–289. https://doi.org/https://doi.org/10.1016/j.chb.2008.12.010

Levinthal, D. A. (2011). A behavioral approach to strategy - What's the alternative? *Strategic Management Journal*, *32*(13), 1517–1523. https://doi.org/10.1002/smj.963

Li, Z., Rohde, K. I. M., & Wakker, P. P. (2017). Improving one's choices by putting oneself in others' shoes – An experimental analysis. *Journal of Risk and Uncertainty*, *54*(1), 1–13. https://doi.org/10.1007/s11166-017-9253-3

Lichtenstein, S., & Fischhoff, B. (1977). Do those who know more also know more about how much they know? *Organizational Behavior and Human Performance*, *20*(2), 159–183. https://doi.org/10.1016/0030-5073(77)90001-0

Lim, L.-H., & Benbasat, I. (1997). The debiasing role of group support systems: an experimental investigation of the representativeness bias. *International Journal of Human Computer Studies*, *47*(3), 453. https://doi.org/10.1006/ijhc.1997.0137

Lindsay, D. S., & Johnson, M. K. (1989). The eyewitness suggestibility effect and memory for source. *Memory & Cognition*, *17*(3), 349–358. https://doi.org/10.3758/BF03198473

Liu, Z., & Stasko, J. T. (2010). Mental models, visual reasoning and interaction in information visualization: A top-down perspective. In *IEEE Transactions on Visualizations and Computer Graphics* (Vol. 16, pp. 999–1008). https://doi.org/10.1109/TVCG.2010.177

Loewenstein, G. (1996). Out of control: Visceral influences on behavior. *Organizational Behavior and Human Decision Processes*, *65*(3), 272–292. https://doi.org/10.0.3.238/obhd.1996.0028

Loewenstein, G. (2005). Hot-cold empathy gaps and medical decision making. *Health Psychology*, *24*(4, Suppl), S49–S56. https://doi.org/10.1037/0278-6133.24.4.S49

Loewenstein, G., O'Donoghue, T., & Rabin, M. (2003). Projection bias in predicting future utility. *The Quarterly Journal of Economics*, *118*(4), 1209–1248. https://doi.org/10.1162/003355303322552784

Loewenstein, J., Thompson, L., & Gentner, D. (1999). Analogical encoding facilitates knowledge transfer in negotiation. *Psychonomic Bulletin and Review*, *6*(4), 586–597. https://doi.org/10.3758/BF03212967

Loftus, E. F. (1979). The malleability of human memory: Information introduced after we view an incident can transform memory. *American Scientist*, *67*(3), 312–320.

Loftus, E. F., & Palmer, J. C. (1974). Reconstruction of automobile destruction: An example of the interaction between language and memory. *Journal of Verbal Learning and Verbal Behavior*, *13*, 585–589. https://doi.org/10.1016/S0022-5371(74)80011-3

Lord, C. G., Lepper, M. R., & Preston, E. (1984). Considering the opposite: A corrective strategy for social judgment. *Journal of Personality and Social Psychology*, *47*(6), 1231–1243. https://doi.org/10.1037/0022-3514.47.6.1231

Lovallo, D., & Kahneman, D. (2003). Delusions of success. *Harvard Business Review*, *81*(7), 56–63.

Lovallo, D., & Sibony, O. (2010). The case for behavioral strategy. *McKinsey Quarterly*, *26*(2), 30–40.

Lovas, B., & Ghoshal, S. (2000). Strategy as guided evolution. *Strategic Management Journal*, *21*(9), 875–896. https://doi.org/10.1002/1097-0266(200009)21:9<875::AID-SMJ126>3.0.CO;2-P

Lucas, B. J., & Nordgren, L. F. (2022). Lay people's beliefs about creativity: evidence for an insight bias. *Trends in Cognitive Sciences*, *26*(1), 6–7. https://doi.org/10.1016/j.tics.2021.09.007

Luchins, A. S. (1942). Mechanization in problem solving: The effect of Einstellung. *Psychological Monographs*, *54*(6), i–95. https://doi.org/10.1037/h0093502

Mack, O., & Khare, A. (2016). Perspectives on a VUCA world. In O. Mack, A. Khare, A. Krämer, & T. Burgartz (Eds.), *Managing in a VUCA world* (pp. 3–19). Cham; Heidelberg: Springer.

MacRae, A. W. (1970). Channel capacity in absolute judgment tasks: An artifact of information bias? *Psychological Bulletin*, *73*(2), 112–121. https://doi.org/10.1037/h0028513

Mahoney, M. J. (1977). Publication prejudices: An experimental study of confirmatory bias in the peer review system. *Cognitive Therapy and Research*, *1*(2), 161–175. https://doi.org/10.1007/BF01173636

Maitland, E., & Sammartino, A. (2015). Decision making and uncertainty: The role of heuristics and experience in assessing a politically hazardous environment. *Strategic Management Journal*, *36*(10), 1554–1578. https://doi.org/10.1002/smj.2297

Malmendier, U., & Tate, G. (2005). CEO overconfidence and corporate investment. *The Journal of Finance*, *60*(6), 2661–2700. https://doi.org/10.1111/j.1540-6261.2005.00813.x

Manzey, D., Reichenbach, J., & Onnasch, L. (2012). Human performance consequences of automated decision aids: The impact of degree of automation and system experience. *Journal of Cognitive Engineering and Decision Making*, *6*(1), 57–87. https://doi.org/10.1177/1555343411433844

March, J. G., & Olsen, J. P. (1976). *Ambiguity and choices in organizations.* Bergen: Universitetsforlaget.

March, J. G., & Simon, H. A. (1958). *Organizations*. New York: Wiley.

Mather, M., & Carstensen, L. L. (2005). Aging and motivated cognition: the positivity effect in attention and memory. *Trends in Cognitive Sciences*, *9*(10), 496–502. https://doi.org/10.1016/J.TICS.2005.08.005

Mather, M., & Johnson, M. K. (2000). Choice-supportive source monitoring: Do our decisions seem better to us as we age? *Psychology and Aging*, *15*(4), 596–606. https://doi.org/10.1037/0882-7974.15.4.596

Maule, A. J., & Hodgkinson, G. P. (2003). Re-appraising managers' perceptual errors: A behavioural decision-making perspective. *British Journal of Management*, *14*(1), 33–37. https://doi.org/10.1111/1467-8551.1401007

Mayer, J. D., & Salovey, P. (1988). Personality moderates the interaction of mood and cognition. In K. Fiedler & J. Forgas (Eds.), *Affect, cognition and social behavior: New evidence and integrative attempts* (pp. 87–99). Toronto: C. J. Hogrefe.

Mayer, John D, McCormick, L. J., & Strong, S. E. (1995). Mood-congruent memory and natural mood: New evidence. *Personality and Social Psychology Bulletin*, *21*(7), 736–746. https://doi.org/10.1177/0146167295217008

Mayer, R. E., & Gallini, J. K. (1990). When is an illustration worth ten thousand words? *Journal of Educational Psychology*, *82*(4), 715–726. https://doi.org/10.1037/0022-0663.82.4.715

Mazzolini, R. (1981). How strategic decisions are made. *Long Range Planning*, *14*(3), 85–96. https://doi.org/10.1016/0024-6301(81)90187-4

McBride, D. M., & Anne Dosher, B. (2002). A comparison of conscious and automatic memory processes for picture and word stimuli: A process dissociation analysis. *Consciousness and Cognition*, *11*(3), 423–460. https://doi.org/10.1016/S1053-8100(02)00007-7

McDaniel, M. A., Anderson, J. L., Derbish, M. H., & Morrisette, N. (2007). Testing the testing effect in the classroom. *European Journal of Cognitive Psychology*, *19*(4–5), 494–513. https://doi.org/10.1080/09541440701326154

McDaniel, M. A., & Einstein, G. O. (1986). Bizarre imagery as an effective memory aid: The importance of distinctiveness. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *12*(1), 54–65. https://doi.org/10.1037/0278-7393.12.1.54

McFadden, D. (1999). Rationality for economists? *Journal of Risk and Uncertainty*, *19*(1–3), 73–105. https://doi.org/10.1023/A:1007863007855

McFadzean, E., & Nelson, T. (1998). Facilitating problem-solving groups: a conceptual model. *Leadership & Organization Development Journal*, *19*(1), 6–13. https://doi.org/10.1108/01437739810368785

McGlone, M. S., & Tofighbakhsh, J. (1999). The Keats heuristic: Rhyme as reason in aphorism interpretation. *Poetics*, *26*(4), 235–244. https://doi.org/10.1016/S0304-422X(99)00003-0

McGlone, M. S., & Tofighbakhsh, J. (2000). Birds of a feather flock conjointly (?): Rhyme as reason in aphorisms. *Psychological Science*, *11*(5), 424–428. https://doi.org/10.1111/1467-9280.00282

McGown, A., Green, G., & Rodgers, P. A. (1998). Visible ideas: information patterns of conceptual sketch activity. *Design Studies*, *19*(4), 431–453. https://doi.org/https://doi.org/10.1016/S0142-694X(98)00013-1

McNulty, E. J. (2021). To see the future more clearly, find your blind spots. *Strategy + Business*.

Meegan, D. (2010). Zero-sum bias: Perceived competition despite unlimited resources. *Frontiers in Psychology*, *1*, 191. https://doi.org/10.3389/fpsyg.2010.00191

Meehl, P. E. (1956). Wanted - a good cook-book. *American Psychologist*, *11*(6), 263–272. https://doi.org/10.1037/h0044164

Meissner, P., & Wulf, T. (2016). Debiasing illusion of control in individual judgment: the role of internal and external advice seeking. *Review of Managerial Science*, *10*(2), 245–263. https://doi.org/10.1007/s11846-014-0144-6

Mengis, J., & Eppler, M. J. (2006). Seeing versus arguing: The moderating role of collaborative visualization in team knowledge integration. *Journal of Universal Knowledge Management*, *1*(3), 151–162.

Milburn, M. A. (1978). Sources of bias in the prediction of future events. *Organizational Behavior and Human Performance*, *21*(1), 17–26. https://doi.org/10.1016/0030-5073(78)90035-1

Miles, W. E., Snow, C. C., & Pfeffer, J. (1974). Organization-environment: Concepts and issues. *Industrial Relations*, *13*(3), 244–264. https://doi.org/10.1111/j.1468-232X.1974.tb00581.x

Milgram, S. (1963). Behavioral study of obedience. *Journal of Abnormal and Social Psychology*, *67*(4), 371–378. https://doi.org/10.1037/h0040525

Miller, D. T., & Norman, S. A. (1975). Actor-observer differences in perceptions of effective control. *Journal of Personality and Social Psychology*, *31*(3), 503–515. https://doi.org/10.0.4.13/h0076485

Miller, D. T., & Ross, M. (1975). Self-serving biases in the attribution of causality: Fact or fiction? *Psychological Bulletin*, *82*(2), 213–225. https://doi.org/10.1037/h0076486

Milligan, G. W., & Cooper, M. C. (1987). Methodology review: Clustering methods. *Applied Psychological Measurement*, *11*(4), 329–354. https://doi.org/10.1177/014662168701100401

Milliken, F. J. (1987). Three types of perceived uncertainty about the environment: State, effect, and response uncertainty. *Academy of Management Review*, *12*(1), 133–143. https://doi.org/10.0.21.89/AMR.1987.4306502

Mintzberg, H. (1978). Patterns in strategy formation. *Management Science*, *24*(9), 934–948. https://doi.org/10.1287/mnsc.24.9.934

Mintzberg, H., Raisinghani, D., & Théorêt, A. (1976). The structure of "unstructured" decision processes. *Administrative Science Quarterly*, *21*(2), 246–275. https://doi.org/10.2307/2392045

Mintzberg, H., & Waters, J. A. (1985). Of strategies, deliberate and emergent. *Strategic Management Journal*, *6*(3), 257–272. https://doi.org/10.1002/smj.4250060306

Mischen, P. A., & Jackson, S. K. (2008). Connecting the dots: Applying complexity theory, knowledge management and social network analysis to policy implementation. *Public Administration Quarterly*, *32*(3), 314.

Mitchell, T. R., & Thompson, L. (1994). A theory of temporal adjustments of the evaluation of events: Rosy Prospection & Rosy Retrospection. In C. Stubbart, J. Porac, & J. Meindl (Eds.), *Advances in managerial cognition and organizational information-processing* (pp. 85–114). Stamford: JAI Press.

Mitchell, T. R., Thompson, L., Peterson, E., & Cronk, R. (1997). Temporal adjustments in the evaluation of events: The "rosy view." *Journal of Experimental Social Psychology*, *33*(4), 421–448. https://doi.org/10.1006/JESP.1997.1333

Monin, B., & Miller, D. T. (2001). Moral credentials and the expression of prejudice. *Journal of Personality and Social Psychology*, *81*(1), 33–43. https://doi.org/10.1037/0022-3514.81.1.33

Montibeller, G., & Winterfeldt, D. (2015). Cognitive and motivational biases in decision and risk analysis. *Risk Analysis: An International Journal*, *35*(7), 1230–1251. https://doi.org/10.1111/risa.12360

Moore, D. A., Carter, A. B., & Yang, H. H. J. (2015). Wide of the mark: Evidence on the underlying causes of overprecision in judgment. *Organizational Behavior and Human Decision Processes*, *131*, 110–120. https://doi.org/10.1016/j.obhdp.2015.09.003

Moore, D. A., & Healy, P. J. (2008). The trouble with overconfidence. *Psychological Review*, *115*(2), 502–517. https://doi.org/10.1037/0033-295X.115.2.502

Moore, D. A., Swift, S. A., Minster, A., Mellers, B., Ungar, L., Tetlock, P., … Tenney, E. R. (2017). Confidence calibration in a multiyear geopolitical forecasting competition. *Management Science*, *63*(11), 3552–3565. https://doi.org/10.1287/mnsc.2016.2525

Moore, D. A., Tenney, E. R., & Haran, U. (2015). Overprecision in judgement. In *The Wiley Blackwell handbook of judgment and decision making* (pp. 182–209). Wiley Online Books. https://doi.org/10.1002/9781118468333

Morewedge, C. K., & Giblin, C. E. (2015). Explanations of the endowment effect: An integrative review. *Trends in Cognitive Sciences*, *19*(6), 339–348. https://doi.org/10.1016/j.tics.2015.04.004

Morewedge, C. K., Yoon, H., Scopelliti, I., Symborski, C. W., Korris, J. H., & Kassam, K. S. (2015). Debiasing decisions: Improved decision making with a single training intervention. *Policy Insights from the Behavioral and Brain Sciences*, *2*(1), 129–140. https://doi.org/10.1177/2372732215600886

Mortell, M., Balkhy, H. H., Tannous, E. B., & Jong, M. T. (2013). Physician "defiance" towards hand hygiene compliance: Is there a theory-practice-ethics gap? *Journal of the Saudi Heart Association*, *25*(3), 203–208. https://doi.org/10.1016/j.jsha.2013.04.003

Morton, J., Crowder, R. G., & Prussin, H. A. (1971). Experiments with the stimulus suffix effect. *Journal of Experimental Psychology*, *91*(1), 169–190. https://doi.org/10.1037/h0031844

Mosier, K. L., Skitka, L. J., Burdick, M. D., & Heers, S. T. (1996). Automation bias, accountability, and verification behaviors. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *40*(4), 204–208. https://doi.org/10.1177/154193129604000413

Mueller, J. S., Melwani, S., & Goncalo, J. A. (2011). The bias against creativity: Why people desire but reject creative ideas. *Psychological Science*, *23*(1), 13–17. https://doi.org/10.1177/0956797611421018

Mumpower, J. L., & Stewart, T. R. (1996). Expert judgement and expert disagreement. *Thinking & Reasoning*, *2*(2/3), 191–212. https://doi.org/10.1080/135467896394500

Muntwiler, C. (2021). Debiasing management decisions: Overcoming the practice/theory gap within the managerial decision process. In E. Tomé (Ed.), *Proceedings of TAKE 2021 - Theory and applications in the knowledge economy conference* (pp. 123–162). Porto: Universidade Portucalense.

Muntwiler, C., & Eppler, M. (2019). Showing what you don't know: The effect of visualization on managers' illusion of explanatory depth. *Academy of Management Proceedings*, *2019*(1), 12475. https://doi.org/10.5465/AMBPP.2019.12475abstract

Murdock, B. B. J. (1962). The serial position effect of free recall. *Journal of Experimental Psychology*, *64*(5), 482–488. https://doi.org/10.1037/h0045106

Murtagh, F., & Legendre, P. (2014). Ward's hierarchical agglomerative clustering method: Which algorithms implement Ward's criterion? *Journal of Classification*, *31*(3), 274–295. https://doi.org/10.1007/s00357-014-9161-z

Mussweiler, T., Strack, F., & Pfeiffer, T. (2000). Overcoming the inevitable anchoring effect: Considering the opposite compensates for selective accessibility. *Personality and Social Psychology Bulletin*, *26*(9), 1142–1150. https://doi.org/10.1177/01461672002611010

Nadeau, R., Cloutier, E., & Guay, J.-H. (1993). New evidence about the existence of a bandwagon effect in the opinion formation process. *International Political Science Review*, *14*(2), 203–213. https://doi.org/10.1177/019251219301400204

Nairne, J. S., Thompson, S. R., & Pandeirada, J. N. S. (2007). Adaptive memory: Survival processing enhances retention. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *33*(2), 263–273. https://doi.org/10.1037/0278-7393.33.2.263

Nawaz, A. (2012). A comparison of card-sorting analysis methods. In *APCHI '12. Proceedings of the 10th Asia Pacific Conference on Computer-Human Interaction Vol. 2* (pp. 583–592). New York, US: Association for Computing Machinery 2012.

Nelson, B., Pei-Jou, K., Melissa, B., & Raymond, G. (2012). Measuring psychographics to assess purchase intention and willingness to pay. *Journal of Consumer Marketing*, *29*(4), 280–292. https://doi.org/10.1108/07363761211237353

Nisbett, R. E., & DeCamp Wilson, T. (1977). The Halo effect: Evidence for unconscious alteration of judgments. *Journal of Personality and Social Psychology*, *35*(4), 250–256. https://doi.org/10.1037/0022-3514.35.4.250

Nisbett, R. E., & Ross, L. (1980). *Human inference: Strategies and shortcomings of social judgment*. Englewood Cliffs: Prentice-Hall.

Nordgren, L. F., Harreveld, F. van, & Pligt, J. van der. (2009). The restraint bias: How the illusion of self-restraint promotes impulsive behavior. *Psychological Science*, *20*(12), 1523–1528. https://doi.org/10.1111/j.1467-9280.2009.02468.x

Norton, M. I., Mochon, D., & Ariely, D. (2012). The IKEA effect: When labor leads to love. *Journal of Consumer Psychology*, *22*(3), 453–460. https://doi.org/10.1016/j.jcps.2011.08.002

Nyhan, B., & Reifler, J. (2010). When corrections fail: The persistence of political misperceptions. *Political Behavior*, *32*(2), 303–330. https://doi.org/10.1007/s11109-010-9112-2

O'Brien, E. J., & Myers, J. L. (1985). When comprehension difficulty improves memory for text. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *11*(1), 12–21. https://doi.org/10.1037/0278-7393.11.1.12

Ohlert, C. R., & Weißenberger, B. E. (2020). Debiasing escalation of commitment: the effectiveness of decision aids to enhance de-escalation. *Journal of Management Control*, *30*(4), 405–438. https://doi.org/10.1007/s00187-019-00290-z

Olsen, R. A. (1997). Desirability bias among professional investment managers: Some evidence from experts. *Journal of Behavioral Decision Making*, *10*(1), 65–72. https://doi.org/10.1002/(SICI)1099-0771(199703)10:1<65::AID-BDM246>3.0.CO;2-S

Oreg, S., & Bayazit, M. (2009). Prone to bias: Development of a bias taxonomy from an individual differences perspective. *Review of General Psychology*, *13*(3), 175–193. https://doi.org/10.1037/a0015656

Oreizy, S. (2019, September). Three cognitive biases undermining executives' strategic decision making ability. *Forbes*.

Paivio, A. (1969). Mental imagery in associative learning and memory. *Psychological Review*, *76*(3), 241–263. https://doi.org/10.1037/h0027272

Paivio, A. (1986). *Mental representations: a dual coding approach*. New York: Oxford University Press.

Park, B., & Rothbart, M. (1982). Perception of out-group homogeneity and levels of social categorization: Memory for the subordinate attributes of in-group and out-group members. *Journal of Personality and Social Psychology*, *42*(6), 1051–1068. https://doi.org/10.1037/0022-3514.42.6.1051

Parker, A. M., Bruine De Bruin, W., & Fischhoff, B. (2007). Maximizers versus satisficers: Decision-making styles, competence, and outcomes. *Judgment and Decision Making*, *2*(6), 342–350.

Parker, A. M., De Bruin, W. B., Fischhoff, B., & Weller, J. (2017). Robustness of decision-making competence: Evidence from two measures and an 11-year longitudinal study. *Journal of Behavioral Decision Making*, *31*(3), 380–391. https://doi.org/10.1002/bdm.2059

Paroutis, S., Franco, L. A., & Papadopoulos, T. (2015). Visual interactions with strategy tools: Producing strategic knowledge in workshops. *British Journal of Management*, *26*, 48–66. https://doi.org/10.1111/1467-8551.12081

Paroutis, S., & Knight, E. (2019). Visuals in open strategy. In D. Seidl, G. Von Krogh, & R. Whittington (Eds.), *Cambridge handbook of open strategy* (pp. 205–218). Cambridge: Cambridge University Press. https://doi.org/10.1017/9781108347921.013

Paterson, H. M., Kemp, R. I., & Forgas, J. P. (2009). Co-witnesses, confederates, and conformity: Effects of discussion and delay on eyewitness memory. *Psychiatry, Psychology and the Law*, *16*(4), S112–S124. https://doi.org/10.1080/13218710802620380

Patt, A., & Zeckhauser, R. (2000). Action bias and environmental decisions. *Journal of Risk and Uncertainty*, *21*(1), 45–72. https://doi.org/10.1023/A:1026517309871

Paul, C. L. (2014). Analyzing card-sorting data using graph visualization. *Journal of Usability Studies*, *9*(13), 87–104. https://doi.org/10.5555/2817713.2817715

Payne, J. W., Bettman, J. R., & Schkade, D. A. (1999). Measuring constructed preferences: Towards a building code. *Journal of Risk and Uncertainty*, *19*(1), 243–270. https://doi.org/10.1023/A:1007843931054

Peón, D., Antelo, M., & Calvo-Solvosa, A. (2017). An inclusive taxonomy of behavioral biases. *European Journal of Government and Economics*, *6*(1), 24–58. https://doi.org/10.17979/ejge.2017.6.1.4322

Perloff, L. S., & Brickman, P. (1982). False consensus and false uniqueness: Biases in perceptions of similarity. *Academic Psychology Bulletin*, *4*(3), 475–494.

Persensky, J. J., & Senter, R. J. (1970). An investigation of "bizarre" imagery as a mnemonic device. *The Psychological Record*, *20*(2), 145–150. https://doi.org/10.1007/BF03393924

Peterson, L. R., Wampler, R., Kirkpatrick, M., & Saltzman, D. (1963). Effect of spacing presentations on retention of a paired associate over short intervals. *Journal of Experimental Psychology*, *66*(2), 206–209. https://doi.org/10.1037/h0046694

Petrusic, W. M., & Baranski, J. V. (1997). Context, feedback, and the calibration and resolution of confidence in perceptual judgments. *The American Journal of Psychology*, *110*(4), 543–572. https://doi.org/10.2307/1423410

Pettibone, J. C., & Wedell, D. H. (2000). Examining models of nondominated decoy effects across judgment and choice. *Organizational Behavior and Human Decision Processes*, *81*(2), 300–328. https://doi.org/10.1006/obhd.1999.2880

Pettigrew, A. M. (1977). Strategy formulation as a political process. *International Studies of Management and Organization*, *7*(2), 78–87. https://doi.org/10.1080/00208825.1977.11656228

Pettigrew, T. F. (1979). The ultimate attribution error: Extending allport's cognitive analysis of prejudice. *Personality and Social Psychology Bulletin*, *5*(4), 461–476. https://doi.org/10.1177/014616727900500407

Petty, R. E., & Cacioppo, J. T. (1984). The effects of involvement on responses to argument quantity and quality: Central and peripheral routes to persuasion. *Journal of Personality and Social Psychology*, *46*(1), 69–81. https://doi.org/10.1037/0022-3514.46.1.69

Pfister, R. A., & Eppler, M. J. (2012). The benefits of sketching for knowledge management. *Journal of Knowledge Management*, *16*(2), 372–382. https://doi.org/10.1108/13673271211218924

Phillips, L. D., & Edwards, W. (1966). Conservatism in a simple probability inference task. *Journal of Experimental Psychology*, *72*(3), 346–354. https://doi.org/10.1037/h0023653

Pilditch, T. D., Fenton, N., & Lagnado, D. (2019). The zero-sum fallacy in evidence evaluation. *Psychological Science*, *30*(2), 250–260. https://doi.org/10.1177/0956797618818484

Pillai, K. G. (2010). Managers' perceptual errors revisited: The role of knowledge calibration. *British Journal of Management*, *21*(2), 299–312. https://doi.org/10.1111/j.1467-8551.2009.00646.x

Pillai, K. G., & Hofacker, C. F. (2020). Comparing the measures of consumer knowledge calibration. *European Journal of Marketing*, *54*(5), 979–998. https://doi.org/10.1108/EJM-12-2019-0875

Platts, M. J. (2001). Verbal and numerical decision analysis: parallels with sketching and drawing. *Journal of Multicriteria Decision Analysis*, *10*(3), 173. https://doi.org/10.1002/mcda.299

Plous, S. (1993). *The psychology of judgement and decision making*. New York: McGraw-Hill.

Pohl, R. F. (2017a). *Cognitive illusions: Intriguing phenomena in thinking, judgment and memory*. (R. F. Pohl, Ed.) (2. Ed.). New York: Routledge/Taylor & Francis Group.

Pohl, R. F. (2017b). Labelling and overshadowing effects. In R. Pohl (Ed.), *Cognitive illusions: Intriguing phenomena in thinking, judgement and memory* (2. ed., pp. 373–389). New York: Routledge/Taylor & Francis Group.

Poppenk, J., Walia, G., McIntosh, A. R., Joanisse, M. F., Klein, D., & Kohler, S. (2008). Why is the meaning of a sentence better remembered than its form? An fMRI study on the role of novelty-encoding processes. *Hippocampus*, *18*(9), 909–918. https://doi.org/10.1002/hipo.20453

Powell, T. C., Lovallo, D., & Fox, C. R. (2011). Behavioral strategy. *Strategic Management Journal*, *32*(13), 1369–1386. https://doi.org/10.1002/smj.968

Pronin, E. (2009). The introspection illusion. In M. P. Zanna (Ed.), *Advances in Experimental Social Psychology* (Vol. 41, pp. 1–68). Elsevier Academic Press. https://doi.org/10.1016/S0065-2601(08)00401-2

Pronin, E., Gilovich, T., & Ross, L. (2004). Objectivity in the eye of the beholder: Divergent perceptions of bias in self versus others. *Psychological Review*, *111*(3), 781–799. https://doi.org/10.1037/0033-295X.111.3.781

Pronin, E., Kruger, J., Ross, L., & Savitsky, K. (2001). You don't know me, but i know you: The illusion of asymmetric insight. *Journal of Personality and Social Psychology*, *81*(4), 639–655. https://doi.org/10.1037//0022-3514.81.4.639

Pronin, E., & Kugler, M. B. (2007). Valuing thoughts, ignoring behavior: The introspection illusion as a source of the bias blind spot. *Journal of Experimental Social Psychology*, *43*(4), 565–578. https://doi.org/10.1016/J.JESP.2006.05.011

Pronin, E., Lin, D. Y., & Ross, L. (2002). The bias blind spot: Perceptions of bias in self versus others. *Personality and Social Psychology Bulletin*, *28*(3), 369–381. https://doi.org/10.1177/0146167202286008

Pronin, E., & Ross, L. (2006). Temporal differences in trait self-ascription: When the self is seen as an other. *Journal of Personality and Social Psychology*, *90*(2), 197–209. https://doi.org/10.1037/0022-3514.90.2.197

Punj, G., & Stewart, D. W. (1983). Cluster analysis in marketing research: Review and suggestions for application. *Journal of Marketing Research*, *20*(2), 134–148. https://doi.org/10.2307/3151680

Quoidbach, J., Gilbert, D. T., & Wilson, T. D. (2013). The end of history illusion. *Science*, *339*(6115), 96–98. https://doi.org/10.1126/science.1229294

Rachinger, M., Müller, C., Rauter, R., Vorraber, W., & Schirgi, E. (2018). Digitalization and its influence on business model innovation. *Journal of Manufacturing Technology Management*, *30*(8), 1143–1160. https://doi.org/10.1108/JMTM-01-2018-0020

Radecki, C. M., & Jaccard, J. (1995). Perceptions of knowledge, actual knowledge, and information search behavior. *Journal of Experimental Social Psychology*, *31*(2), 107–138. https://doi.org/10.1006/JESP.1995.1006

Raghubir, P., & Srivastava, J. (2009). The denomination effect. *Journal of Consumer Research*, *36*(4), 701–713. https://doi.org/10.1086/599222

Rahman, N., & De Feis, G. L. (2009). Strategic decision-making: Models and methods in the face of complexity and time pressure. *Journal of General Management*, *35*(4), 43–59. https://doi.org/10.1177/030630700903500204

Ramnath, V. R., McSharry, D. G., & Malhotra, A. (2020). Do no harm: Reaffirming the value of evidence and equipoise while minimizing cognitive bias in the coronavirus disease 2019 era. *Chest*, *158*(3), 873–876. https://doi.org/10.1016/j.chest.2020.05.548

Rand, W. M. (1971). Objective criteria for the evaluation of clustering methods. *Journal of the American Statistical Association*, *66*(336), 846–850. https://doi.org/10.1080/01621459.1971.10482356

Rehder, B., Schreiner, M. E., Wolfe, M. B. W., Laham, D., Landauer, T. K., & Kintsch, W. (1998). Using latent semantic analysis to assess knowledge: Some technical considerations. *Discourse Processes*, *25*(2–3), 337–354. https://doi.org/10.1080/01638539809545031

Reisberg, D. (1987). External representations and the advantages of externalizing one's thoughts. In *Proceedings of the 9th Annual Conference of the Cognitive Science Society* (pp. 281–293). Hillsdale: Lawrence Erlbaum Associates.

Remane, G., Hanelt, A., Wiesboeck, F., & Kolbe, L. (2017). Digital maturity in traditional industries - An exploratory analysis. In *Proceedings of the 25th European Conference on Information Systems (ECIS)* (pp. 143–157). Guimaraes, Portugal.

Remus, W. E., & Kottemann, J. E. (1986). Toward intelligent decision support systems: An artificially intelligent statistician. *MIS Quarterly*, *10*(4), 403–418. https://doi.org/10.5555/12894.12902

Revlin, R., Leirer, V., Yopp, H., & Yopp, R. (1980). The belief-bias effect in formal reasoning: The influence of knowledge on logic. *Memory & Cognition*, *8*(6), 584–592. https://doi.org/10.3758/BF03213778

Reypens, C., & Levine, S. S. (2018). Behavior in behavioral strategy: Capturing, measuring, analyzing. In M. Augter, C. Fang, & V. Rindova (Eds.), *Behavioral strategy in perspective (Advances in strategic management)* (Vol. 39, pp. 221–246). Bingley: Emerald Publishing Limited. https://doi.org/10.1108/S0742-3322201839

Rich, P. (1992). The organizational taxonomy: Definition and design. *The Academy of Management Review*, *17*(4), 758–781. https://doi.org/10.2307/258807

Ricketts, J. A. (1990). Powers-of-ten information biases. *MIS Quarterly*, *14*(1), 63–77. https://doi.org/10.2307/249309

Risen, J., & Gilovich, T. (2006). Informal logical fallacies. In R. J. Sternberg, H. L. Roediger III, & D. F. Halpern (Eds.), *Critical thinking in psychology* (pp. 110–130). Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511804632.008

Ritov, I., & Baron, J. (1990). Reluctance to vaccinate: Omission bias and ambiguity. *Journal of Behavioral Decision Making*, *3*(4), 263–277. https://doi.org/10.1002/bdm.3960030404

Robinson, E. S., & Brown, M. A. (1926). Effect of serial position upon memorization. *The American Journal of Psychology*, *37*(4), 538–552. https://doi.org/10.2307/1414914

Rogers, T. B., Kuiper, N. A., & Kirker, W. S. (1977). Self-reference and the encoding of personal information. *Journal of Personality and Social Psychology*, *35*(9), 677–688. https://doi.org/10.1037//0022-3514.35.9.677

Roney, C. J. R., & Sansone, N. (2015). Explaining the gambler's fallacy: Testing a gestalt explanation versus the "law of small numbers." *Thinking & Reasoning*, *21*(2), 193–205. https://doi.org/10.1080/13546783.2014.942367

Rose, T. (2008). Optimism, overconfidence and entrepreneurial activity. *Management Decision*, *46*(7), 986–1001. https://doi.org/10.1108/00251740810890177

Rosenthal, R., Persinger, G. W., Vikan-Kline, L. L., & Fode, K. L. (1963). The effect of experimenter outcome-bias and subject set on awareness in verbal conditioning experiments. *Journal of Verbal Learning and Verbal Behavior*, *2*(3), 275–283. https://doi.org/10.1016/S0022-5371(63)80094-8

Rosnow, R., & Rosenthal, R. (1997). *People studying people: artifacts and ethics in behavioral research*. New York: W.H. Freeman.

Ross, L, Greene, D., & House, P. (1977). The "false consensus effect": An egocentric bias in social perception and attribution processes. *Journal of Experimental Social Psychology*, *13*(3), 279–301. https://doi.org/10.1016/0022-1031(77)90049-X

Ross, L, & Stillinger, C. (1991). Barriers to conflict resolution. *Negotiation Journal*, *7*(4), 389–404. https://doi.org/10.1007/BF01000332

Ross, Lee. (1977). The intuitive psychologist and his shortcomings: Distortions in the attribution process. *Advances in Experimental Social Psychology*, *10*(C), 173–220. https://doi.org/10.1016/S0065-2601(08)60357-3

Ross, M., & Sicoly, F. (1979). Egocentric biases in availability and attribution. *Journal of Personality and Social Psychology*, *37*(3), 322–336. https://doi.org/10.1037/0022-3514.37.3.322

Rothbart, M., & Snyder, M. (1970). Confidence in the prediction and postdiction of an uncertain outcome. *Canadian Journal of Behavioural Science / Revue Canadienne Des Sciences Du Comportement*, *2*(1), 38–43. https://doi.org/10.1037/h0082709

Roy, S., Narahari, Y., & Deshmukh, O. D. (2015). A perspective on computer assisted assessment techniques for short free-text answers. In E. Ras & D. Joosten-ten Brinke (Eds.), *Computer assisted assessment. Research into E-Assessment. TEA 2015. Communications in computer and information science, Vol. 571* (pp. 96–109). Cham: Springer. https://doi.org/10.1007/978-3-319-27704-2_10

Rozenblit, L., & Keil, F. (2002). The misunderstood limits of folk science: An illusion of explanatory depth. *Cognitive Science*, *26*(5), 521–562. https://doi.org/10.1207/s15516709cog2605_1

Rudman, L. A., & Goodwin, S. A. (2004). Gender differences in automatic in-group bias: Why do women like women more than men like men? *Journal of Personality and Social Psychology*, *87*(4), 494–509. https://doi.org/10.1037/0022-3514.87.4.494

Russo, J. E., & Schoemaker, P. J. H. (1992). Managing overconfidence. *Sloan Management Review*, *33*(2), 7–17. https://doi.org/10.12691/jbe-3-1-2

Rutledge, R. W. (1995). The ability to moderate recency effects through framing of management accounting information. *Journal of Managerial Issues*, *7*(1), 27–40.

Sadler, P., & Woody, E. (2003). Is who you are who you're talking to? Interpersonal style and complementarily in mixed-sex interactions. *Journal of Personality and Social Psychology*, *84*(1), 80–96. https://doi.org/10.1037/0022-3514.84.1.80

Samuelson, W., & Zeckhauser, R. (1988). Status quo bias in decision making. *Journal of Risk and Uncertainty*, *1*(1), 7–59. https://doi.org/10.1007/BF00055564

Sanchez, J. C. (1993). The long and thorny way to an organizational taxonomy. *Organization Studies*, *14*(1), 73–92. https://doi.org/10.1177/017084069301400106

Sanna, L. J., & Schwarz, N. (2004). Integrating temporal biases: The interplay of focal thoughts and accessibility experiences. *Psychological Science*, *15*(7), 474–481. https://doi.org/10.1111/j.0956-7976.2004.00704.x

Saposnik, G., Redelmeier, D., Ruff, C. C., & Tobler, P. N. (2016). Cognitive biases associated with medical decisions: a systematic review. *BMC Medical Informatics and Decision Making*, *16*(1), 138. https://doi.org/10.1186/s12911-016-0377-1

Savitsky, K. (1997). Perceived transparency and the leakage of emotional states: Do we know how little we show? *Dissertation Abstracts International: Section B: The Sciences and Engineering*, *58*(6-B), 3371.

Savitsky, K., & Gilovich, T. (2003). The illusion of transparency and the alleviation of speech anxiety. *Journal of Experimental Social Psychology*, *39*(6), 618–625. https://doi.org/10.1016/S0022-1031(03)00056-8

Schkade, D. A., & Kahneman, D. (1998). Does living in california make people happy? A focusing illusion in judgments of life satisfaction. *Psychological Science*, *9*(5), 340–436. https://doi.org/10.1111/1467-9280.00066

Schneider, S. C., & De Meyer, A. (1991). Interpreting and responding to strategic issues: The impact of national culture. *Strategic Management Journal*, *12*(4), 307–320. https://doi.org/10.1002/smj.4250120406

Schrager, J. E., & Madansky, A. (2013). Behavioral strategy: a foundational view. *Journal of Strategy and Management*, *6*(1), 81–95. https://doi.org/10.1108/17554251311296576

Schulz-Hardt, S., Jochims, M., & Frey, D. (2002). Productive conflict in group decision making: genuine and contrived dissent as strategies to counteract biased information seeking. *Organizational Behavior and Human Decision Processes*, *88*(2), 563–586. https://doi.org/10.1016/S0749-5978(02)00001-8

Schumacher, C., Keck, S., & Tang, W. (2020). Biased interpretation of performance feedback: The role of CEO overconfidence. *Strategic Management Journal*, *41*(6), 1139–1165. https://doi.org/10.1002/smj.3138

Schwarz, R. M. (2017). *The skilled facilitator. a comprehensive resource for consultants, facilitators, coaches, and trainers*. Hoboken: Jossey-Bass.

Schweiger, D. M., Sandberg, W. R., & Rechner, P. L. (1989). Experiential effects of dialectical inquiry, devil's advocacy and consensus approaches to strategic decision making. *Academy of Management Journal*, *32*(4), 745–772. https://doi.org/10.5465/256567

Schwenk, C. R. (1984). Cognitive simplification processes in strategic decision-making. *Strategic Management Journal*, *5*(2), 111–128. https://doi.org/10.1002/smj.4250050203

Schwenk, C. R. (1986). Information, cognitive biases, and commitment to a course of action. *Academy of Management Review*, *11*(2), 298–310. https://doi.org/10.2307/258461

Schwenk, C. R. (1988). The cognitive perspective on strategic decision making. *Journal of Management Studies*, *25*(1), 41–55. https://doi.org/10.1111/j.1467-6486.1988.tb00021.x

Schwenk, C. R. (1995). Strategic decision making. *Journal of Management*, *21*(3), 471–493. https://doi.org/10.1177/014920639502100304

Schwenk, C. R., & Cosier, R. A. (1993). Effects of consensus and devil's advocacy on strategic decision-making. *Journal of Applied Social Psychology*, *23*(2), 126–139. https://doi.org/10.1111/j.1559-1816.1993.tb01056.x

Schwenk, C. R., & Valacich, J. S. (1994). Effects of devil′s advocacy and dialectical inquiry on individuals versus groups. *Organizational Behavior and Human Decision Processes*, *59*(2), 210–222. https://doi.org/10.1006/obhd.1994.1057

Scopelliti, I., Morewedge, C. K., McCormick, E., Min, H. L., Lebrecht, S., & Kassam, K. S. (2015). Bias blind spot: Structure, measurement, and consequences. *Management Science*, *61*(10), 2468–2486. https://doi.org/10.1287/mnsc.2014.2096

Scott, S. G., & Bruce, R. A. (1995). Decision-making style: The development and assessment of a new measure. *Educational and Psychological Measurement*, *55*(5), 818–831. https://doi.org/10.1177/0013164495055005017

Seifert, C. M., & Patalano, A. L. (1991). Memory for incomplete tasks: A re-examination of the Zeigarnik effect. In *Proceedings of the Thirteenth Annual Conference of the Cognitive Science Society* (pp. 114–119). Mahwah: Erlbaum.

Shaffer, J. D. (1961). Use of data from consumer food purchase panels in market development research. *Journal of Farm Economics*, *43*(4), 889–897. https://doi.org/10.2307/1236023

Shafir, E., Diamond, P., & Tversky, A. (1997). Money illusion. *The Quarterly Journal of Economics*, *112*(2), 341–374. https://doi.org/10.1162/003355397555208

Shah, A. K., & Oppenheimer, D. M. (2008). Heuristics made easy: An effort-reduction framework. *Psychological Bulletin*, *134*(2), 207–222. https://doi.org/10.1037/0033-2909.134.2.207

Shah, J. J., Smith, S. M., & Vargas-Hernandez, N. (2003). Metrics for measuring ideation effectiveness. *Design Studies*, *24*(2), 111–134. https://doi.org/https://doi.org/10.1016/S0142-694X(02)00034-0

Shanteau, J. (1974). Component processes in risky decision making. *Journal of Experimental Psychology*, *103*(4), 680–691. https://doi.org/10.1037/h0037157

Sharot, T., Riccardi, A. M., Raio, C. M., & Phelps, E. A. (2007). Neural mechanisms mediating optimism bias. *Nature*, *450*(7166), 102–105. https://doi.org/10.1038/nature06280

Shaver, K. G. (1970). Defensive attribution: Effects of severity and relevance on the responsibility assigned for an accident. *Journal of Personality and Social Psychology*, *14*(2), 101–113. https://doi.org/10.1037/h0028777

Shaw, J. I. (1971). Selective attention in learning compound social structures. *The Journal of Social Psychology*, *85*(2), 293–297. https://doi.org/10.1080/00224545.1971.9918577

Shefrin, H., & Statman, M. (1985). The disposition to sell winners too early and ride losers too long: Theory and evidence. *The Journal of Finance*, *40*(3), 777–790. https://doi.org/10.1111/j.1540-6261.1985.tb05002.x

Sherman, S. J., Cialdini, R. B., Schwartzman, D. F., & Reynolds, K. D. (1985). Imagining can heighten or lower the perceived likelihood of contracting a disease: The mediating effect of ease of imagery. *Personality and Social Psychology Bulletin*, *11*(1), 118–127. https://doi.org/10.1177/0146167285111011

Shih, W. C. (2020). Increasing the level of abstraction as a strategy for accelerating the adoption of complex technologies. *Strategy Science*, *6*(1), 54–61. https://doi.org/10.1287/stsc.2020.0116

Shimizu, T., Matsumoto, K., & Tokuda, Y. (2013). Effects of the use of differential diagnosis checklist and general de-biasing checklist on diagnostic performance in comparison to intuitive diagnosis. *Medical Teacher*, *35*(6), e1218–e1229. https://doi.org/10.3109/0142159X.2012.742493

Shrestha, Y. R., Ben-Menahem, S. M., & von Krogh, G. (2019). Organizational decision-making structures in the age of artificial intelligence. *California Management Review*, *61*(4), 66–83. https://doi.org/10.1177/0008125619862257

Shrivastava, P., & Grant, J. H. (1985). Empirically derived models of strategic decision-making processes. *Strategic Management Journal*, *6*(2), 97–113. https://doi.org/10.1002/smj.4250060202

Shweder, R. A., Casagrande, J. B., Fiske, D. W., Greenstone, J. D., Heelas, P., Cognition, L. of C. H., & Lancy, D. F. (1977). Likeness and likelihood in everyday thought: Magical thinking in judgments about personality. *Current Anthropology*, *18*(4), 637–658. https://doi.org/10.1086/201974

Shycon, H. N. (1973). All around the model: Perspectives on MS applications. *Interfaces*, *4*(1), 40–43. https://doi.org/10.1287/inte.4.3.23

Sibony, O., Lovallo, D., & Powell, T. C. (2017). Behavioral strategy and the strategic decision architecture of the firm. *California Management Review*, *59*(3), 5–21. https://doi.org/10.1177/0008125617712256

Silk-Eglit, G., & Kurtz, K. J. (2011). Types of cognitive content and the role of relational processing in the illusion of explanatory depth. In *Proceedings of the Annual Meeting of the Cognitive Science Society, 33* (pp. 643–648).

Simon, H. A. (1955). A behavioral model of rational choice. *The Quarterly Journal of Economics*, *69*(1), 99–118. https://doi.org/10.2307/1884852

Simon, H. A. (1972). Theories of bounded rationality. In C. B. McGuire & R. Radner (Eds.), *Decision and organization* (pp. 161–176). Amsterdam: North-Holland Publishing Company.

Simon, H. A. (1987). Making management decisions: The role of intuition and emotion. *The Academy of Management Executive*, *1*(1), 57–64. https://doi.org/10.5465/ame.1987.4275905

Simon, H. A. (1990). Bounded rationality. In J. Eatwell, M. Milgate, & P. Newman (Eds.), *Utility and probability* (pp. 15–18). London: Palgrave Macmillan. https://doi.org/10.1007/978-1-349-20568-4_5

Simonson, I. (1989). Choice based on reasons: The case of attraction and compromise effects. *Journal of Consumer Research*, *16*(2), 158–174. https://doi.org/10.1086/209205

Sinclair, S. (1909). *Semmelweis: His life and doctrine*. Manchester: University of Manchester Publications.

Singh, H., Aggarwal, R., & Cojuharenco, I. (2015). Strike a happy medium: The effect of IT knowledge on venture capitalist's overconfidence in IT investments. *MIS Quarterly*, *39*(4), 887–908. https://doi.org/10.25300/MISQ/2015/39.4.7

Sklad, M., & Diekstra, R. (2014). The development of the heuristics and biases scale (HBS). *Procedia - Social and Behavioral Sciences*, *112*, 710–718. https://doi.org/10.1016/j.sbspro.2014.01.1221

Slamecka, N. J. (1968). An examination of trace storage in free recall. *Journal of Experimental Psychology*, *76*(4, Pt.1), 504–513. https://doi.org/10.1037/h0025695

Slamecka, N. J., & Graf, P. (1978). The generation effect: Delineation of a phenomenon. *Journal of Experimental Psychology: Human Learning and Memory*, *4*(6), 592–604. https://doi.org/10.1037/0278-7393.4.6.592

Slovic, P., & Fischhoff, B. (1977). On the psychology of experimental surprises. *Journal of Experimental Psychology: Human Perception and Performance*, *3*(4), 544–551. https://doi.org/10.1037/0096-1523.3.4.544

Slovic, P., Fischhoff, B., & Lichtenstein, S. (1977). Behavioral decision theory. *Annual Review of Psychology*, *28*(1), 1–38. https://doi.org/10.1016/0001-6918(84)90018-0

Slovic, P., Monahan, J., & MacGregor, D. G. (2000). Violence risk assessment and risk communication: The effects of using actual cases, providing instruction, and employing probability versus frequency formats. *Law and Human Behavior*, *24*(3), 271–296. https://doi.org/10.1023/A:1005595519944

Smith, K. G., Collins, C. J., & Clark, K. D. (2005). Existing knowledge, knowledge creation capability, and the rate of new product introduction in high-technology firms. *Academy of Management Journal*, *48*(2), 346–357. https://doi.org/10.5465/AMJ.2005.16928421

Sniezek, J. A., & Henry, R. A. (1989). Accuracy and confidence in group judgment. *Organizational Behavior and Human Decision Processes*, *43*(1), 1–28. https://doi.org/10.1016/0749-5978(89)90055-1

Snyder, C. R., Shenkel, R. J., & Lowery, C. R. (1977). Acceptance of personality interpretations: The "Barnum effect" and beyond. *Journal of Consulting and Clinical Psychology*, *45*(1), 104–114. https://doi.org/10.1037/0022-006X.45.1.104

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, *104*, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

Soll, J. B., Milkma, K. L., & Payne, J. W. (2015). A user's guide to debiasing. In G. Keren & G. Wu (Eds.), *The Wiley Blackwell handbook of judgment and decision making* (pp. 924–951). https://doi.org/doi:10.1002/9781118468333.ch33

Song, S., & Agogino, A. M. (2004). Insights on designers' sketching activities in new product design teams. In *Proceedings of the ASME 2004 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference. Volume 3a: 16th International Conference on Design Theory and Methodology.* (pp. 351–360). Salt Lake City. https://doi.org/10.1115/DETC2004-57474

Sorenson, O. (2005). Social networks, informational complexity and industrial geography. In D. Fornahl, C. Zellner, & D. B. Audretsch (Eds.), *The role of Labour mobility and informal networks for knowledge transfer* (pp. 79–96). Boston: Springer. https://doi.org/10.1007/0-387-23140-4_5

Sparrow, B., Liu, J., & Wegner, D. M. (2011). Google effects on memory: Cognitive consequences of having information at our fingertips. *Science*, *333*(6043), 776–778. https://doi.org/10.1126/science.1207745

Spicer, D. P., & Sadler-Smith, E. (2005). An examination of the general decision making style questionnaire in two UK samples. *Journal of Managerial Psychology*, *20*(2), 137–149. https://doi.org/10.1108/02683940510579777

Spranca, M., Minsk, E., & Baron, J. (1991). Omission and commission in judgment and choice. *Journal of Experimental Social Psychology*, *27*(1), 76–105. https://doi.org/10.1016/0022-1031(91)90011-T

Stanovich, K. E. (1999). *Who is rational? Studies of individual differences in reasoning.* Mahwah: Lawrence Erlbaum Associates.

Stanovich, K. E. (2009). Distinguishing the reflective, algorithmic, and autonomous minds: Is it time for a tri-process theory? In J. S. B. T. Evans & K. Frankish (Eds.), *In two minds: Dual processes and beyond.* (pp. 55–88). New York: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199230167.003.0003

Stanovich, K. E., Toplak, M. E., & West, R. F. (2008). The development of rational thought: A taxonomy of heuristics and biases. *Advances in Child Development and Behavior*, *36*, 251–285. https://doi.org/10.1016/S0065-2407(08)00006-2

Stanovich, K. E., & West, R. E. (1998). Individual differences in rational thought. *Journal of Experimental Psychology*, *127*(2), 161–188. https://doi.org/10.1037/0096-3445.127.2.161

Stanovich, K. E., & West, R. F. (2008). On the relative independence of thinking biases and cognitive ability. *Journal of Personality and Social Psychology*, *94*(4), 672–695. https://doi.org/10.1037/0022-3514.94.4.672

Stanovich, K. E., West, R., & Toplak, M. E. (2016). *The rationality quotient. Toward a test of rational thinking.* Cambridge: The MIT Press.

Staw, B. M. (1976). Knee-deep in the big muddy: A study of escalating commitment to a chosen course of action. *Organizational Behavior and Human Performance*, *16*(1), 27–44. https://doi.org/10.1016/0030-5073(76)90005-2

Stenning, K., & Oberlander, J. (1997). A cognitive theory of graphical and linguistic reasoning: logic and implementation. *Cognitive Science*, *19*(1), 97–140. https://doi.org/10.1207/s15516709cog1901_3

Stone, D. N., & Ziebart, D. A. (1995). A model of financial incentive effects in decision making. *Organizational Behavior and Human Decision Processes*, *61*(3), 250–261. https://doi.org/10.1006/obhd.1995.1020

Strong, E. K. J. (1912). The effect of length of series upon recognition memory. *Psychological Review*, *19*(6), 447–462. https://doi.org/10.1037/h0069812

Suls, J., & Wan, C. K. (1987). In search of the false-uniqueness phenomenon: Fear and estimates of social consensus. *Journal of Personality and Social Psychology*, *52*(1), 211–217. https://doi.org/10.1037/0022-3514.52.1.211

Summerfelt, H., Lippman, L., & Hyman, I. (2010). The effect of humor on memory: Constrained by the pun. *Journal of General Psychology*, *137*(4), 376–394. https://doi.org/10.1080/00221309.2010.499398

Sunstein, C. R. (2002). Probability neglect: Emotions, worst cases, and law. *The Yale Law Journal*, *112*(1), 61–107. https://doi.org/10.2307/1562234

Svedholm-Häkkinen, A. M., & Lindeman, M. (2018). Actively open-minded thinking: development of a shortened scale and disentangling attitudes towards knowledge and people. *Thinking & Reasoning*, *24*(1), 21–40. https://doi.org/10.1080/13546783.2017.1378723

Svenson, O. (2008). Decisions among time saving options: When intuition is strong and wrong. *Acta Psychologica*, *127*(2), 501–509. https://doi.org/10.1016/j.actpsy.2007.09.003

Swedberg, R. (2016). Can you visualize theory? On the use of visual thinking in theory pictures, theorizing diagrams, and visual sketches. *Sociological Theory*, *34*(3), 250–275. https://doi.org/10.1177/0735275116664380

Sweller, J. (2020). Cognitive load theory and educational technology. *Educational Technology Research and Development*, *68*(1), 1–16. https://doi.org/10.1007/s11423-019-09701-3

Tanaka, J. W., Kiefer, M., & Bukach, C. M. (2004). A holistic account of the own-race effect in face recognition: evidence from a cross-cultural study. *Cognition*, *93*(1), B1–B9. https://doi.org/10.1016/J.COGNITION.2003.09.011

Tang, F., Hess, T. J., Valacich, J. S., & Sweeney, J. T. (2014). The effects of visualization and interactivity on calibration in financial decision-making. *Behavioral Research in Accounting*, *26*(1), 25. https://doi.org/10.2308/bria-50589

Tang, Y., Li, J., & Yang, H. (2012). What I see, what I do: How executive hubris affects firm innovation. *Journal of Management*, *41*(6), 1698–1723. https://doi.org/10.1177/0149206312441211

Tarakci, M., Ates, N. Y., Porck, J. P., van Knippenberg, D., Groenen, P. J. F., & de Haas, M. (2014). Strategic consensus mapping: A new method for testing and visualizing strategic consensus within and between teams. *Strategic Management Journal*, *35*(7), 1053–1069. https://doi.org/10.1002/smj.2151

Taylor, D. M., & Doria, J. R. (1981). Self-serving and group-serving bias in attribution. *Journal of Social Psychology*, *113*(2), 201–211. https://doi.org/10.1080/00224545.1981.9924371

Taylor, S. E., & Brown, J. D. (1988). Illusion and well-being: A social psychological perspective on mental health. *Psychological Bulletin*, *103*(2), 193–210. https://doi.org/10.1037/0033-2909.103.2.193

Thaler, R. H. (1980). Toward a positive theory of consumer choice. *Journal of Economic Behavior and Organization*, *1*(1), 39–60. https://doi.org/10.1016/0167-2681(80)90051-7

Thaler, R. H. (1981). Some empirical evidence on dynamic inconsistency. *Economics Letters*, *8*(3), 201–207. https://doi.org/10.1016/0165-1765(81)90067-7

Thaler, R. H., & Sunstein, C. R. (2008). *Nudge. Improving decisions about health, wealth, and happiness.* New Haven: Yale University Press.

Thaler, R. H., Tversky, A., Kahneman, D., & Schwartz, A. (1997). The effect of myopia and loss aversion on risk taking: An experimental test. *The Quarterly Journal of Economics*, *112*(2), 647–661. https://doi.org/10.1162/003355397555226

Theil, H. (1956). On the theory of economic policy. *The American Economic Review*, *46*(2), 360–366.

Thomas, O. (2018). Two decades of cognitive bias research in entrepreneurship: What do we know and where do we go from here? *Management Review Quarterly*, *68*(2), 107–143. https://doi.org/10.1007/s11301-018-0135-9

Thompson, S. C. (1999). Illusions of control: How we overestimate our personal influence. *Current Directions in Psychological Science*, *8*(6), 187–190. https://doi.org/10.1111/1467-8721.00044

Thomsen, A. (1941). Psychological projection and the election: A simple class experiment. *The Journal of Psychology*, *11*(1), 115–117. https://doi.org/10.1080/00223980.1941.9917021

Thunholm, P. (2004). Decision-making style: habit, style or both? *Personality and Individual Differences*, *36*(4), 931–944. https://doi.org/https://doi.org/10.1016/S0191-8869(03)00162-4

Tiefenbeck, V., Tasic, V., Fleisch, E., Goette, L., Degen, K., Lalive, R., & Staake, T. (2016). Overcoming salience bias: How real-time feedback fosters resource conservation. *Management Science*, *64*(3), 1458–1476. https://doi.org/10.1287/mnsc.2016.2646

Titchener, E. B. (1895). Affective memory. *The Philosophical Review*, *4*(1), 65–76. https://doi.org/10.2307/2175845

Toet, A., Brouwer, A., Bosch, K., & Korteling, J. E. (2016). Effects of personal characteristics on susceptibility to decision bias. *International Journal of Humanities and Social Sciences*, *8*(5), 1–17.

Toplak, M. E., West, R. F., & Stanovich, K. E. (2014). Rational thinking and cognitive sophistication: Development, cognitive abilities, and thinking dispositions. *Developmental Psychology*, *50*(4), 1037–1048. https://doi.org/10.1037/a0034910

Torraco, R. J. (2005). Writing integrative literature reviews: Guidelines and examples. *Human Resource Development Review*, *4*(3), 356–367. https://doi.org/10.1177/1534484305278283

Torraco, R. J. (2016). Writing integrative literature reviews: Using the past and present to explore the future. *Human Resource Development Review*, *15*(4), 404–428. https://doi.org/10.1177/1534484316671606

Tourangeau, R., & Rasinski, K. A. (1988). Cognitive processes underlying context effects in attitude measurement. *Psychological Bulletin*, *103*(3), 299–314. https://doi.org/10.1037/0033-2909.103.3.299

Tsai, M.-H., Melia, N. V., & Hinsz, V. B. (2019). The effects of perceived decision-making styles on evaluations of openness and competence that elicit collaboration. *Personality and Social Psychology Bulletin*, *46*(1), 124–139. https://doi.org/10.1177/0146167219843934

Tubbs, R. M., Gaeth, G. J., Levin, I. P., & Van Osdol, L. A. (1993). Order effects in belief updating with consistent and inconsistent evidence. *Journal of Behavioral Decision Making*, *6*(4), 257–269. https://doi.org/10.1002/bdm.3960060404

Tullis, T., & Wood, L. (2004). How many users are enough for a card-sorting study. In *Usability Professionals Association (UPA) 2004 Conference, Minneapolis, Minnesota, June 7-11, 2004*.

Tulving, E. (1974). Cue-dependent forgetting. *American Scientist*, *62*(1), 74–82.

Tulving, E., & Psotka, J. (1971). Retroactive inhibition in free recall: Inaccessibility of information available in the memory store. *Journal of Experimental Psychology*, *87*(1), 1–8. https://doi.org/10.1037/h0030185

Tversky, A., & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive Psychology*, *5*(2), 207–232. https://doi.org/10.1016/0010-0285(73)90033-9

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, *185*(4157), 1124–1131. https://doi.org/10.1126/science.185.4157.1124

Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science*, *211*(4481), 453–458. https://doi.org/10.1126/science.7455683

Tversky, A., & Kahneman, D. (1983). Extensional versus intuitive reasoning: The conjunction fallacy in probability judgment. *Psychological Review*, *90*(4), 293–315. https://doi.org/10.1037/0033-295X.90.4.293

Tversky, A., & Kahneman, D. (1986). Rational choice and the framing of decisions. *Journal of Business*, *59*(4), S251–S278.

Tversky, A., & Koehler, D. J. (1994). Support theory: A nonextensional representation of subjective probability. *Psychological Review*, *101*(4), 547–567. https://doi.org/10.1037/0033-295X.101.4.547

Tversky, A., & Shafir, E. (1992). The disjunction effect in choice under uncertainty. *Psychological Science*, *3*(5), 305–309. https://doi.org/10.1111/j.1467-9280.1992.tb00678.x

Tversky, B. (2011). Visualizing thought. *Topics in Cognitive Science*, *3*(3), 499–535. https://doi.org/10.1111/j.1756-8765.2010.01113.x

Tversky, B., & Kessell, A. F. (2014). Thinking in action. *Pragmatics & Cognition*, *22*(2), 206–223. https://doi.org/10.1075/pc.22.2.03tve

Underwood, B. J., & Freund, J. S. (1970). Testing effects in the recognition of words. *Journal of Verbal Learning and Verbal Behavior*, *9*(1), 117–125. https://doi.org/10.1016/S0022-5371(70)80018-4

Usher, J. A., & Neisser, U. (1993). Childhood amnesia and the beginnings of memory for four early life events. *Journal of Experimental Psychology: General*, *122*(2), 155–165. https://doi.org/10.1037/0096-3445.122.2.155

Vaara, E., & Whittington, R. (2012). Strategy-as-practice: Taking social practices seriously. *Academy of Management Annals*, *6*(1), 285–336. https://doi.org/10.5465/19416520.2012.672039

van Brussel, S., Timmermans, M., Verkoeijen, P., & Paas, F. (2020). 'Consider the opposite' – Effects of elaborative feedback and correct answer feedback on reducing confirmation bias – A pre-registered study. *Contemporary Educational Psychology*, *60*, 101844. https://doi.org/10.1016/j.cedpsych.2020.101844

Van den Steen, E. (2017). A formal theory of strategy. *Management Science*, *63*(8), 2616–2636. https://doi.org/10.1287/mnsc.2016.2468

Van Wijk, J. J. (2005). The value of visualization. In *VIS 05. IEEE Visualization 2005* (pp. 79–86). Minneapolis, MN.

Veinott, B., Klein, G. A., & Wiggings, S. (2010). Evaluating the effectiveness of the premortem technique on plan confidence. In *Proceedings of the 7th International ISCRAM Conference*. Seattle.

von Krogh, G. (2018). Artificial intelligence in organizations: New opportunities for phenomenon-based theorizing. *Academy of Management Discoveries*, *4*(4), 404–409. https://doi.org/10.5465/amd.2018.0084

von Restorff, H. (1933). Über die Wirkung von Bereichsbildungen im Spurenfeld. *Psychological Research*, *18*(1), 299–342.

Voss, J. L., Federmeier, K. D., & Paller, K. A. (2011). The potato chip really does look like Elvis! Neural hallmarks of conceptual processing associated with finding novel shapes subjectively meaningful. *Cerebral Cortex*, *22*(10), 2354–2364. https://doi.org/10.1093/cercor/bhr315

Vuori, N., & Vuori, T. (2014). Comment on “Heuristics in the strategy context” by Bingham and Eisenhardt (2011). *Strategic Management Journal*, *35*(11), 1689–1697. https://doi.org/10.1002/smj.2259

Vuori, T. O., & Huy, Q. N. (2016). Distributed attention and shared emotions in the innovation process: How nokia lost the smartphone battle. *Administrative Science Quarterly*, *61*(1), 9–51. https://doi.org/10.1177/0001839215606951

Wagenaar, W. A., & Keren, G. B. (1985). Calibration of probability assessments by professional blackjack dealers, statistical experts, and lay people. *Organizational Behavior and Human Decision Processes*, *36*(3), 406–416. https://doi.org/10.1016/0749-5978(85)90008-1

Wagenaar, W. A., & Sagaria, S. D. (1975). Misperception of exponential growth. *Perception & Psychophysics*, *18*(6), 416–422. https://doi.org/10.3758/bf03204114

Wagenaar, W. A., & Timmers, H. (1979). The pond-and-duckweed problem; Three experiments on the misperception of exponential growth. *Acta Psychologica*, *43*(3), 239–251. https://doi.org/10.1016/0001-6918(79)90028-3

Walker, D., & Vul, E. (2014). Hierarchical encoding makes individuals in a group seem more Aattractive. *Psychological Science*, *25*(1), 230–235. https://doi.org/10.1177/0956797613497969

Walker, W. R., Skowronski, J., Gibbons, J., Vogl, R., & Thompson, C. (2003). On the emotions that accompany autobiographical memories: Dysphoria disrupts the fading affect bias. *Cognition and Emotion*, *17*(5), 703–723. https://doi.org/10.1080/02699930302287

Walker, W. R., & Skowronski, J. J. (2009). The fading affect bias: But what the hell is it for? *Applied Cognitive Psychology*, *23*(8), 1122–1136. https://doi.org/10.1002/acp.1614

Walny, J., Huron, S., & Carpendale, S. (2015). An exploratory study of data sketching for visual representation. *Computer Graphics Forum*, *34*(3), 231–240. https://doi.org/10.1111/cgf.12635

Walters, D. J., Fernbach, P. M., Fox, C. R., & Sloman, S. A. (2017). Known unknowns: A critical determinant of confidence and calibration. *Management Science*, *63*(12), 3999–4446. https://doi.org/10.1287/mnsc.2016.2580

Wang, J. Z. T. R. J. H. (1998). The relation between order effects and frequency learning in tactical decision making. *Thinking & Reasoning*, *4*(2), 123–145. https://doi.org/10.1080/135467898394184

Ward, J. H. (1963). Hierarchical grouping to optimize an objective function. *Journal of the American Statistical Association*, *58*(301), 236–244. https://doi.org/10.1080/01621459.1963.10500845

Washburne, J. N. (1927). An experimental study of various graphic, tabular, and textual methods of presenting quantitative material. *Journal of Educational Psychology*, *18*(7), 465–476. https://doi.org/10.1037/h0070054

Wason, P. C. (1960). On the failure to eliminate hypotheses in a conceptual task. *Quarterly Journal of Experimental Psychology*, *12*(3), 129–140. https://doi.org/10.1080/17470216008416717

Wason, P. C., & Johnson-Laird, P. N. (1972). *Psychology of reasoning: Structure and content. Psychology of reasoning: Structure and content.* Oxford: Harvard University Press.

Watkins, M. J., & Peynircioglu, Z. F. (1990). The revelation effect: When disguising test items induces recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *16*(6), 1012–1020. https://doi.org/10.1037/0278-7393.16.6.1012

Wattanacharoensil, W., & La-ornual, D. (2019). A systematic review of cognitive biases in tourist decisions. *Tourism Management*, *75*, 353–369. https://doi.org/https://doi.org/10.1016/j.tourman.2019.06.006

Waytz, A., Cacioppo, J., & Epley, N. (2010). Who sees human? The stability and importance of individual differences in anthropomorphism. *Perspectives on Psychological Science*, *5*(3), 219–232. https://doi.org/10.1177/1745691610369336

Weber, E. U., & Hsee, C. (1998). Cross-cultural differences in risk perception, but cross-cultural Similarities in attitudes towards perceived risk. *Management Science*, *44*(9), 1205–1217. https://doi.org/10.1287/mnsc.44.9.1205

Weber, M., & Camerer, C. F. (1998). The disposition effect in securities trading: An experimental analysis. *Journal of Economic Behavior and Organization*, *33*(2), 167–184. https://doi.org/10.1016/S0167-2681(97)00089-9

Weinstein, N. D. (1980). Unrealistic optimism about future life events. *Journal of Personality and Social Psychology*, *39*(5), 806–820. https://doi.org/10.1037/0022-3514.39.5.806

Weller, J., Ceschi, A., Hirsch, L., Sartori, R., & Costantini, A. (2018). Accounting for individual differences in decision-making competence: Personality and gender differences. *Frontiers in Psychology*, *9*, 2258. https://doi.org/10.3389/fpsyg.2018.02258

Welsh, M. B., Begg, S. H., & Bratvold, R. B. (2007). Efficacy of bias awareness in debiasing oil and gas judgments. In D. S. McNamara & J. G. Trafton (Eds.), *Proceedings of the 29th Annual Cognitive Science Society* (pp. 1647–1652). Cognitive Science Society.

West, R. F., Meserve, R. J., & Stanovich, K. E. (2012). Cognitive sophistication does not attenuate the bias blind spot. *Journal of Personality and Social Psychology*, *103*(3), 506–519. https://doi.org/10.1037/a0028857

West, R. F., Toplak, M. E., & Stanovich, K. E. (2008). Heuristics and biases as measures of critical thinking: Associations with cognitive ability and thinking dispositions. *Journal of Educational Psychology*, *100*(4), 930–941.

Westerman, D. L., Miller, J. K., & Lloyd, M. E. (2017). Revelation effects in remembering, forecasting, and perspective taking. *Memory & Cognition*, *45*(6), 1002–1013. https://doi.org/10.3758/s13421-017-0710-7

Westerman, G., Calméjane, C., Bonnet, D., Ferraris, P., & McAfee, A. (2011). Digital transformation: A roadmap for billion-dollar organizations. *MIT Sloan Management Review*, 1–68.

Westerman, G., Tannou, M., Bonnet, D., Ferraris, P., & McAfee, A. (2012). The digital advantage: How digital leaders outperform their peers in every industry. *MIT Sloan Management and Capgemini Consulting*, *2*, 2–23.

Westley, F., & Waters, J. A. (1988). Group facilitation skills for managers. *Management Learning*, *19*(2), 134–143. https://doi.org/10.1177/135050768801900207

Westmoreland, S., Schmidt, L., & Ruocco, A. (2011). Analysis of capstone design reports: Visual representations. *Journal of Mechanical Design*, *133*(5), 1–7. https://doi.org/10.1115/1.4004015

Whittington, R. (1996). Strategy as practice. *Long Range Planning*, *29*(5), 731–735. https://doi.org/10.1016/0024-6301(96)00068-4

Wilde, G. J. S. (1982). The theory of risk homeostasis: Implications for safety and health. *Risk Analysis*, *2*(4), 209–225. https://doi.org/10.1111/j.1539-6924.1982.tb01384.x

Wilgosh, L. R. (1970). *The interaction between pictures and their labels in the memory of four-year-old children*. McMaster University, Hamilton.

Williams, B., & Bernard, W. (1981). *Moral luck: Philosophical papers 1973-1980*. Cambridge: Cambridge University Press.

Wilson, T. D., & Brekke, N. (1994). Mental contamination and mental correction: Unwanted influences on judgments and evaluations. *Psychological Bulletin*, *116*(1), 117–142. https://doi.org/10.1037/0033-2909.116.1.117

Wilson, T. D., & Gilbert, D. T. (2005). Affective forecasting: Knowing what to want. *Current Directions in Psychological Science*, *14*(3), 131–134. https://doi.org/10.1111/j.0963-7214.2005.00355.x

Wittenbaum, G. M., Hubbell, A. P., & Zuckerman, C. (1999). Mutual enhancement: Toward an understanding of the collective preference for shared information. *Journal of Personality and Social Psychology*, *77*(5), 967–978. https://doi.org/10.1037/0022-3514.77.5.967

Wolf, Carola, & Floyd, S. W. (2017). Strategic planning research: Toward a theory-driven agenda. *Journal of Management*, *43*(6), 1754–1788. https://doi.org/10.1177/0149206313478185

Wolpe, N., Wolpert, D. M., & Rowe, J. B. (2014). Seeing what you want to see: priors for one's own actions represent exaggerated expectations of success. *Frontiers in Behavioral Neuroscience*, *8*, 232. https://doi.org/10.3389/fnbeh.2014.00232

Wong, G., Greenhalgh, T., Westhorp, G., Buckingham, J., & Pawson, R. (2013). RAMESES publication standards: meta-narrative reviews. *BMC Medicine*, *11*(1), 20–34. https://doi.org/10.1186/1741-7015-11-20

Wood, J., Badawood, D., Dykes, J., & Slingsby, A. (2011). Ballotmaps: Detecting name bias in alphabetically ordered ballot papers. *IEEE Trans Vis Comput Graph*, *17*(12), 2384–2391.

Wulf, F. (1922). Beiträge zur Psychologie der Gestalt. *Psychologische Forschung*, *1*(1), 333–373. https://doi.org/10.1007/BF00410394

Xiong, C., Shapiro, J., Hullman, J., & Franconeri, S. (2020). Illusion of causality in visualized data. *IEEE Transactions on Visualization and Computer Graphics*, *26*(1), 853–862. https://doi.org/10.1109/TVCG.2019.2934399

Yang, M. C., & Cham, J. G. (2007). An analysis of sketching skill and its role in early stage engineering design. *Journal of Mechanical Design*, *129*(5), 476–482. https://doi.org/10.1115/1.2712214

Yankova, K. (2015). *The influence of information order effects and trait professional skepticism on auditors' belief revisions : A theoretical and empirical analysis*. Wiesbaden: Springer Gabler.

Yates, J. F., Jagacinski, C. M., & Faber, M. D. (1978). Evaluation of partially described multiattribute options. *Organizational Behavior and Human Performance*, *21*(2), 240–251. https://doi.org/10.1016/0030-5073(78)90052-1

Yoo, Y., Henfridsson, O., & Lyytinen, K. (2010). Research commentary: The new organizing logic of digital innovation: An agenda for information systems research. *Information Systems Research*, *21*(4), 724–735. https://doi.org/10.1287/isre.1100.0322

Zagury-Orly, I., & Schwartzstein, R. M. (2020). Covid-19 - a reminder to reason. *New England Journal of Medicine*, *383*(3), e12. https://doi.org/10.1056/NEJMp2009405

Zajac, E. J., & Bazerman, M. H. (1991). Blind spots in industry and competitor analysis: Implications of interfirm (mis)perceptions for strategic decisions. *Academy of Management Review*, *16*(1), 37–56. https://doi.org/10.5465/amr.1991.4278990

Zajonc, R. B. (1968). Attitudinal effects of mere exposure. *Journal of Personality and Social Psychology*, *9*, 1–27. https://doi.org/10.1037/h0025848

Zajonc, R. B. (2001). Mere exposure: A gateway to the subliminal. *Current Directions in Psychological Science*, *10*(6), 224–228. https://doi.org/10.1111/1467-8721.00154

Zakay, D., & Block, R. A. (2004). Prospective and retrospective duration judgments: an executive-control perspective. *Acta Neurobiol Exp (Wars)*, *64*(3), 319–328.

Zalewski, A., Borowa, K., & Ratkowski, A. (2017). On cognitive biases in architecture decision making. In A. Lopes & R. de Lemos (Eds.), *Software Architecture. ECSA 2017. Lecture Notes in Computer Science, vol 10475* (pp. 123–137). Cham: Springer. https://doi.org/10.1007/978-3-319-65831-5_9

Zappala, M., Reed, A. L., Beltrani, A., Zapf, P. A., & Otto, R. K. (2018). Anything you can do, I can do better: Bias awareness in forensic evaluators. *Journal of Forensic Psychology Research and Practice*, *18*(1), 45–56. https://doi.org/10.1080/24732850.2017.1413532

Zeigarnik, B. (1927). Das Behalten erledigter und unerledigter Handlungen. *Psychologische Forschung*, *9*, 1–85. https://doi.org/10.1007/BF02409755

Zelenski, J. M., & Larsen, R. J. (2002). Predicting the future: How affect-related personality traits influence likelihood judgments of future events. *Personality and Social Psychology Bulletin*, *28*(7), 1000–1010. https://doi.org/10.1177/014616720202800712

Zvielli, A., Bernstein, A., & Koster, E. H. W. (2014). Temporal dynamics of attentional bias. *Clinical Psychological Science*, *3*(5), 772–788. https://doi.org/10.1177/2167702614551572

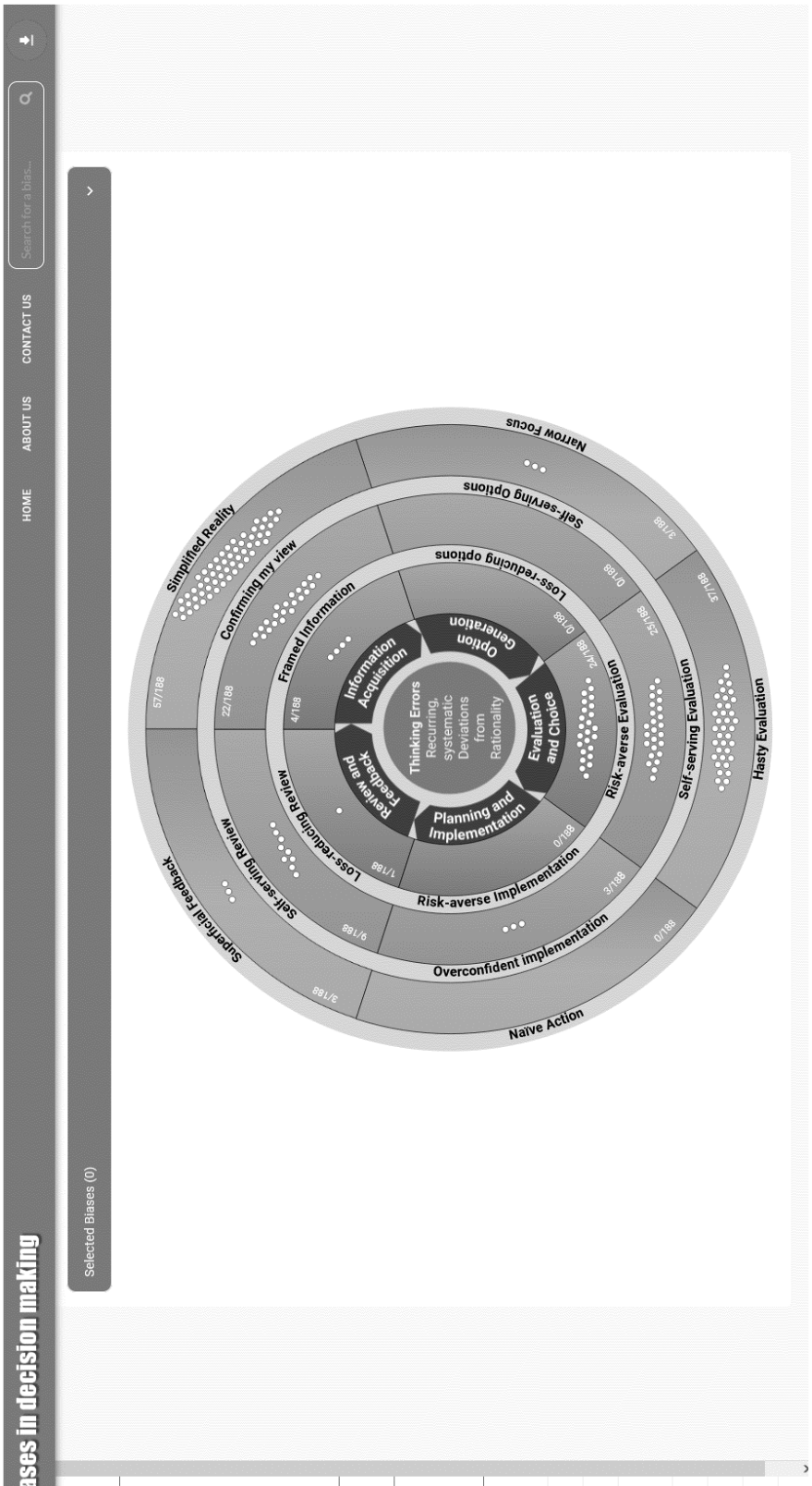
Zwaan, L., & Hautz, W. E. (2019). Bridging the gap between uncertainty, confidence and diagnostic accuracy: calibration is key. *BMJ Quality & Safety*, *28*(5), 352–355. https://doi.org/10.1136/bmjqs-2018-009078

Zwaan, L., Monteiro, S., Sherbino, J., Ilgen, J., Howey, B., & Norman, G. (2017). Is bias in the eye of the beholder? A vignette study to assess recognition of cognitive biases in clinical case workups. *BMJ Quality & Safety*, *26*(2), 104–110. https://doi.org/10.1136/bmjqs-2015-005014

Appendix A: Ideal Types of Cognitive Biases, BIASMAP

Bias Ideal Type	Description
Simplified information acquisition	Biases that lead to (over)-simplified acquisition of information based on the motivation for interpretable and comprehensive reality.
Simplified option generation	Biases that lead to an (over-)simplified generation of alternatives.
Simplified evaluation and choice	Biases that lead to (over-)simplified evaluation and decision rules and as a consequence to (over)-simplified decisions.
Simplified planning and implementation	Biases that (over)-simplify the planning, communicating, and implementing of actions.
Simplified review and feedback	Biases that lead to (over)-simplified feedback and learning cycle based on a decision's outcome.
Self-confirmatory information acquisition	Biases that filter the acquired information towards the reinforcement of a consistent individual's self-view.
Self-confirmatory option generation	Biases that lead to a self-confirmatory generation of alternatives and options.
Self-confirmatory evaluation and choice	Biases that lead judgement and decision rules towards the reinforcement of a consistent individual's self-view.
Self-confirmatory planning and implementation	Biases that lead to plan, communicate, and implement a decision to support and reinforce one's consistent self-view.
Self-confirmatory review and feedback	Biases that flaw feedback and learning cycles by confirming one's existing, consistent self-view.
Loss/Gain lens in information acquisition	Biases that frame information depending on individual's loss/gain perception.
Loss/Gain lens in option generation	Biases that influence the generation of alternatives based on approach or avoidance temperaments
Loss/Gain lens in evaluation and choice	Biases that lead to a deviation in risk-aversion/risk-seeking decisions based on loss/gain-perception.
Loss/Gain lens in planning and implementation	Biases that frame a decision output/implementation.
Loss/Gain lens in review and feedback	Biases that filter feedback and learning cycles in terms of loss/gain.

BIASMAP: bias.visual-literacy.org



Appendix B: Overview of Classified Cognitive Biases

Simplified Information Acquisition

Nr.	Cognitive Bias	Description	Managerial Axis	Psychological Axis	Reference	Mentions*	First mentioned
1.1	Stereotyping	Assuming characteristics of individuals based on the membership of a certain group.	"the impact of ethnicity on interpretation could occur even without participants' awareness. She asked participants to rate a target's ambiguously hostile behavior after subliminally priming them with words related to both the social category and the stereotype of African Americans (but excluding words directly related to violence)." p. 1315	"how faster, more automatic processing along the irrelevant dimension (as suggested by the Stroop research) might bias each stage of relevant processing (the solid arrows)" p. 1326	(Correll, Park, Judd, & Wittenbrink, 2002)	179'000	(Lapiere & Farnsworth, 1936)
1.2	Anthropo-morphism	The tendency to characterize animals, objects, and abstract concepts as possessing human-like traits, emotions, and intentions.	"The anthropomorphic appearance of a product (such as a watch that appears to be smiling when its hands are set to 10:10) can increase liking of that product as well" p. 227	"Cognitive psychologists have examined anthropocentrism as a process of inductive reasoning about biological kinds (Anggoro, Waxman, & Medin, 2008; Waxman & Medin, 2007), and developmental psychologists have assessed children's capacity to perceive humanlike intentions in nonhuman stimuli (Scholl & Tremoulet, 2000) in the trajectory of learning to reason about mental states." p. 220	(Waytz, Cacioppo, & Epley, 2010)	64'600	(Kant, 1788)
1.3	Attentional bias	Weighted extraction of information.	Selective attention to appetitive and aversive stimuli" p. 772	Due to the functional importance of early and fast processing of motivationally relevant information, theories have argued that selective attention will be allocated to emotionally evocative information (Lang,	(Zvielli, Bernstein, & Koster, 2014)	42'400	(Hamilton & Copeman, 1970)

				Bradley, & Cuthbert, 1997; Öhman, Flykt, & Lundqvist, 2000). Dysregulation in this "emotional attention" process – termed attentional bias (AB) – has been linked to a cascade of information processing biases and behaviour" p. 772			
1.4	Halo effect	The tendency to evaluate a person by their overall attractive-ness.	"These results indicate that global evaluations of a person can induce altered evaluations of the person's attributes, even when there is sufficient information to allow for independent assessments of them." p. 250	"a deduction from an implicit personality theory holding that "nice people tend to have nice attributes and less nice people have less nice attributes." Similarly, the global evaluation may alter the interpretation of the meaning or evaluation of ambiguous attributes." p. 250	(Nisbett & DeCamp Wilson, 1977)	29'100	(Knight, 1923)
1.5	Fundamental attribution error (or correspond-dence bias)	The tendency to draw inferences about a person's dispositions from behaviors that can be entirely explained by the situations in which they occur.	"When people observe behavior, they often conclude that the person who performed the behavior was predisposed to do so – that the person's behavior corresponds to the person's unique dispositions." p. 21	"describes 4 mechanisms (lack of awareness, unrealistic expectations, inflated categorizations, and incomplete corrections)" p. 21	(Gilbert & Malone, 1995)	19'850	(Lee Ross, 1977)
1.6	Selection/Surv ivor bias	Unconscious use of inadequate and incomplete samples of data.	"the bias that results from using nonrandomly selected samples to estimate behavioral relationships as an ordinary specification bias that arises because of a missing data problem." p. 153	"Sample selection bias may arise in practice for two reasons. First, there may be self-selection by the individuals or data units being investigated. Second, sample selection decisions by analysts or data processors operate in much the same fashion as self-selection." p. 153	(Heckman, 1979)	18'600	(Blackwell & Hodges, 1957)
1.7	Information bias	Seeking more information even if irrelevant for decision.	"Subjects evaluated questions as worth asking even when there is no answer that can change the hypothesis that will be accepted as a basis for action." p. 88	"a kind of insufficient thinking (Baron, 1985, Chap. 3). The information heuristic results from failure to consider relevance for action." p. 109	(Baron, Beattie, & Hershey, 1988)	9580	(MacRae, 1970)

1.8	Availability bias	Higher estimation of probability if the events are easier to remember.	“instances or associations could be brought to mind” p. 208	“because people estimate combinatorial values by extrapolating from an initial impression” p. 215	(Tversky & Kahneman, 1973)	8870	(Tversky & Kahneman, 1973)
1.9	Base rate fallacy	Ignoring the base rate probability.	“representing events in the form of natural frequencies” p. 242	“An appropriate representation can induce people to substitute reasoning by rules with reasoning by association.” p. 253	(Barbey & Sloman, 2007)	8430 (base rate fallacy & base rate bias & base rate neglect)	(Kahneman & Tversky, 1972)
1.10	Weber-Fechner law	Small differences in large quantities are harder to perceive than vice-versa.	“perceived intensity of a stimulus depends on its context” p. 93	“We can generate exact counts of small collections (one to three objects), in contrast to larger collections, for which we must either create rough estimates or serially count” p. 93	(Choo & Franconeri, 2014)	7710	(Fechner, 1860)
1.11	Illusory correlation	The inaccurate perception of a relation between unrelated events and items.	“These relationships are called "illusory correlations" because the naive Ss reported observing them, although they were actually absent in the experimental materials” p. 272	“These data suggest that whether or not a clinician reports a given category of percepts as a correlate of homosexuality is determined primarily by the strength of its verbal associative connection to the symptom, rather than by objective reality.” p. 274	(Chapman & Chapman, 1969)	6’600	(Chapman, 1967)
1.12	Pareidolia	Tendency to perceive a specific, often meaningful image in a random or ambiguous visual pattern.	“the common tendency to project something not actually present onto a nebulous object like a cloud, shadow, or inkblot is known as ‘‘pareidolia”” p. 2354	“Finding meaning in ambiguous stimuli appears to depend on conceptual evaluation and cortical processing events similar to those typically observed for known objects“ p. 2354	(Voss, Feder-meier, & Paller, 2011)	2170	(Kahlbaum, 1865)
1.13	Anthropo-centric thinking	The tendency to use human analogies as a basis for reasoning about other, less familiar, biological phenomena.	“Although undoubtedly useful for adaptive reasoning and social cognition, anthropocentric thinking can result in misrepresentation of the place of human beings in the natural world.” p. 2	“A cognitive construal is an intuitive, often implicit, way of thinking about the world. It might be a set of assumptions, a type of explanation, or a predisposition to a particular type of reasoning.” p. 2	(Coley, Arenson, Xu, & Tanner, 2017)	1’190	(Kafka, 1936)

1.14	Regressive bias	Observer's overesti-mation of low frequencies and under-estimation of high frequencies.	"observer's appreciation of relevant environmental probabilities" p. 81	"errors were of a lawful nature. Low frequencies were systematically overestimated and high frequencies were systematically underestimated" p. 84	(Attneave, 1953)	390	(Attneave, 1953)
1.15	Clustering illusion	Seeing patterns in random data/noise.	"To the untrained eye," Feller remarks, "randomness appears as regularity or tendency to cluster." P. 436	"It is certainly harder to imagine an uncertain process yielding a nonrepresentative outcome than to imagine the same process yielding a highly representative outcome. The former outcome, of course, produces more surprise, which is a form of mental effort." p. 542	(Kahneman & Tversky, 1972)	299	(Kahneman & Tversky, 1972)
1.16	Women are wonderful effect	More positive attributions are associated to women.	"People of both sexes report greater liking for women than men, due, in part, to viewing women as more communal (the "women are wonderful" effect) ." p. 495	"women having several sources that promote automatic in-group bias (cognitive balance, a match between maternal caregivers and own gender, and male threat beliefs) that are either not shared by men (cognitive balance) or that hinder male preference (maternal nurturance, male threat beliefs). .... These discrepancies help to explain why women show dramatically greater liking for women than men show for men at the automatic level." p. 507	(Rudman & Goodwin, 2004)	234	(Eagly & Mladinic, 1994)
1.17	Group attribution error	Tendency to infer the attitudes of an entire social group strictly based on one group member's behavior and vice-versa.	"our tendency to ignore external determinants of behavior and to assume a correspondence between behavior and some underlying attitude." P. 564	"the same way that people fail to properly weight external constraints on individual behavior, we suggest that they fail to account properly for structural constraints on group decisions when making inferences about people's attitudes from group decisions." p. 565	(Allison & Messick, 1985)	233	(Lee Ross, 1977)
1.18	Complete-ness	The faulty perception of an apparently complete or logical data set and	"Pruned tree subjects clearly did not appreciate how much had been left out, and, as a consequence, they overestimated	"The fact that omission of major branches triggered only minimal awareness of the inadequacies of the pruned tree lent strong support to the availability hypothesis over the	(Fischhoff, Slovic, & Lichtenstein, 1978)	194	(Fischhoff et al., 1978)

		insensitivity to omitted information.	the exhaustiveness of the branches they saw.” p. 335	credibility hypothesis, as did the modest improvement when subjects' attention was focused on completeness.” p. 342/343			
1.19	Out-group homogeneity bias	In-group members perceive their own group as more variegated and complex than do out-group members.	"Stereotypic characteristics were perceived as more prevalent by the out-group than by the in-group whereas counterstereotypic attitudes were perceived as more prevalent by the in-group than by the out-group." p. 1058	“the failure to encode or learn the subordinate attributes of the out-group perpetuates the view of the out-group as relatively homogeneous and undifferentiated".p. 1067	(Park & Rothbart, 1982)	152	(Park & Rothbart, 1982)
1.20	Cheerleader effect	People seem more attractive in a group than in isolation.	“a perception of individual faces as being more attractive than they would otherwise be perceived to be.” p. 230	“these phenomena suggest that individual faces will seem more attractive when presented in a group because they will appear more similar to the average group face, which is more attractive than group members’ individual faces. p. 230	(Walker & Vul, 2014)	108	(Walker & Vul, 2014)
1.21	Scale effect	The perceived variability of data depends on the presentation scale.	“The present studies also demonstrated a clear difference between frequency scales and probability scales. Frequency scales consistently led to lower estimates of the likelihood of harm for a given case.” p. 289	“a framework based upon the notion of probabilistic mental models to explain the probability/frequen-cy discrepancy in terms of different reference classes evoked by the two types of judgments.” p. 290	(Slovic, Monahan, & MacGregor, 2000)	44	(Ricketts, 1990)
1.22	Rhyme as reason effect	Statements that rhyme are perceived as more likely to be true.	“the role that poetic form can play in people’s perceptions of the accuracy of aphorisms as descriptions of human behavior.” p. 424	“Our results suggest that rhyme, like repetition, affords statements an enhancement in processing fluency that can be misattributed to heightened conviction about their truthfulness.” p. 424	(McGlone & Tofigh-bakhsh, 2000)	39	(McGlone & Tofighbakhsh, 1999)

Subcategory Recall/Memory Biases in Simplified Information Acquisition							
1.23	False memory	Imagination is mistaken as memory.	"How accurately do we remember the details of a complex event, like a traffic accident, that has happened in our presence?" p. 585	"we propose that the subject first forms some representation of the accident he has witnessed. The experimenter then, while asking, "About how fast were the cars going when they smashed into each other?" supplies a piece of external information, namely, that the cars did indeed smash into each other. When these two pieces of information are integrated, the subject has a memory of an accident that was more severe than in fact it was." p. 588	(Loftus & Palmer, 1974)	26'400	(Lanza, 1881)
1.24	Suggestibility	Ideas suggested by a questioner are mistaken as memory.	"When tested, misled subjects often claim to have seen things that actually were only suggested." p. 349	"Although these results are not incompatible with the hypothesis that memories from different sources may be integrated, they do contradict the more specific hypothesis that suggestibility consists of newer information updating older memories." p. 355	(Lindsay & Johnson, 1989)	26'100	(Titchener, 1895)
1.25	Serial-positio-ning effect (recency, primacy)	First (primacy) and last (recency) items in a list are best recalled.	"We have presented data to show that the serial position curve of free recall is characterized by a rather steep (possibly exponential) primacy effect, an S shaped recency effect, and a horizontal asymptote extending between the primacy and recency effect." p. 486	One possible explanation is in terms of short-term proactive and retroactive inhibition. That is, each word in a list is both preceded by anywhere from 0 to (L - 1) other words and followed by anywhere from (L - 1) to 0 other words. Up to a point, the more preceding words the more short-term PI and the more succeeding words the more short-term RI. The PI and RI effects presumably summate to determine the total inhibitory effects. p. 488	(Murdock, 1962)	18'800	(Robinson & Brown, 1926)

1.26	Testing effect	Tested information is better recalled.	“Laboratory studies show that taking a test on studied material promotes subsequent learning and retention of that material on a final test (termed the testing effect).” p. 494	“it seems reasonable that both successful retrieval (recall) and processing of feedback after not being able to retrieve the correct answer contributed to the effective use of short answer quizzing in this experiment.” p. 510	(McDaniel, Anderson, Derbish, & Morrisette, 2007)	6’950	(Underwood & Freund, 1970)
1.27	Self-generation effect (or generation effect)	Recall is easier for self-generated content then content simply read.	“the generation effect, or memorial advantage for stimuli that are generated rather than simply read.” p. 669	“The first class consists of explanations that appeal to semantic memory involvement. The second class consists of explanations that attribute the effect to the process of generation itself. For example, generation requires increased arousal or increased cognitive effort. In addition to these two classes, more recently a third class of explanations has attempted to account for the effect as an artifact of displaced.” p. 669	(Crutcher & Healy, 1989)	6’100	(Slamecka & Graf, 1978)
1.28	Spacing effect	Information presented spaced not massed is easier to recall.	“This spacing effect can be found in both memory for laboratory lists and memory for material resembling everyday.” p. 371	“massed items receive deficient processing because they seem familiar when repeated, and subjects believe that these items are already well learned.” p. 375	(Greene, 1989)	5’450	(Peterson, Wampler, Kirkpatrick, & Saltzman, 1963)
1.29	Childhood amnesia	Events from early childhood are harder to recall.	“The life history of any adult begins with a period from which no events are remembered. Although this "childhood amnesia" has been much discussed since Freud (1916/1963) first called attention to it” p. 155	“As noted above, the neural mechanisms serving episodic memory may not be fully mature until about the second birthday. Even in the 3rd and 4th years, only a few specially privileged experiences – here, sibling birth and hospitalization – are likely to persist into adult memory. All other events from this period, even important ones like a death or a move, still fall victim to the pervasive adult amnesia for early childhood. When memories do begin to appear, they are relatively thin and incomplete.” p. 164	(Usher & Neisser, 1993)	4500	(Freud, 1905)

1.30	Tip of the tongue pheno-menon	Recall of parts of an item, but frustratingly not the whole.	“The retrieval of information from memory is a relatively automatic procedure that we take for granted because it usually is quick and effortless. On occasion, however, memory falters: We are sure that the information is in memory but are temporarily unable to access it. The tip-of-the-tongue experience (TOT) is a common label for this difficulty.” p. 204	“Speculations on the cause of the TOT experience have centered around two positions: incomplete activation and blocking. With the incomplete activation viewpoint, the TOT represents a normal word-search process that has been drastically slowed. The word-finding activity is on course but becomes stuck in the vicinity of the target because of insufficient targetword information. In contrast, the blocking perspective suggests that the TOT represents a memory search that has become sidetracked in the wrong memory location.” p. 215	(Brown, 1991)	4’240	(Brown & McNeill, 1966)
1.31	Von Restorff effect	Better recall for distinctive items.	“The isolation effect is a well-known memory phenomenon whose discovery is frequently attributed to von Restorff (1933). If all but one item of a list are similar on some dimension, memory for the different item will be enhanced” p. 105	“Modern theory of the isolation effect emphasizes perceptual salience and accompanying differential attention to the isolated item as necessary for enhanced memory” p. 105	(Hunt, 1995)	3’870	(von Restorff, 1933)
1.32	Picture superiority effect	Images are easier to recall than words.	“Increased memory performance for picture stimuli over word stimuli has been found in countless studies of recall and recognition.” p. 424	“dual-coding theory, which was first proposed by Paivio. Paivio claimed that picture stimuli held an advantage over words because they are dually encoded.” “sensory-semantic theory suggested by Nelson and his. According to Nelson (1979), pictures hold two encoding advantages over words. First, pictures are perceptually more distinct from one another than are words. Therefore, each picture is encoded more uniquely, increasing its chance for retrieval.” p. 424	(McBride & Anne Dosher, 2002)	3’470	(Paivio, 1969)

1.33	Misinforma-tion effect	Accurate recall is influenced by new but wrong information between event and recall.	“The present results show that when participants talk to a confederate about an event that they both witnessed, they are likely to report misinformation introduced by the confederate when later questioned individually.” p. S120	“The present results supported the hypothesis that confederate-present groups who received misinformation would show less accurate memory for the misled items than individuals in the nodiscussion control group. That is, participants incorporated misinformation provided by the confederate into their own individual account.” p. S120	(Paterson, Kemp, & Forgas, 2009)	2’990	(Loftus, 1979)
1.34	Labelling effect/ verbal oversha-dowing	A verbal label on a stimulus raises recall.	“The labelling effect describes cases in which a verbal label is affixed to a stimulus and then exerts its distorting influence in subsequent judgement or recall of that stimulus.” p. 373	“Following up on Carmichael et al (1932), Hanawalt and Demarest (1939) questioned whether the effect of verbal suggestions on the reproductions of visual forms was grounded in a change of the corresponding memory trace or not. They assumed that the labels did not change the memory representation of the perceived forms, but rather, the labels were used as an aid in reconstructing forgotten parts of the figure” p. 378	(Pohl, 2017b)	2’760	(Wilgosh, 1970)
1.35	Reminiscence bump	Older people easier recall early-life/adole-scence memories.	“the disproportionately higher recall of early-life memories – by older adults.” p. 85	“Therefore, "reminiscence effects reflect the availability of a pool of vivid memories from this era" (Fitzgerald, 1988, p. 261; i.e., the effects are due to salience rather than mere nostalgia)” p. 90	(Jansari & Parkin, 1996)	2’060	(Fitzgerald, 1988)
1.36	Zeigarnik effect	Uncompleted or interrupted tasks are remembered better than completed ones.	“After performing all of the tasks, though not always to completion, the subjects were asked to report all of the problems using a free recall method. Zeigarnik found that unfinished tasks were 90% more likely to be recalled than finished ones.” p. 115	“keeping track of the status of problem attempts and being able to use that information in retrieving those past failures would be very useful in the later solution of the interrupted problems. If a goal to solve a problem is not satisfied, information about that failure can be used to preserve and encode the problem keeping track of the	(Seifert & Patalano, 1991)	1’900	(Zeigarnik, 1927)

				status of problem attempts and being able to use that information in retrieving those past failures would be very useful in the later solution of the interrupted problems. If a goal to solve a problem is not satisfied, information about that failure can be used to preserve and encode the problem" p. 119			
1.37	Cryptomnesia	Unintended plagiarism (inspiration mistaken for self-generated).	"Cryptomnesia refers to generating a word, an idea, a song, or a solution to a problem, with the belief that it is either totally original, or at least original within the present context. In actuality, the item is not original, but one which has been produced by someone else (or even oneself) at some earlier time." p. 432	"This deficit is most likely due to the impoverished processing of incoming information as one anticipates his or her impending participation." p. 440	(Brown & Murphy, 1989)	1660	(Jung, 1902)
1.38	Levels-of-processing effect	Deep level processed information is easier to recall.	"deeper encodings took longer to accomplish and were associated with higher levels of performance on the subsequent memory test" p. 268	"A congruous encoding yields superior memory performance because a more elaborate trace is laid down and because in such cases the structure of semantic memory can be utilized more effectively to facilitate retrieval." p. 268	(Craik & Tulving, 1975)	1'340	(Craik & Tulving, 1975)
1.39	Cross-race effect	Superior memory for own-race faces.	"A robust finding in the cross-cultural research is that people's memories for faces of their own race are superior to their memories for other-race faces." p. B1	"To summarize our results, it was found that Caucasian participants demonstrated holistic processing for the recognition of Caucasian faces and featural processing for the recognition of unfamiliar Asian faces. Asian participants demonstrated holistic recognition for both Asian and Caucasian faces. Given that participants in this study had extensive exposure to members of their own race, these findings indicate that	(Tanaka, Kiefer, & Bukach, 2004)	1'310	(Brigham & Malpass, 1985)

				experience of own-race faces promotes holistic processing." p. B7			
1.40	Source confusion	The imagining of an event which never really happened can increase the perceived certainty that it did in fact occur.	"memory illusions and distortions that can contribute to false confessions in which individuals believe they are guilty and create false memories to support those beliefs." p. 567	"Thus, when one's memory for an imagined event is unusually vivid and has little information regarding cognitive operations, such as when the event was relatively easy to imagine, heuristic judgment processes will likely result in an incorrect source attribution in which the imagined event is believed to have been real." p. 571	(Henkel & Coffman, 2004)	1'260	(Belli, 1989)
1.41	Digital amnesia (or google effect)	Harder to recall easy searchable information.	"when people expect to have future access to information, they have lower rates of recall of the information itself and enhanced recall instead for where to access it" p. 776	"when people expect information to remain continuously available (such as we expect with Internet access), they are more likely to remember where to find it than to remember the details of the item. One could argue that this is an adaptive use of memory – to include the computer and online search engines as an external memory system that can be accessed at will" p. 779"	(Sparrow, Liu, & Wegner, 2011)	1194	(Brabazon, 2006)
1.42	Cue-dependent forgetting	Hard to recall memory without information cues.	"Memory for an event is always a product of information from two sources. The first is conceptualized as the memory trace - information laid down and retained in a person's memory store as a result of the original perception of the event. Its postulation is necessary to account for the residual effects of the event. The other source is the retrieval cue - information present in the individual's cognitive environment at the time the retrieval occurs." p. 74	"failure of retrieval of perfect intact trace information. A person's cognitive environment will change over time, the relevant retrieval information is absent, and as a consequence the trace information available in the store becomes inaccessible". p. 74	(Tulving, 1974)	873	(Tulving & Psotka, 1971)

1.43	Revelation effect	Information presented in incomplete form leads to a higher recognition.	"The revelation effect is a robust phenomenon in episodic memory whereby stimuli that immediately follow a simple cognitive task are more likely to garner positive responses on a variety of memory tests, including autobiographical memory judgments." p. 1002	"an enhanced sense of familiarity for the to-be judged item either due to misattributed activation of information in memory or due to an enhanced sense of fluency for the item that follows a revelation task caused by the relative difficulty of the revelation task" p. 1003	(Westerman, Miller, & Lloyd, 2017)	757	(Watkins & Peynircioglu, 1990)
1.44	Telesco-ping effect	The displacement of events in time in recall.	"We found a small backward telescoping effect for recent news events and a large forward telescoping effect for remote events." p. 138	"It successfully predicted the dating formats that people prefer for dating events, and also the difference in size of the telescoping effect between the dating formats, on the basis of the availability of secondary temporal information." p. 146	(Janssen, Chessa, & Murre, 2006)	731	(Shaffer, 1961)
1.45	List-length effect	Items from a longer list are harder to recall.	"The list-length effect refers to the finding that items from a longer list are recognized more poorly than items from a shorter list." p. 232	"Consistent with the assumption that the hit portion of the list-length mirror effect is due to less recollection-based recognition" p. 244	(Cary & Reder, 2003)	703	(Strong, 1912)
1.46	Modality effect (or mode bias)	Recall depends on modality of information.	"The modality effect is participant's superior recall of auditory recency (end) items relative to visual recency items when researchers present stimulus sequences for memorization" p. 84	"Because of the prominence of modality effects in the literature, researchers have developed several theories to explain this persistent phenomenon. These theories include, but are not limited to, the precategorical acoustic storage (PAS) theory, revised PAS theory, working-memory model, separate-streams hypothesis, feature model, and object-oriented episodic record (O-OER) model. "p. 84/85	(Gibbons, Velkey, & Partin, 2008)	693	(Washburne, 1927)
1.47	Continued influence effect	Previous information influences recall even after correction.	"information previously encoded into memory can influence inferences and judgments, even when more recent information discredits it. … The findings suggest that misinformation can still	"our results support the hypothesis that continued influence from misinformation depends on its propensity for becoming involved in causal inferences and does not depend on simple heightened availability in	(Johnson & Seifert, 1994)	534	(Johnson & Seifert, 1994)

			influence inferences one generates after a correction has occurred; however, providing an alternative that replaces the causal structure it affords can reduce the effects of misinformation." p. 1420	memory. Further, having a causal alternative associated with the correction of misinformation decreases, but does not completely eliminate, its influence." p. 1433			
1.48	Leveling and sharpening	The exaggeration and/or weakening of selected characteristics of the original figure in recall.	"subjects draw geometrical figures from memory" p. 488	"which reflect systematic self-governed modifications of the memory trace toward simpler and more regular patterns (''good form'')." p. 488	(Koriat, Gold-smith, & Pansky, 2000)	488	(Wulf, 1922)
1.49	Bizarreness effect	Bizarre items are easier to recall.	"bizarre imagery should lead to better recall in any learning situation that provides a contrast by which bizarre encodings are distinctive relative to other encodings." p. 63	"bizarre imagery enhances memory when there exist common encodings in the learning context so that bizarre encodings become distinctive." p. 63	(McDaniel & Einstein, 1986)	445	(Persensky & Senter, 1970)
1.50	Illusory truth effect	A repeated plausible statement is believed to be true.	"there was a significant increase in the validity judgements for the repeated statements." P. 111	"frequency is a key attribute to memory, playing a fundamental role in discriminating among memories" p. 112	(Hasher, Goldstein, & Toppino, 1977)	395	(Hasher et al., 1977)
1.51	Humor effect	Humorous information is easier to recall.	"that pun humor improved both recall and recognition memory following incidental encoding" p. 376	"multiple constraints available in some materials, such as songs and poems, limit reconstruction and thus aid memory" p. 391	(Summerfelt, Lippman, & Hyman, 2010)	266	(Fry, 1986)
1.52	Survival processing effect	Words processed in a survival context are remembered better than words processed in non-survival contexts.	"Words judged for their relevance in a survival context are remembered better than words processed in non-survival contexts. This phenomenon is known as the survival processing effect." p. 1228	"evidence that human learning and memory systems have been selectively tuned during evolution to process and retain information that is relevant to fitness" p. 1229	(Kroneisen, Rummel, & Erdfelder, 2016)	216	(Nairne, Thompson, & Pandeirada, 2007)

1.53	Next-in-line effect	Hard to recall items just before/after a perfor-mance.	“Subjects who performed tended not to recall words read 9 sec before and after their performance ("scallop effect"), and this loss increased with performance difficulty” p. 320	“The scallop would occur because he attends to performance cues at the expense of other available cues including the cues (words) measured in the experiment. This shift should begin the moment the subject perceives being next in line, perhaps 9 or 7 sec (including retrograde loss) before performing, and from this moment he stops attending to words except as cues to begin his own performance.” p. 322	(Brenner, 1973)	132	(Brenner, 1973)
1.54	Part-list cueing effect	Harder to recall after exposition to subset of the information.	“The provision of context, even to the maximum degree possible, simply did not facilitate recall performance.” p. 510	“He encodes and stores this general representation of the list structure, while at the same time the specific item traces are being stored independently. Later, if free recall is requested, he uses this general representation of the list to form a retrieval plan which then guides his search, more or less successfully, for the independent item traces.“ p. 511	(Slamecka, 1968)	79	(Slamecka, 1968)
1.55	Verbatim effect	Easier to recall gist than exact wording.	“This is behaviorally well documented in studies on memory for prose, in which the meaning of novel sentences is typically well remembered but information pertaining to exact wording and syntax is not. The neural basis of this ‘verbatim effect’ is poorly understood.” p. 909	“Our findings suggest that the verbatim effect can be linked to hippocampally-based novelty-assessment processes that operate based on semantic relationships.” p. 909	(Poppenk et al., 2008)	22	(Anderson & Paulson, 1977)
1.56	Processing difficulty effect	Information which is difficult to understand is easier to recall.	“subjects took longer to comprehend a line of text when it contained an unpredictable target word, but this increased processing time facilitated recognition of the unpredictable word.” p. 12	“when readers encounter concepts that are difficult to integrate, they will reprocess earlier portions of a text in an attempt to integrate the unexpected concept with the text. If successful, this reprocessing will improve memory for selected portions of a text.” p. 12	(O’Brien & Myers, 1985)	21	(O’Brien & Myers, 1985)

1.57	Suffix effect	An irrelevant sound at the end of a list diminishes recency effect in recalling.	“Essentially, the suffix effect removes the advantage of auditory over visual presentation.” p. 169	“The proposed mechanism for the suffix effect is that the suffix overwrites information in PAS before such information can be used (or in some way "protected") by S.” p. 169	(Morton, Crowder, & Prussin, 1971)	11	(Morton et al., 1971)

*Mentions of this bias, based on Google Scholar per September/October 2019

Simplified Option Generation

Nr.	Cognitive Bias	Description	Managerial Axis	Psychological Axis	Reference	Mentions*	First mentioned
2.1	Functional fixedness	Alternative uses of artifacts not imaginable due to traditional use.	“Subjects become ‘‘fixed’’ on the design function of the object, and problem solving suffers relative to control conditions in which the object’s function is not demonstrated.” p. 1	“Converging lines of evidence suggest that cognitive systems underwriting the acquisition and representation of knowledge about artifacts are distinct from those for natural kinds” p. 1	(German & Barrett, 2005)	4’310	(Duncker, 1945)
2.2	Problem-solving set	The tendency to familiar – mechanized – solutions based on the problem set.	“Luchins and Luchins termed this interference "mechanization" in problem solving. In their view, mental set ("Einstellung") was a type of habituated behavior which resulted in the mechanical tendency to persist using familiar solutions when more direct (but new or novel) solutions could be used.” p. 262	“This change from context-dependence to context-independence can be termed "contextual generalization". Contextual generalization in problem solving is the formation of a particular sequence of operations (a rule) from a specific stimulus configuration which is then applied to subsequent problems.” p. 266	(Kearsley, 1975)	1’990	(Luchins, 1942)
2.3	Subtractive neglect	The tendency to overlook subtractive changes or options.	“Low rates of subtraction raise two broad possibilities about the thought processes that produce them: people might generate both kinds of ideas and then disproportionately choose additive ones, or they might overlook subtractive ideas altogether” p. 259	“First, additive changes may be incrementally easier to process. Any component that can be subtracted must first be understood as part of the artefact before it can be considered as ‘not’ part of the artefact. … Second, over time, additive changes may come to be viewed more positively than subtractive changes. …	(Adams, Converse, Hales, & Klotz, 2021)	Not yet**	(Adams et al., 2021)

				Finally, these processes operate in an environment that may, probabilistically, offer more good opportunities to add than to subtract: originals require building before honing; the number of components that can be subtracted is always bound by what exists" p. 259			

*Mentions of this bias, based on Google Scholar per September/October 2019

**Mentions of this bias, based on Google Scholar per January 2021

Simplified Evaluation and Choice

Nr.	Cognitive Bias	Description	Managerial Axis	Psychological Axis	Reference	Mentions*	First mentioned
3.1	Salience bias	The tendency to focus on items that are more prominent.	"some features of a decision are often vivid and perceptible, while others are diffuse and difficult to quantify. This creates a bias in favor of the salient, leading individuals to make suboptimal decisions in both their professional and their private lives." p. 1458	"For instance, the delicious smell and taste of a cake is often more salient than the calories and nutritional aspects of that craving, prompting many individuals to let their dietary resolutions slide. In the corporate world, managers often tend to neglect the cost and duration of ancillary business processes such as compliance, or administrative tasks, as these processes are much less visible to them than the organization's core business." p. 1458	(Tiefenbeck et al., 2016)	132'000	(Nisbett & Ross, 1980)
3.2	Contrast effect	The contrast effect is a change in evaluation because of previous exposure to a similar item different in some characteristics.	"an evaluator's dating decision is negatively correlated with the attractiveness of the prior target even after controlling for current target attributes and the evaluator's own selectiveness." p. 445	"This relationship is confined to recent interactions, consistent with a perceptual error, but not learning or the presence of a quota in affirmative responses." p. 444	(Bhargava & Fisman, 2014)	15'900	(Berkowitz, 1960)

3.3	Negativity bias	Stronger weighting of negative cues in evaluations.	"The predicted preferential weighting for negative and for extreme cues was the major effect" p. 901	"As a strategy of selective effort, such a process makes sense. Perceivers must ration social attention or be overwhelmed. In this instance, people seem to allocate processing time in an adaptive manner." p. 904	(Fiske, 1980)	15'100	(Kanouse & Hanson, 1971)
3.4	Money illusion	The tendency to think in nominal rather than real monetary values.	"We thus interpret money illusion as a bias in the assessment of the real value of economic transactions, induced by a nominal evaluation." p. 348	"People attend to nominal value because it is salient, easy to gauge, and in many cases provides a reasonable estimate of real worth." p. 366	(Shafir, Diamond, & Tversky, 1997)	13'800	(I. Fisher, 1929)
3.5	Magical thinking	The tendency to ignore or denote causal relationships in decisions.	"I shall examine this cognitive-processing perspective on magical thinking by focusing upon everyday personality judgments." p. 638	"Magical thinking is an expression of a cognitive-processing limitation of the human mind. It is that form of noncorrelational reasoning utilized when objects and events conceptually (or semantically) affiliate or exclude one another in our minds." p. 637	(Shweder et al., 1977)	8'210	(Rothbart & Snyder, 1970)
3.6	Imaginability bias	Events that are imaginable are perceived as more likely.	"Prior research has demonstrated that imaging hypothetical future events may render those events subjectively more likely. The suggestion has been made that this effect is due to the increased availability in memory of the events imagined." p. 118	"The results support the notion, that the effect of imagining events or outcomes on judgements of likelihood is mediated by the ease or difficulty of initially making the image available". p. 122	(Sherman, Cialdini, Schwartzman, & Reynolds, 1985)	8'190	(Tversky & Kahneman, 1973)
3.7	Conjunction fallacy	A conjunction P(A&B) appears more probable than its constituents P(A) and P(B).	"how lay people and experts evaluate the probabilities of uncertain events" p. 293	"natural assessments that are routinely carried out" p. 294	(Tversky & Kahneman, 1983)	7'240	(Tversky & Kahneman, 1983)
3.8	Regression towards the mean	The tendency to ignore the regression towards the mean in predictions.	"when a prediction is based on information of imperfect predictability, it should be regressed toward the mean of the distribution of the uncertain event; the lower the predictability, the greater the magnitude of the regression should be.	"The reason for this is, of course, that the sole criterion is perceived similarity. Normatively important considerations such as base rates, data reliability, and data predictability are ignored. These departures from Bayes' Theorem are important when	(Joyce & Biddle, 1981)	6'170	(Galton, 1886)

			Only when the information has perfect predictive ability should the prediction be nonregressive." p. 328	different decisions result from the different probability judgments, and these decisions have materially different expected payoffs." p. 324			
3.9	Linear bias (or exponential growth bias)	The tendency to underestimate exponential future growth.	"underestimation of exponential growth." p. 239	The results show that underestimation of growth becomes worse when the number of updatings increases from 3 to 7: the more information, the worse the extrapolation. This effect can also be observed in every-day life when changes are more readily detected by people that have been away a long time. The absence of significant interactions with b and t,, suggests that the Ss used a quantity sampling strategy." p. 249	(Wagenaar & Timmers, 1979)	4'000	(Wagenaar & Sagaria, 1975)
3.10	Gambler's fallacy/ Monte Carlo fallacy	The gambler's fallacy is the expectation of a reversal following a run of a particular outcome.	"The gambler feels that the fairness of the coin entitles him to expect that any deviation in one direction will soon be cancelled by a corresponding deviation in the other." p.194	"people overestimate how similar a small sample will be to the characteristics of a population" p. 194 "the heart of the gambler's fallacy is a misconception of the fairness of the laws of chance". p. 194	(Roney & Sansone, 2015)	3'290	(Jarvik, 1951)
3.11	Curse of knowledge	The tendency of experts to assume that novices have the same knowledge.	"The informed participants were asked to predict what uninformed participants would estimate as the companies' earnings for the additional year, and in doing so failed to fully ignore their privileged information. That is, they were biased in their predictions - 'cursed', so to speak, by the privileged knowledge they possessed." p. 447	"the curse of knowledge is the by-product of an otherwise adaptive learning system... These researchers argue that our brains are geared toward acquiring knowledge (not ignoring it!) and readily integrate new information or update old information. Although this routine updating may worsen perspective taking, it serves an adaptive function by keeping track of new events and focusing our cognitive resources towards the most up-to-date information." p. 448	(Birch, Brosseau-Liard, Haddock, & Ghrear, 2017)	2'720	(Camerer, Loewenstein, & Weber, 1989)

3.12	Hot-hand fallacy	Believing that the chance of hitting is greater following a hit than following a miss.	“tend to take more shots than they normally would” p. 302	“People’s intuitive conceptions of randomness depart systematically from the laws of chance” p. 296	(Gilovich, Vallone, & Tversky, 1985)	2’710	(Gilovich et al., 1985)
3.13	Focusing illusion	The tendency to focus to much on a subset of the information.	“When a judgment about an entire object or category is made with attention focused on a subset of that category, a focusing illusion is likely to occur, whereby the attended subset is overweighted relative to the unattended subset.” p. 340	“The psychological explanation of the illusion is that it is difficult or impossible to simultaneously allocate appropriate weights to considerations that are at the focus of attention and to considerations that are currently in the background.” p. 345	(Schkade & Kahneman, 1998)	2’610	(Schkade & Kahneman, 1998)
3.14	Illusion of validity	People predict the outcome that appears most representative of the evidence not according to probability.	"people often predict by selecting the outcome (for example, an occupation) that is most representative of the input (for example, the description of a person)." p. 1126	"The internal consistency of a pattern of inputs is a major determinant of one's confidence in predictions based on these inputs." p. 1126	(Tversky & Kahneman, 1974)	2’220	(Kahneman & Tversky, 1973)
3.15	Empathy gap	Decisions influenced by a current emotional state and the overestimation of how long this current state will be present.	“transformations wrought by affect have important consequences for decision making” p. S49	“under the influence of affect, maximizing short-term gratification with inadequate attention to long-term consequences … Because people who are in “cold” states tend to underestimate the motivational force of their own future hot states” p. S49	(Loewenstein, 2005)	2’170	(Loewenstein, 1996)
3.16	Projection bias	The tendency to assume that future tastes or preference will be the same as today.	“People exaggerate the degree to which their future tastes will resemble their current tastes. We present evidence from a variety of domains which demonstrates the prevalence of such projection bias.” p. 1209	“which suggests that underappreciation of adaptation plays a significant role in the discrepancy.” p. 1213	(Loewenstein, O’Donoghue, & Rabin, 2003)	2’100	(Loewenstein et al., 2003)
3.17	Unit bias	The tendency to believe that an existing an offered unit of some entity is the appropriate	“Unit bias is a sense that a single entity (within a reasonable range of sizes) is the appropriate amount to engage, consume, or consider.” p. 521	“A second account attributes unit bias to cultural norms and learning. That is, cultures package things in natural consumption units. … Consumption norms	(Geier, Rozin, & Doros, 2006)	2’000	(Geier et al., 2006)

		and optimal amount for consumption.		promote both the tendency to complete eating a unit and the idea that a single unit is the proper portion." p. 524			
3.18	Automation bias	Decisions rely on automated aids without reflection.	"According to Mosier and Skitka (1996), the availability of automated aids can lead the user to make decisions that are not based on a thorough analysis of all available information but that are strongly biased by the automatically generated advice, a phenomenon that they have referred to as "automation bias." p. 59	"Instead, it seems that they were related to a more subtle sort of automation induced bias in information processing that was reflected not in an obvious neglect of automation verification but in a withdrawal of attentional resources from processing the available (and looked-at) system data." p. 76	(Manzey, Reichenbach, & Onnasch, 2012)	1'750	(Mosier, Skitka, Burdick, & Heers, 1996)
3.19	Identifiable victim effect	The tendency to offer more (help, donations) to clearly identifiable victims.	"The identifiable victim effect (IVE) refers to individuals' tendency to offer greater help to specific, identifiable victims than to anonymous, statistical victims." p. 199	"identifiable victims represent highly concentrated distributions of risk within a specific reference group. In effect, identifiable victims become their own reference group" p. 238	(Lee & Feeley, 2016)	1'160	(Jenni & Loewenstein, 1997)
3.20	Ballot names bias/ballot order effect	The order of names influences voting choices.	"the degree to which the position of a candidate's name on the ballot paper influences the number of votes received by the candidate" p. 2384	"Krosnick proposed the theory of recency and primacy when looking at how choices are made from a selection when presented sequentially in time (recency) and in space (primacy)" p. 2385	(Wood, Bada-wood, Dykes, & Slingsby, 2011)	1'150	(Avichai, 1979)
3.21	Similarity bias	The tendency to judge probability of events by perceived similarity.	"This supports the position that subjects in both the probability-judgement groups were basing their orderings largely on similarity". p. 72	"a small study by which representativeness was ranked" p. 70	(Bar-Hillel, 1982)	1'150	(Bar-Hillel, 1974)
3.22	Isolation effect	The focus on randomly perceived distinctive components of choices.	"This approach to choice problems may produce inconsistent preferences, because a pair of prospects can be decomposed into common and distinctive components in more than one way, and different decom-positions sometimes lead to different preferences. We refer to this	"In order to simplify the choice between alternatives, people often disregard components that the alternatives share, and focus on the components that distinguish them." p. 271	(Kahneman & Tversky, 1979)	1'050	(Kahneman & Tversky, 1979)

			phenomenon as the isolation effect." p. 271				
3.23	Overprecision (an aspect of overconfi-dence)	Overconfidence in one's quality of judgement.	"An excessive faith in the quality of our judgment – what we will call overprecision – is a form of overconfidence." (Moore, Tenney, & Haran, 2015, p. 182)	"Despite their excessive width, people look overprecise by traditional measures because their estimates are so bad. This result strongly suggests that overprecision is attributable to people's failure to accurately calibrate the error distributions around their own beliefs." (Moore, Carter, & Yang, 2015, p. 119)	(Moore, Carter, et al., 2015; Moore, Tenney, et al., 2015)	867 (Overcon-fidence: 113'000)	(Moore & Healy, 2008) Overcon-fidence: (Lichtenstein & Fischhoff, 1977)
3.24	Insensitivity to sample size	Ignoring the sample size in probability estimation.	"Evaluate the probability of obtaining a particular result" p. 1125	"This fundamental notion of statistics is evidently not part of people's repertoire o intuitions" p.1125	(Tversky & Kahneman, 1974)	757	(Tversky & Kahneman, 1974)
3.25	Negative creativity bias (or bias against creativity)	The tendency to assess creative ideas as more negative.	"The results of both experiments demonstrated the existence of a negative bias against creativity (relative to practicality) when participants experienced uncertainty. Furthermore, this bias against creativity interfered with participants' ability to recognize a creative idea. These results reveal a concealed barrier that creative actors may face as they attempt to gain acceptance for their novel ideas." p. 13	"Our results show that regardless of the degree to which people are open minded, when they feel motivated to reduce uncertainty (either because they have an immediate goal of reducing uncertainty or they feel uncertain generally), they may experience more negative associations with creativity, which results in lower evaluations of a creative idea." p. 16	(Mueller, Melwani, & Goncalo, 2011)	437	(Mueller et al., 2011)
3.26	Distinction bias	The tendency to view two options as more dissimilar when evaluating them simultaneously than when evaluating them separately.	"Our analysis of JE and SE implies that when people predict how much of a difference two values – for example, two salary levels – will make to their happiness, they are likely to overpredict the difference. We refer to this overprediction effect as the distinction bias". p. 682	"Choices and predictions are often made in the joint evaluation (JE) mode, in which the choosers or predictors compare multiple options or scenarios. On the other hand, the actual experience typically takes place in the single evaluation or separate evaluation (SE) mode, in which experiencers face only the option or scenario they or others have chosen for them. Because of the JE/SE	(Hsee & Zhang, 2004)	380	(Hsee & Zhang, 2004)

				difference, people in JE may overpredict the experiential difference between alternatives in SE." p. 681			
3.27	Trait ascription bias	The tendency to see own traits as variable and traits of others as predictable.	"perceiving the present versus the past or future self can lead people to perceive themselves in the past and future in a way that is more observer-like than actor-like." p. 197	"Although Jones and Nisbett emphasized differences in availability or salience of information, they also noted differences in access to information, such as that "[t]ypically, the actor has more, and more precise, information than the observer about his own emotional states and his intentions" (p. 85)." p. 206	(Pronin & Ross, 2006)	309	(Pronin & Ross, 2006)
3.28	Surrogation	Imitate measures of a goal as the goal.	"To the extent that those scores imperfectly measure customer satisfaction, managers' strategy-related judgments and decisions may be flawed if they surrogated customer satisfaction with the survey scores." p. 106	"Attribute substitution occurs when an individual has a judgment to make regarding a complex "target attribute," and instead relies on a more easily accessible "heuristic attribute" in his judgment process. A key condition necessary for attribute substitution (and, in turn, for surrogation) to occur is the relative inaccessibility of the target attribute (the strategic construct)." p. 106	(Choi, Hecht, & Tayler, 2013)	304	(Choi, Hecht, & Tayler, 2012)
3.29	Certainty bias	The tendency to look for decision heuristics providing certainty to rule some hypothesis in or out.	"Certainty bias involves overattention to the probability of ruling some hypothesis in, or out, with certainty." p. 90	"people might adopt a simplifying heuristic, in which they ask simply how likely a question is to establish or rule out one or more hypotheses with 100% certainty. We call this the certainty heuristic." p. 90	(Baron et al., 1988)	258	(Theil, 1956)
3.30	Opportunity cost neglect	The tendency to neglect opportunity costs in decisions.	"As a first step, we chose instead to investigate whether individuals in an experimental situation would rely on OC if information about them was provided." p. 317	"If decision makers behave as did our S's, we are left with the interesting question of why. They either ignore or treat opportunity costs as inferior to outlay costs when normative economic models, say, opportunity and outlay costs, are equivalent." p. 327	(Becker, Ronen, & Sorter, 1974)	256 (Opportu-nity costs in decision making: 131'000)	(Becker et al., 1974)

3.31	Zero-risk bias	The proportion of risk reduction is weighted stronger than the absolute risk reduction.	"Several studies have found that people want to give priority to large proportional reductions of small risks, even though the absolute reduction is small relative to other options." p. 1151	"People worry more about the proportion of risk reduced than about the number of people helped. This may be part of a more general confusion about quantities." p. 1151	(Baron, 2003)	188	(Baron, Gowda, & Kunreuther, 1993)
3.32	Appeal to novelty (argumentum ad novitatem)	The tendency to prefer newer options over older.	"people prefer the newer option across a range of domains" p. 506	"We propose a newness as heuristic hypothesis to explain our finding: in tasks involving the complexity of assessing probabilities and predicting values (Tversky and Kahneman 1974), people will use newness a shortcut to resolve choice difficulty." p. 506	(Jie & Li, 2016)	170	(Risen & Gilovich, 2006)
3.33	Subadditivity effect	The overall probability is estimated as less than the (added) probabilities estimations of the sub-parts.	"to evaluate the probability of uncertain events" p. 574	"When people assess their degree of belief in an implicit disjunction, they do not normally unpack the hypothesis into its exclusive components and add their support, as required by extensionality. Instead, they tend to form a global impression that is based primarily on the most representative or available cases." p. 549	(Tversky & Koehler, 1994)	121	(Shanteau, 1974)
3.34	Time-saving bias	Overestimation of time savings by increased speed.	"biases unaided decisions about traffic planning" p. 503	"this heuristic simplifies to the Ratio rule" p. 501	(Svenson, 2008)	104	(Svenson, 2008)
3.35	Zero-sum bias	The tendency to perceive decisions as zero-sum game (one's gain, another one's losses).	"reasoning error is due to a zero-sum perspective on evidence, wherein people assume that evidence that supports one causal hypothesis must disconfirm its competitor." p. 250	this error is based on the misconception of evidential support as a finite, shared resource across the hypotheses under contention. This zero-sum conceptualization of support is appropriate only if hypotheses truly are both exclusive and exhaustive." p. 252	(Pilditch, Fenton, & Lagnado, 2019)	76	(Meegan, 2010)
3.36	Less is better effect	The preference of the lesser option in separate	"This less-is-better effect occurred only when the options were evaluated	"These results are explained in terms of the evaluability hypothesis, which states that	(Hsee, 1998)	63	(Hsee, 1998)

		but not joint evaluations.	separately, and reversed itself when the options were juxtaposed." p. 107	separate evaluations of objects are often influenced by attributes which are easy to evaluate rather than by those which are important." p. 107			
3.37	Well-travelled road effect	Underestimation of the difficulty of repeating a familiar task and overestimation of the difficulty of a novel task.	"experienced duration depends on attention to temporal information, which competes with attention to nontemporal information. When a person is not aware that a duration judgment must be made until later (retrospective paradigm), remembered duration depends on incidental memory for temporal information." p. 319	"experienced duration decreases as the difficulty of the nontemporal information-processing task increases." p 320	(Zakay & Block, 2004)	19	(Zakay & Block, 2004)

*Mentions of this bias, based on Google Scholar per September/October 2019

Simplified Planning and Implementation

No cognitive biases were classified into this category.

Simplified Review and Feedback

Nr.	Cognitive Bias	Description	Managerial Axis	Psychological Axis	Reference	Mentions*	First mentioned
5.1	Moral luck	Moral blame depends on outcome not just intent and action.	"judgements of deserved punishment for failed attempts to harm are mitigated when the intended harm coincidentally occurs by some independent mechanism, relative to when the harm does not occur at all." p. 375	"the present study provides evidence for a distinction between two processes of moral judgment, one which assesses causal responsibility for harm and another which assesses culpable mental states." p. 376	(Cushman, 2008)	12'800	(Williams & Bernard, 1981)
5.2	Outcome bias	The tendency to evaluate decisions and decision makers only by outcome.	"Outcome Bias in Decision Evaluation - this effect of outcome knowledge on evaluation" p. 569	"Our results suggest that people may confuse their evaluations of decisions with the evaluations of the consequences themselves." p. 578	(Baron & Hershey, 1988)	5'580	(Rosenthal, Persinger, Vikan-Kline, & Fode, 1963)

5.3	Duration neglect (peak-end rule)	In evaluating prior experiences people neglect the duration.	“The central finding of the present research was that the duration of affective episodes had little effect on people's retrospective evaluations of their experiences.” p. 54	“Although people may be aware of duration and consider it important in the abstract, we suggest that what comes most readily to mind in evaluating episodes are the salient moments of those episodes and the affect associated with those moments.” p. 54	(Fredrickson & Kahneman, 1993)	2’460	(Fredrickson & Kahneman, 1993)

*Mentions of this bias, based on Google Scholar per September/October 2019

Self-confirmatory Information Acquisition

Nr.	Cognitive Bias	Description	Managerial Axis	Psychological Axis	Reference	Mentions*	First mentioned
6.1	Confirmation bias	Favoring of information that confirms rather disconfirms preferred beliefs.	“Confirmatory bias is the tendency to emphasize and believe experiences which support one's views and to ignore or discredit those which do not.” p. 161	“This refers to the tendency for humans to seek out, attend to, and sometimes embellish experiences which support or "confirm" their beliefs. Confirmatory experiences are selectively welcomed and granted easy credibility. Disconfirmatory experiences, on the other hand, are often ignored, discredited, or treated with obvious defensiveness.” p. 161	(Mahoney, 1977)	34’700	(Wason & Johnson-Laird, 1972)
6.2	Naïve realism	The belief that WE see reality objectively.	“Out of all the occurrences going on in the environment, a person selects those that have some significance for him from his own egocentric position in the total matrix.” p. 133	“We behave according to what we bring to the occasion, and what each of us brings to the occasion is more or less unique. And except for these significances which we bring to the occasion, the happenings around us would be meaningless occurrences, would be "inconsequential." p. 133	(Hastorf & Cantril, 1954)	8’410	(Lenzen, 1934)

6.3	Not invented here syndrome	The tendency to value items from an external source negatively.	“The not-invented-here syndrome (NIH) describes a negative attitude toward knowledge (ideas, technologies) derived from an external source.” p. 193	“These examples are all characterized by an individual attempt to defend self-perception, rank, or status.” p. 197	(Antons & Piller, 2015)	8’180	(Shycon, 1973)
6.4	False consensus effect	The overestimation of the agreement of others with one’s own opinion.	"that raters’ perceptions of social consensus and their social inferences about actors reflect the raters’ own behavioral choices." p. 294	"His intuitive estimates of deviance and normalcy, and the host of social inferences and interpersonal responses that accompany such estimates, are systematically and egocentrically biased in accord with his own behavioral choices." p. 295	(Ross, Greene, & House, 1977)	6’510	(Ross et al., 1977)
6.5	Third-person effect	The tendency to see others more affected by mass media than oneself.	“the third-person hypothesis: that an individual who is exposed to a persuasive communication via the mass media will see this communication as having a greater effect on other people than in himself or herself.” p. 4	“But if the third-person effect hypothesis is correct, why are not the facts and the arguments on the "correct" side as well as the "wrong" side seen as having a disproportionate effect on others? Perhaps the material on the "correct" side is not seen as persuasive at all; it is merely a statement of the obvious and therefore cannot be expected to have an impact on attitudes.” p. 11	(Davison, 1983)	6’220	(Davison, 1983)
6.6	Positivity effect	Positive events are easier to recall than negative ones (especially for older people).	“This positivity effect in older adults’ memories” p. 496	“In summary, older adults show positivity biases in memory that manifest themselves in a variety of ways, including selectively remembering a higher proportion of positive stimuli and a lower proportion of negative stimuli than younger adults do, attributing remembered choice features to options in ways that should satisfy emotional goals, and reconstructing autobiographical memories so they seem more positive than they actually were. These biases help	(Mather & Carstensen, 2005)	5’330	(Shaw, 1971)

				improve the moods of older people." p. 500			
6.7	Hostile attribution bias	The tendency to read ambiguous intends as hostile.	"aggressive children display a marked attributional bias to infer hostile intent following a peer-instigated negative event (e.g., being pushed while waiting in line), particularly when the cause of the event is portrayed as." p. 731	"Aggressive youths were also more likely to state that they would feel angry toward the peer and to endorse hostile behavioral alternatives" p. 738	(Graham, Hudley, & Williams, 1992)	4'210	(Dodge & Coie, 1987)
6.8	Self-reference effect	Self-related information is easier to recall.	"In two experiments, incidental recall of the rated words indicated that adjectives rated under the self-reference task were recalled the best. These results indicate that self-reference is a rich and powerful encoding process." p. 677	"The central aspect of self-reference is that the self acts as a background or setting against which incoming data are interpreted or coded." p. 678	(Rogers, Kuiper, & Kirker, 1977)	3'020	(Rogers et al., 1977)
6.9	Mood-congruent memory	Memories are elicited congruent to mood.	"The mood-congruent memory effect states that happy people will better remember happy than sad materials, whereas sad people will better remember sad than happy materials (or remember such materials equally)." p. 736	"According to one influential version of the theory, a subset of such nodes represents individual moods such as happiness and sadness. As a person enters a given mood, the mood's correspondent node in memory is activated, and that activation spreads to associated concepts, thereby assisting in the encoding and/or retrieval of mood-associated ideas (which are typically mood-congruent)." p. 737	(Mayer, McCormick, & Strong, 1995)	2'570	(Gilligan & Bower, 1983)
6.10	Just-world hypothesis	The tendency to believe that people get what they deserve.	"These behaviors range from helping or compensating the victim to psychological rationalization of the victim's fate—for example, perceiving the victim's fate as deserved (and, therefore, less unfair) because of her unworthy character." p. 129	"when the notion of a just world is threatened by contrary evidence, like the innocent victim in Lerner and Simmons's experiment, people may engage in a variety of behaviors that help to maintain a sense of justice" p. 129	(Hafer & Begue, 2005)	2'140	(Lerner & Simmons, 1966)

6.11	Ultimate attribution error	The tendency to attribute failures of outgroup people to behavior or personality and of ingroup people to situation.	“when prejudiced people perceive what regard as a negative act by an outgroup member, they will more than others attribute it dispositionally, often as genetically determined, in comparison with to the same act by an ingroup member” p. 461	“They have generally attributed such positive behavior as dispositionally caused, as further evidence of their being decent, upstanding human beings. Yet it is precisely this mode of explanation that is now in conflict with their established conceptions of the disliked group.” p. 465	(Pettigrew, 1979)	2’110	(Pettigrew, 1979)
6.12	Backfire effect	Individual beliefs get stronger after a correction attempt.	“Results indicate that corrections frequently fail to reduce misperceptions among the targeted ideological group. We also document several instances of a ‘‘backfire effect’’ in which corrections actually increase misperceptions.” p. 303	“Specifically, people tend to display bias in evaluating political arguments and evidence, favoring those that reinforce their existing views and disparaging those that contradict their views.” p. 307	(Nyhan & Reifler, 2010)	1’910	(Tourangeau & Rasinski, 1988)
6.13	Consistency bias (or self-consistency bias)	The belief that we are more consistent in our attitudes, opinions, and beliefs than we actually are.	“The term “consistency bias” refers to people’s tendency to judge their own interpersonal behavior in a given situation in accordance with their general self-images, even if their actual behavior in the situation is partial led out.” p. 137	“The consistency bias may be rooted in self-concept stability. It is likely to inflate estimates of consistency across self-reports of interpersonal behavior” p. 137	(Leising, 2011)	1’850	(Sadler & Woody, 2003)
6.14	False unique-ness	The tendency to qualify individual traits as unique, even when they are not.	“the perception that one's attributes are more unique than is the case.” p. 211	“false-uniqueness effect was found on the part of low-fear subjects, as they tended to underestimate the incidence of low fear among their peers. These findings are consistent with a motivational interpretation that emphasizes the individual's need to justify or normalize stigmatized behavior and to bolster perceived self-competence.” p. 211	(Suls & Wan, 1987)	1’500	(Perloff & Brickman, 1982)
6.15	Barnum effect (Forer effect, subjective validation)	High accuracy ratings for vague and very general personality descriptions.	“The term "Barnum effect," … refers to the phenomenon whereby people willingly accept personality interpretations comprised of vague statements with a high base-rate	“This finding is consistent with recent theory and research suggesting that in certain situations individuals prefer to be unique from others rather than similar to them.” p. 108	(Snyder, Shenkel, & Lowery, 1977)	1’470	(Meehl, 1956)

			occurrence in the general population." p. 104				
6.16	Illusion of transparency	The overestimation of the insights others have in one' own mental state.	"to an illusion of transparency,or a belief that their thoughts, feelings, and emotions are more apparent to others than is actually the case". p. 618	"These individuals may anchor on their internal sensations of anxiety, correct insufficiently for the fact that others are less privy to those sensations than they are themselves, and consequently overestimate the extent to which their anxiety is apparent to onlookers. " p. 619	(Savitsky & Gilovich, 2003)	1'400	(Savitsky, 1997)
6.17	IKEA effect	Item connected to self-effort are higher valued.	"IKEA effect – the increase in valuation of self-made products." p. 453	"self-assembly of products may allow people to both feel competent and display evidence of that competence – their creation – thus permitting them to signal desired attributes to themselves and others." p. 459	(Norton, Mochon, & Ariely, 2012)	1'030	(Norton et al., 2012)
6.18	Illusion of explanatory depth	The tendency to believe that we understand complex phenomena better than we really do.	"People feel they understand complex phenomena with far greater precision, coherence, and depth than they really do" p. 521	"In short, if people have a drive for coherence and sense coherence when it emerges in a set of beliefs, they may confuse that sense of coherence with a more detailed understanding. Indeed, this may be a more accurate way of characterizing the levels-of-understanding confusion." p.557	(Rozenblit & Keil, 2002)	842	(Rozenblit & Keil, 2002)
6.19	Actor-observer asymmetry	The tendency of actors to explain and verify their behavior due to the situation.	"perceptual differences between active and passive observers in a conflict situation." p. 503	"The pervasive tendency for people to wish to believe that they have environmental control is an integral postulate in a number of psychological theories." p. 512	(Miller & Norman, 1975)	622	(Jones & Nisbett, 1971)
6.20	Defensive attribution hypothesis	People attribute less responsibility for negative outcomes to people perceived similar.	"when subjects are asked to consider the responsibility of a person whose imputed personal characteristics are similar to their own, they are more lenient both in the attribution of responsibility and in	"Assuming that self-protective attribution of responsibility will take place whenever a perceiver is confronted by a relevant, negative outcome" p. 102	(Shaver, 1970)	603	(Shaver, 1970)

			other judgments of the situation than when the characteristics imputed to the stimulus person are different from their own." p. 108				
6.21	Fading affect bias	Negative emotions fade more than positive ones.	"The net result of the FAB is the relative preservation of positive emotions over negative emotions in autobiographical memory." p. 1125	"This emerges when one considers autobiographical memory to serve an important function as part of an emotion-regulating self-system that is oriented towards: (a) promoting a positive view of the self; (b) promoting an optimistic view of the world; (c) strengthening peoples' connections with others." p. 1124	(Walker & Skowronski, 2009)	600	(Walker, Skowronski, Gibbons, Vogl, & Thompson, 2003)
6.22	Illusion of asymmetric insight	The belief that one knows more about others than others know about oneself.	"People, it is hypothesized, show an asymmetry in assessing their own interpersonal and intrapersonal knowledge relative to that of their peers. Six studies suggested that people perceive their knowledge of their peers to surpass their peers' knowledge of them." p. 639	"The more general theoretical point to be made is that a variety of cognitive and perceptual factors may produce assessments of self relative to others that, more often than not, are self-enhancing in their consequences." p. 652	(Pronin, Kruger, Ross, & Savitsky, 2001)	147	(Pronin et al., 2001)

*Mentions of this bias, based on Google Scholar per September/October 2019

Self-confirmatory Option Generation

Nr.	Cognitive Bias	Description	Managerial Axis	Psychological Axis	Reference	Mentions*	First mentioned
7.1	Insight bias	The tendency to undervalue persistence and overvalue insight in the creative process	"This research found that people consistently underestimated how many ideas they would generate during the second round" p.6	"One explanation relates to the subjective experience of idea generation itself. Specifically, the feeling of effortfulness experienced while generating ideas (also called metacognitive fluency). … This more pleasant experience	(Lucas & Nordgren, 2022)	Not yet	(Lucas & Nordgren, 2022)

				of insight, versus persistence, leads people to think and feel more positively about insight" p.7			

*Mentions of this bias, based on Google Scholar per February 2022

Self-confirmatory Evaluation and Choice

Nr.	Cognitive Bias	Description	Managerial Axis	Psychological Axis	Reference	Mentions*	First mentioned
8.1	Illusion of control	The tendency to overestimate one's influence in externally driven events.	"people often overestimate their control even in situations governed purely by chance." p. 187	"Because the benefits of believing oneself to have control (e.g., positive mood and increased motivation) may be realized even if one's control is illusory, it seems reasonable to suggest that people are often motivated to overestimate their control." p. 189	(Thompson, 1999)	22'100	(Langer, 1975)
8.2	Desirability bias (or wishful thinking)	The tendency to overpredict desirable outcomes and underpredict unwanted outcomes.	"Desirability bias is the tendency to overpredict desirable outcomes and underpredict unwanted outcomes." p. 65	"Budescu and Bruderman (1995) refute Koehler's (1994) contention that desirability bias is confounded with Langer's (1975) 'illusion of control, and McKenna's (1993) contention that the illusion of control is a necessary condition for desirability bias to occur." p. 66	(Olsen, 1997)	20'400	(Thomsen, 1941)
8.3	In-group favoritism (in-group bias)	The tendency to prefer people from one's own group.	"People show favoritism toward ingroup members and indifference, hostility, or mistrust toward outgroup members." p. 1845	"whenever people have a shared interest in distinguishing among themselves in terms of their unobservable information, whatever that means in a given situation." p. 1848	(Efferson, Lalive, & Fehr, 2008)	16'500	(Billig, 1973)

8.4	Optimism bias	The tendency to perceive positive outcomes more probable than negative ones.	"People believe that negative events are less likely to happen to them than to others, and they believe that positive events are more likely to happen to them than to others." p. 807	"the majority of factors they brought to mind were ones that increased the likelihood that it would turn out the way they would like." p. 819	(Weinstein, 1980)	12'900	(Milburn, 1978)
8.5	Escalation of commitment	The tendency to increase commitment despite suboptimal outcome.	"It is commonly expected that individuals will reverse decisions or change behaviors which result in negative consequences. Yet, within investment decision contexts, negative consequences may actually cause decision makers to increase the commitment of resources and undergo the risk of further negative consequences." p. 27	"Self-perception theory predicts that individuals will re-evaluate their behavior so that it conforms to their own notions of how one might feel or behave if he were acting rationally." p. 40	(Staw, 1976)	11'200	(Staw, 1976)
8.6	Anchoring bias	Final decisions affected by the original starting point.	"anchoring bias is caused by insufficient adjustment because final judgements are assimilated toward the starting point of a judge's deliberations" p. 35	"confirmatory search and selective accessibility mechanisms of the confirmatory hypothesis testing model" p. 38	(Furnham & Boo, 2011)	7'570	(Chapman & Volkmann, 1939)
8.7	Illusory superiority (better-than-average effect or above-average effect, an aspect of overconfi-dence: over-placement)	Overplacement of one's own abilities.	"When people are asked to compare their abilities to those of their peers, they predominantly provide self-serving assessments that appear objectively indefensible." p. 1082	"This article proposes that such assessments occur because the meaning of most characteristics is ambiguous, which allows people to use self-serving trait definitions when providing self-evaluations." p. 1082	(Dunning, Meyerowitz, & Holzberg, 1989)	4'740	(Dunning et al., 1989)
8.8	Omission bias	Harmful actions are evaluated as worse than harmful inactions (omissions).	"Subjects often rated harmful omissions as less immoral, or less bad as decisions, than harmful commissions." p. 76	"omission bias in the moral sphere allows people to feel righteous by abstaining from sins of commission, even while they neglect (through omission) the suffering	(Spranca, Minsk, & Baron, 1991)	4'550	(Ritov & Baron, 1990)

				of others, which they could ameliorate at a small cost. In the sphere of personal decisions, omission bias helps people to avoid blaming themselves for their own misfortunes that they could have avoided through action." p. 105			
8.9	Belief bias	The tendency to evaluate judgements based on the believability of the arguments.	"The claim is that when presented with deductive arguments to evaluate, subjects will make judgments upon a priori beliefs rather than on the basis of logical argument." p. 295	"The picture that finally emerges is that logic and belief conflict throughout, but they do so at different levels. When subjects focus primarily on the conclusion, belief biases are maximal and logical effects are minimal. Such subjects often rationalize their responses by referring to irrelevant information." p. 305	(Evans, Barston, & Pollard, 1983)	4'190	(Revlin, Leirer, Yopp, & Yopp, 1980)
8.10	Dunning-Kruger effect	Incompetent people overestimate their competence (and vice-versa).	"reach erroneous conclusions and make unfortunate choices" p. 1121	"People tend to hold overly favorable views of their abilities in many social and intellectual domains" p. 1121	(Kruger & Dunning, 1999)	1'950	(Kruger & Dunning, 1999)
8.11	Bias blind spot	The belief that other people are more affected to biases as oneself.	"People see themselves as less susceptible to bias than others." p. 565	"the bias blind spot is rooted at least in part in an introspection illusion. These results suggest that the tendency to impute bias more to others than to the self is rooted in peo- ple's tendency to value introspective information – at the expense of considering actions – when assessing bias in themselves, but not others." p. 575	(Pronin & Kugler, 2007)	1'810	(Pronin, Lin, & Ross, 2002)
8.12	Hard-easy-effect (an aspect of overconfi-dence: over-estimation)	Overconfidence for hard tasks, underconfi-dence for easy tasks.	"take a test, assess confidence for every question, and estimate their percentile of performance" p. 78	"people are biased in their assessments of ability. The current results confirm that these two biases are closely related. Individuals who believe they are better than average are also more likely to be overconfident" p. 91	(Larrick, Burson, & Soll, 2007)	1'140	(Lichtenstein & Fischhoff, 1977)

8.13	Worse-than-average effect (or below-average effect)	The underestimation of own strengths in relation to others in tasks perceived as difficult.	“individuals sometimes hold unrealistically negative impressions of their strengths and achievements—sentiments apparently common enough to have spawned a booming industry offering self-help books and confidence-building audiotapes” p. 221	“People base their assessments of how they compare with their peers on their own level of ability ("How skilled am I?") and insufficiently take into account the skills of the comparison group ("How skilled are my peers?")- As a result, people tend to see themselves as above average in domains in which absolute skills tend to be high (or the threshold for successful performance is low) and below average in domains in which absolute skills tend to be low (or the threshold for successful performance is high)." p. 222	(Kruger, 1999)	942	(Kruger, 1999)
8.14	Mood-congruent judgment	The influence of mood on judgment.	“The mood-congruent judgement effect states that mood-congruent material will be judged as possessing "greater merit" in many ways. For example, a happy person will judge positive events as more likely to occur than negative events, pleasant examples as more representative of categories than unpleasant examples, and positive thoughts as possessing higher imagery than negative thoughts.” p. 736	“Explanations for mood-congruent judgement are sometimes appended to such spreading-activation descriptions. For example, biased memories of the past are said to bias judgements about the future that are based on such memories.” p. 737	(Mayer et al., 1995)	627	(Mayer & Salovey, 1988)
8.15	Exaggerated expectation	Higher expectations of success for self-generated actions.	“perception of self-generated actions” p. 10	“bias in people’s perception of their performance results from unrealistic expectations of their own performance” p. 1	(Wolpe, Wolpert, & Rowe, 2014)	367	(Wagenaar & Keren, 1985)
8.16	End of history illusion	The tendency to believe that we stay the same persons for the rest of our live.	“Young people, middle-aged people, and older people all believed they had changed a lot in the past but would change relatively little in the future. … This “end of history illusion” had practical consequences, leading people to	“People also like to believe that they know themselves well, and the possibility of future change may threaten that belief. In short people are motivated to think well of themselves and to feel secure in that understanding, and the end of history	(Quoidbach, Gilbert, & Wilson, 2013)	244	(Quoidbach et al., 2013)

			overpay for future opportunities to indulge their current preferences." p. 96	illusion may help them accomplish these goals." p. 98			
8.17	Congruence bias	The tendency to seek confirmation for the favorable hypothesis in evaluation.	"The results showed that those subjects, who reached two or more incorrect conclusions, were unable, or unwilling to test their hypotheses. The implications are discussed in relation to scientific thinking." p. 129	"Generating an instance corresponds to doing an experiment, knowledge that the instance conforms, or does not conform, corresponds to its result, and an incorrect announcement corresponds to an inference from uncontrolled data. The kind of attitude which this task demands is that implicit in the formal analysis of scientific procedure proposed by Popper (1959). It consists in a willingness to attempt to falsify hypotheses, and thus to test those intuitive ideas which so often carry the feeling of certitude." p. 139	(Wason, 1960)	225	(Wason, 1960)
8.18	Semmelweis reflex	The tendency to reject new evidence or new knowledge because it contradicts established norms, beliefs or paradigms.	"The evidence derived from infection prevention, control literature and from the authors' own clinical observations and experiences suggest indifference to evidence- based practice (EBP) recommendations." p. 205	"If non-compliance with HH were the result of a theory–practice gap, then Argyris and Schon's model of double-loop learning which subjects all variables to critical scrutiny could modify and explain current hand hygiene outcomes." p. 207	(Mortell, Balkhy, Tannous, & Jong, 2013)	223	(Sinclair, 1909)
8.19	Restraint bias	The tendency to overestimate one's own ability to resist temptations.	"The restraint bias matters because it leads people to overexpose themselves to temptation, thereby promoting impulsive behavior." p. 1523	"they will overestimate their impulse-control capacity, whereas when they are in a hot, impulsive state, they will have a more realistic view of their capacity for impulse control." p. 1524	(Nordgren, Harreveld, & Pligt, 2009)	219	(Nordgren et al., 2009)
8.20	Shared infor-mation bias	The tendency to ignore the information only few members of a group are aware of (and focus on information the majority is aware of).	"decision-making task tend to undervalue information that a single member shares with the group, especially when that information conflicts with their prior conclusions." p. 249	"value information that can be corroborated by others because it provides a degree of social validation. Finally, Brodbeck et al. noted that individuals evaluate information as more	(Baker, 2010)	175	(Wittenbaum, Hubbell, & Zuckerman, 1999)

				credible when it is consistent with their personal opinions" p. 253			
8.21	Social comparison bias	The tendency to decisions which do not compete one's own strength.	"We hypothesize that people who have high standing on a relevant dimension (e.g., quantity of publications) begin to protect their social comparison context by making recommendations that prevent others, who might surpass them on the relevant dimension, from entering their comparison context." p. 97	"People strive for self-validation only in the domain on which their self-concept is staked. As a result, a person's self-esteem fluctuates only when people experience threats to the domains on which contingencies of self-worth are staked and not on the domains where self-worth is not at stake." p. 98	(Garcia, Song, & Tesser, 2010)	156	(Alloy, Albright, & Clements, 1987)
8.22	Moral credential effect	The tendency to prejudiced attitudes with beforehand established nonprejudiced credentials.	"Three experiments supported the hypothesis that people are more willing to express attitudes that could be viewed as prejudiced when their past behavior has established their credentials as nonprejudiced persons." p.33	"In other words, moral credentials do not serve solely to make one appear less prejudiced to others; they also serve, at least partially, to reaffirm one's self-image as a nonprejudiced person." p. 39	(Monin & Miller, 2001)	122	(Monin & Miller, 2001)
8.23	Ben Franklin effect	The tendency to like people to whom a favor was given.	"Under certain circumstances, when an individual performs a favor for another person, his liking for that person will increase." p. 371	"Accordingly, if an individual performs a favor for a person about whom he initially has neutral or negative feelings, he may come to like that person as a means of justifying his having performed the favor." p. 372	(Jecker & Landy, 1969)	62	(Jecker & Landy, 1969)
8.24	System justification bias	The tendency to justify unfair systems to defend status quo.	"The first is to understand how and why people provide cognitive, affective, and behavioral support for the status quo, even when doing so appears to conflict with personal and group." p. 587	"Our theoretical analysis suggests that system justification among members of low status groups is especially likely to occur when competing motives for ego justification and group justification are relatively low in salience. Put another way, implicit and unobtrusive behavioral measures may reveal evidence of group-disserving judgments that people would like to hide." p. 599	(Jost, Pelham, & Carvallo, 2002)	52	(Jost et al., 2002)

8.25	Fact-value confusion	The tendency to weight values over facts in judgement.	"they unwittingly allow values to influence their judgements when the issue is poorly formulated or the evidence is unclear." p. 201	"A potential cause of such confusion is the desire that experts are likely to feel to be responsive to policy makers. When experts are specifically asked to address questions of "what ought to be" they are likely to respond, even though it is impossible for them to respond "objectively" or "scientifically". When questions of facts and values are intermixed, pressure mounts for policy makers to attempt to become "amateur scientists" and/or for scientists to assume the role of "de facto policy makers"". p. 201	(Mumpower & Stewart, 1996)	44	(Hammond & Adelman, 1976)
8.26	Action bias	The tendency to favor action over inaction, often to our benefit	"When there is a choice between two roughly comparable good things, they like to choose the one with which they will be most closely associated, especially if they will not be blamed for the absence of a good outcome in the area not chosen." p. 50	"people value positive outcomes more if those outcomes resulted from an action attributable to them. If they are to get full credit for a success, it should be demonstrably their doing." p. 51	(Patt & Zeckhauser, 2000)	2'450**	(Patt & Zeckhauser, 2000)

*Mentions of this bias, based on Google Scholar per September/October 2019

**Mentions of this bias, based on Google Scholar per December 2021

Self-confirmatory Planning and Implementation

Nr.	Cognitive Bias	Description	Managerial Axis	Psychological Axis	Reference	Mentions*	First mentioned
9.1	Experimenter effect (or Pygmalion effect or observer-expectancy effect)	One's expectations influence the behavior of others.	"When the researcher's hypothesis or expectation leads unintentionally to behavior toward the research participants that increases the likelihood that the researcher's expectation will be confirmed, we call this an expectancy effect." p. 42/43	"This is a different kind of self-fulfilling prophecy, a "competing prophecy;' which is at odds with the expectancy cues and yet overcomes them in a uniquely self-fulfilling way." p. 52	(Rosnow & Rosenthal, 1997)	12'000	(Kintz, Delprato, Mettee, Persons, & Schappe, 1965)
9.2	Planning fallacy	Overoptimistic in task implementation prediction.	"The planning fallacy refers to a prediction phenomenon, all too familiar to many, wherein people underestimate the time it will take to complete a future task, despite knowledge that previous tasks have generally taken longer than planned." p. 1	"The signature of the planning fallacy, then, is not that planners are optimistic but that they maintain their optimism about the current project in the face of historical evidence to the contrary." p.3	(Buehler, Griffin, & Peetz, 2010)	3'700	(Kahneman & Tversky, 1982)
9.3	Extrinsic incentive bias	The tendency to believe that others are more extrinsically motivated than oneself.	"people predict that others are more motivated than themselves by extrinsic incentives (job security, pay) and less motivated by intrinsic incentives (learning new things). ... Organizations must convince their members to adopt the goals of the organization." p. 25	"Observers have no information about actors' intrinsic motivation, but they seem to use their own (egocentric) reac- tions to a job to infer the actor's reactions." p. 49	(Heath, 1999)	31	(Heath, 1999)

*Mentions of this bias, based on Google Scholar per September/October 2019

Self-confirmatory Review and Feedback

Nr.	Cognitive Bias	Description	Managerial Axis	Psychological Axis	Reference	Mentions*	First mentioned
10.1	Hindsight bias	The tendency to recall past predictions for a specific outcome as more accurate after seeing the outcome.	“remembered predictions may be consistently biased in a manner explored in the study reported here. In particular, we have found that events reported to have happened tend to be assigned higher postdictive than predictive probabilities” p. 2	“He may, however, find himself so "anchored" in his present (After) state of mind that his previous state is beyond retrieval, i.e., his adjustment is inadequate. The probability value which he produces from this underadjusted state of mind (P2) will tend to lie between what he presently believes (his postdicted probability) and what he originally believed.” p. 13	(Fischhoff & Beyth, 1975)	19’600	(Fischhoff & Beyth, 1975)
10.2	Self-serving bias	The tendency to attribute positive results to oneself and the external factors to negative outcomes.	“Lance displays the self-serving bias, the explanatory pattern that involves external attributions (e.g. task difficulty, luck, or uncooperative others) for outcomes that disfavor the self but internal attributions (e.g. one's own ability, effort, or determination) for outcomes that favor the self.” p. 23	“Lance's self-protecting strategy involves denying his share of responsibility for a negative test outcome and placing the responsibility on situational factors or other persons.” p. 23	(Campbell & Sedikides, 1999)	17’600	(Miller & Ross, 1975)
10.3	Reactance	Reactance is a reaction (often counter-action) to offers, persons, rules, or regulations that threaten or eliminate specific behavioral freedoms. Reactance occurs when a person feels that someone or something is taking away their	“In contrast, theoretical perspectives that address the involuntary loss of an attractive object are uniform in predicting an increase in the attractiveness of the objects. Failure to recognize this distinction (as in Allen & Allen, 1974) creates theoretical confusion and empirical ambiguity.” p. 938	“According to reactance theory, individuals possess specific behavioral freedoms that are established by past and/or present behavior as well as by expectations about future behavior. Theoretically, when a behavior that the individual believes him/herself to be free to engage in is threatened with elimination or is actually eliminated, psychological reactance is aroused and	(Brehm, 1981)	16’900	(Brehm, 1966)

		choices or limiting the range of alternatives.		the individual is motivated to restore the freedom.” p. 938			
10.4	Egocentric bias	Post-action overestimation of one’s own contribution.	“Five experiments were conducted to assess biases in availability of information in memory and attributions of responsibility for the actions and decisions that occurred during a previous group interaction.” p. 322	“Although focusing on one's own inputs in failure situations may lower self-esteem, it does permit one to perceive personal control over the activity. Hence, efficacy motivation could account for these results.” p. 334	(Ross & Sicoly, 1979)	6’720	(Ross & Sicoly, 1979)
10.5	Spotlight effect	The tendency to overestimate how people noticed one’s own behavior.	"Whether assessing their positive (e.g., advancing the discussion) or negative (e.g., offending someone) contributions, participants overestimated the salience of their own behavior to the other members of the group" p. 217	“When individuals are themselves quite conscious of their own actions or appearance, they are particularly likely to overestimate their prominence in the eyes of others. When individuals are less focused on themselves—when their behavior is routinized and automatic, or when they have acclimated to some aspect of their appearance as in Study 5 – they may be less likely to feel like they are in the spotlight." p. 220	(Gilovich, Medvec, & Savitsky, 2000)	1’960	(Gilovich & Savitsky, 1999)
10.6	Group-serving bias	The tendency to attribute positive results to the group’s actions and negative results to external factors.	“Similar results were obtained when players were asked to make causal attributions about the other team’s influence on the achievement of their own team’s goal”. p. 208	“Claiming that the other team played well under conditions of failure would offer the team an explanation for failure which would be less damaging than it would be to admit that one’s own team played poorly.” p. 208	(Taylor & Doria, 1981)	510	(Taylor & Doria, 1981)
10.7	Naïve cynicism	The tendency to predict that others are more self-serving in their assessment of responsibility.	"Evidence from several lab and field studies is presented that indicates that people have cynical intuitions about how others assess responsibility." p. 743	"Finally, people report using information about themselves more than information about others when making such judgments" p. 744	(Kruger & Gilovich, 1999)	317	(Kruger & Gilovich, 1999)
10.8	Rosy retrospection	Recall of events is more positive than the actual experience.	“people’s expectations of personal events are more positive than their actual experience during the event itself, and	“The ‘‘rosy view’’ phenomenon is associated with an increase in the number of negative thoughts during the event	(Mitchell, Thompson,	197	(Mitchell & Thompson, 1994)

			their subsequent recollection of that event is more positive than the actual experience." p. 421	which seem to be caused by distractions, disappointment, and a less positive view of the self. However, these effects are short-lived; within days after the event, people have much more positive evaluations of the event." p. 421	Peterson, & Cronk, 1997)		
10.9	Illusion of external agency	The tendency to attribute positive outcomes to mysterious external agents.	"People typically underestimate their capacity to generate satisfaction with future outcomes. When people experience such self-generated satisfaction, they may mistakenly conclude that it was caused by an influential, insightful, and benevolent external agent." p. 690	"subjectively optimize their outcomes is as a kind of psychological immune system that protects the individual from the emotional consequences of undesired outcomes." p. 691	(Gilbert, Brown, Pinel, & Wilson, 2000)	118	(Gilbert et al., 2000)

*Mentions of this bias, based on Google Scholar per September/October 2019

Loss/Gain Lens in Information Acquisition

Nr.	Cognitive Bias	Description	Managerial Axis	Psychological Axis	Reference	Mentions*	First mentioned
11.1	Social desirability bias	The tendency to respond to questionnaires in a socially approved manner.	"Social desirability refers to making oneself look good in terms of prevailing cultural norms when answering to specific survey questions." p. 2028	"The behavioral model of SEU-theory can be applied to study respondents' perceptions in sensitive surveys, by modelling perceived losses and gains in the interview situation and investigating their impact on the respondent's decision of whether to respond truthfully or not" p. 2031	(Krumpal, 2013)	65'300	(Edwards, 1957)
11.2	Endowment effect	The tendency for people who own a good to value it more than people who do not.	"The endowment effect is the tendency for people who own a good to value it more than people who do not." p. 339	"Attribute sampling bias could be used as a process account of loss aversion in the context of the endowment effect. Similar to 'decision-by-sampling' and 'value construction', however, it ascribes differences in the subjective value of gains and losses to an interaction of	(Morewedge & Giblin, 2015)	22'700	(Thaler, 1980)

				constraints of attention and memory with features of the environment." p. 345			
11.3	Framing effect	Different perception of the same information or problem depending on if it is framed towards gain or losses.	"The frame that a decision-maker adopts is controlled partly by the formulation of the problem and partly by the norms, habits, and personal characteristics of the decision-maker." p. 453	"However, we propose that the details of the phenomena described in this article are better explained by prospect theory and by an analysis of framing than by ad hoc appeals to the notion of cost of thinking." p. 458	(Tversky & Kahneman, 1981)	20'000	(Tversky & Kahneman, 1981)
11.4	Ostrich effect	The tendency to avoid negative information.	"Individuals should monitor and attend to information more actively given preliminary good news but "put their heads in the sand" by avoiding additional information given adverse prior news. We test for such an "ostrich effect"" p. 95	"Selective exposure may also play an evolutionary role in helping people live with risk and, thereby, obtain the potential long-term benefits of risk-taking. Thus, in a finance context, the ostrich effect may lower, to some extent, the required market equity premium. p. 112	(Karlsson, Loewenstein, & Seppi, 2009)	850	(Galai & Sade, 2006)

*Mentions of this bias, based on Google Scholar per September/October 2019

Loss/Gain Lens in Option Generation

No cognitive biases were classified into this category.

Loss/Gain Lens in Evaluation and Choice

Nr.	Cognitive Bias	Description	Managerial Axis	Psychological Axis	Reference	Mentions*	First mentioned
13.1	Mere-exposure effect (or familiarity)	The tendency to affect choices by familiarity of items and options.	"In the mere-repeated-exposure paradigm, an individual is repeatedly exposed to a particular stimulus object, and the researcher records the individual's emerging preference for that object." p. 224	"The consequences of repeated exposures benefit the organism in its relations to the immediate animate and inanimate environment. They allow the organism to distinguish objects and habitats that are safe from those that are not, and they are the most primitive basis of social attachments." p. 227	(Zajonc, 2001)	208'860	(Zajonc, 1968)
13.2	Conservatism	Insufficient probability revision by new information.	"processing of probabilistic information" p. 353	"Conservatism was unaffected by prior probabilities, remained constant as the amount of data increased, and decreased as the diagnostic value of each datum decreased. More learning occurred under payoff than under nonpayoff conditions and between-S variance was less under payoff conditions." p. 346	(Phillips & Edwards, 1966)	53'000	(Phillips & Edwards, 1966)
13.3	Loss aversion	The tendency to avoid losses is stronger than to acquiring gains.	"making a series of decisions about the allocation of assets." p. 648	"myopic loss aversion is the combination of a greater sensitivity to losses than to gains and a tendency to evaluate outcomes frequently." p. 647	(Thaler, Tversky, Kahneman, & Schwartz, 1997)	50'500	(Kahneman & Tversky, 1979)
13.4	Status quo bias	The tendency to avoid options that demand a change.	"The main finding is that decision makers exhibit a significant status quo bias. Subjects in our experiments adhered to status quo choices more frequently than would be predicted by the canonical model." p. 8	"Thus, we conclude that status quo bias is a general experimental finding—consistent with, but not solely prompted by, loss aversion." p. 36	(Samuelson & Zeckhauser, 1988)	26'000	(Hershey, Kunreuther, & Schoemaker, 1982)
13.5	Bandwagon effect	The tendency to do (or believe) things because many other	"This study undertakes an empirical test of the "bandwagon effect"-individuals rallying to the majority." p. 203	"I argue that, if agents are risk-averse, the underdog's supporters will find voting more costly and thus will participate at a	(Nadeau, Cloutier, & Guay, 1993)	17'700	(Blankenship, 1940)

		people do (or believe) the same.		lower rate. The relationship between risk attitudes and turnout choices has received very little attention. Kam (2012) finds a positive relationship between risk-acceptance and general political participation, but no effect of risk attitudes on turnout in elections." p. 469			
13.6	Hyperbolic discounting (or present bias)	The tendency to weight short-term awards stronger than long-term benefits.	"They could take the money now or wait until later. They were asked how much they would require to make waiting just as attractive as getting the money now." p. 203	Put simply, the relative marginal price of waiting for rewards appears to decline as the time necessary to wait increases." p. 205	(Thaler, 1981)	17'500	(Thaler, 1981)
13.7	Sunk cost fallacy	The tendency to continue an endeavor once an investment in money, effort, or time has been made.	"The sunk cost effect is manifested in a greater tendency to continue an endeavor once an investment in money, effort, or time has been made. Evidence that the psychological justification for this behavior is predicated on the desire not to appear wasteful is presented." p. 124	"Thaler's (1980) explanation of the sunk cost effect is based on prospect theory. Two features of prospect theory seem particularly pertinent to the analysis of the sunk cost effect." p. 130	(Arkes & Blumer, 1985)	13'600	(Thaler, 1980)
13.8	Disposition effect	The tendency to sell an asset that has accumulated in value and resist selling an asset that has declined in value.	"The 'disposition effect' is the tendency to sell assets that have gained value ('winners') and keep assets that have lost value ('losers')." p. 167	"Disposition effects can be explained by the two features of prospect theory: the idea that people value gains and losses relative to a reference point (the initial purchase price of shares), and the tendency to seek risk when faced with possible losses, and avoid risk when a certain gain is possible." p. 167	(Weber & Camerer, 1998)	9'510	(Shefrin & Statman, 1985)
13.9	Risk compen-sation (or risk homeo-stasis)	The tendency to adjust one's behavior in response to the perceived level of risk.	"Risk compensation occurs if people react to a safety law or regulation by acting less safely." p. 84	"These experiments show clearly that people modify their behavior in response to changes in the reward and penalty structure of their environment." p. 86	(Hedlund, 2000)	5'690	(Wilde, 1982)

13.10	Attraction effect (or decoy effect)	The choice can be influenced by irrelevant dominated alternatives.	“Managerially, the results lead to the counterintuitive conclusion that there are times when profitability of a product line can be increased by adding a (dominated) alternative that virtually no one ever chooses. The effect of the dominated alternative is to draw attention to a more profitable item rather than to generate direct sales.” p. 90	“The reward prediction error (RPE) reflects the difference between received and expected rewards and acts as the central teaching signal in reinforcement learning. We propose the novel hypothesis that, similar to its effect on preferential choices, the attraction effect influences expectations about rewards” p. 372	(Huber, Payne, & Puto, 1982)	5’070	(Huber et al., 1982)
13.11	Compromise effect	The tendency to choose non-extreme options.	“a priori predictions concerning choice behavior. Still, examining the reasons for selecting alternatives, especially in relatively simple problems, might improve our understanding of choice behavior under uncertainty.” p. 158	“This is because the negative reason associated with a loss on one attribute will tend to loom larger than the reason associated with the gain on the other attribute.” p. 171	(Simonson, 1989)	2’400	(Simonson, 1989)
13.12	Impact bias	The tendency to predict future emotional reactions as more intense.	"People predict that emotional reactions to events will be more intense than actually turns out to be the case." (Sanna & Schwarz, 2004, p. 474)	"People work to understand events so that they can repeat the good ones and avoid repeating the bad ones, but in understanding these events people may reduce their ability to be moved by them." (Wilson & Gilbert, 2005, p. 133)	(Sanna & Schwarz, 2004; Wilson & Gilbert, 2005)	2’090	(Gilbert, Driver-Linn, & Wilson, 2002)
13.13	Neglect of probability	Probabilities of outcomes are ignored.	“may neglect the issue of probability, in a way that can lead to either indifference to real risks or costly expenditures for little or no gain.” p. 63	Indeed, we might easily see prospect theory as emphasizing a form of probability neglect.” p. 65 “It has been suggested that people often decide as they do because they anticipate their own regret.” p. 66” “Note that if probability neglect is involved, this is not a point about the availability heuristic, which leads people not to neglect probability, but to answer the question of probability by substituting a hard question (What is the statistical	(Sunstein, 2002)	1’800	(Baron, 2000)

				risk?) with an easy question (Do salient examples readily come to mind?).” p. 82			
13.14	Ambiguity effect	The tendency to avoid options for which the probability of a favorable outcome is unknown.	“the effects of 'ambiguity' on decision making can be described in terms of the salience of missing information.” p. 265	“Ambiguity concerning the consequences of action increases the reluctance to act, but there is no corresponding effect of the omission option. A possible explanation of this result is that ambiguity increases the feeling of responsibility for a bad outcome that a decision maker causes.” p. 276	(Ritov & Baron, 1990)	1’740	(Frisch & Baron, 1988)
13.15	Reactive devaluation	Negative evaluation of options originated by an antagonist.	“the Hatfields might change that assessment in light of the fact that it was the McCoys who made the relevant proposal.” p. 394	“We may simply, even reflexively, conclude that any trades of concessions proposed by our enemy must be relatively advantageous to that enemy and relatively disadvantageous to us. … The focus of our attention might change, such that any potential losses will loom even larger, and any gains even smaller, than before.” p. 394	(Ross & Stillinger, 1991)	1’070	(Ross & Stillinger, 1991)
13.16	Disjunction effect	The tendency to delay actual decisions because of an unknown outcome in a sequentially following decision.	“Most subjects, however, rejected the second gamble when the outcome of the first was not known This pattern of preference clearly violates Savage's STP, we call It the disjunction effect.” p. 306	“These data can be interpreted in terms of the value function of prospect theory” p. 307	(Tversky & Shafir, 1992)	963	(Tversky & Shafir, 1992)
13.17	Segregation bias	Segregated (isolated) evaluation of sequenced alternatives leads to different choice outcomes.	“If individuals have to evaluate a portfolio or sequence of lotteries, their judgment is influenced by the portfolio presentation mode.” p. 730	“Because of loss aversion, this type of mental accounting leads to a lower overall evaluation of a portfolio of mixed lotteries as exemplarily demonstrated by Benartzi and Thaler (1995).” p. 730	(Langer & Weber, 2001)	742	(Kahneman & Tversky, 1979)
13.18	Authority bias	The predisposition towards opinions and	“Yet, 26 subjects abandon this tenet in following the instructions of an authority who has no special powers to enforce his	“the remarks and outward behavior of many participants that in punishing the	(Milgram, 1963)	737	(Milgram, 1963)

		actions of authority persons.	commands. To disobey would bring no material loss to the subject; no punishment would ensue." p. 376	victim they are often acting against their own values." p. 376 "under obligation to aid the experimenter. He has made a commitment, and to disrupt the experiment is a repudiation of this initial promise of aid." p. 377			
13.19	Pessimism bias	The tendency to see positive outcomes less probable for oneself.	"The tendency to expect good things in the future is known as optimism. Extreme optimism can be harmful as it can promote an underestimation of risk and poor planning. In contrast, a pessimistic view is correlated with severity of depression symptoms" p. 102	"For example, both the rACC and amygdala were more sensitive to positive stimuli in subjects that focused on obtaining goals (promotional context) and to negative stimuli in subjects that focused on avoiding failure (prevention context)." p. 104	(Sharot, Riccardi, Raio, & Phelps, 2007)	574	(Hummer, Dember, Melton, & Schefft, 1992)
13.20	Phantom effect	The tendency to affect choices by dominant but unavailable alternatives.	"When asked to choose an alternative from the set, participants are told that the decoy is unavailable. Thus, this decoy is a "phantom" alternative, as it is present in the choice set but cannot be selected. Under these conditions, participants prefer the alternative that is dominated by the decoy." p. 302	"These additional reasons can be thought of as emergent dimensions that arise from the demands of the task or social situation. One such emergent dimension may be the need to justify a decision to others. For example, dominance is an emergent value that provides a qualitative argument for making a choice." p. 303	(Pettibone & Wedell, 2000)	404	(Highhouse, 1996)
13.21	Denomination effect	The tendency to spend more money when it is denominated in small amounts rather than large amounts.	"In two of the three field studies, individuals spent more once the decision to spend had been made." p. 701	"the denomination effect is contingent on individual differences in people's desire to reduce the pain of paying associated with spending. The results suggest that the denomination effect occurs because large denominations are psychologically less fungible than smaller ones, allowing them to be used as a strategic device to control and regulate spending." p. 701	(Raghubir & Srivastava, 2009)	217	(Raghubir & Srivastava, 2009)
13.22	Sexual over-perception bias	The tendency to over- or underestimate the sexual interest of	"natural selection will often produce adaptively biased systems of judgment,	"It is possible that men and women are biased toward overperceiving the sexual interest of high mate value individuals	(Haselton, 2003)	211	(Bondurant & Donat, 1999)

		another person in oneself.	even when these systems produce more errors than alternative designs." p. 34	because missing their potential interest was more costly over selective history than was overestimating their interest." p. 43			
13.23	Pseudo-certainty effect	The tendency to frame some alternatives as certain.	“The failure to construct a canonical representation in decision problems contrasts with other cognitive tasks in which such representations are generated automatically and effortlessly.” p. S256	“However, the preferences in the two problems differ: most subjects made a risk-averse choice in problem 11 but not in problem 10. We call this phenomenon the pseudo-certainty effect because an out- come that is actually uncertain is weighted as if it were certain.” p. S268	(Tversky & Kahneman, 1986)	139	(Tversky & Kahneman, 1981)
13.24	Partial information bias	Options with only partially available information are devalued towards options with complete information.	“Results indicated that subjects tended to devalue the partial profiles relative to the complete profiles.” p. 240	“A general conclusion that can be drawn from the decision-making literature is that people avoid uncertainty. It appears that most people are "risk averse" in the sense that when given the choice between, for example, $1.00 for sure and a gamble offering $2.00 if a fair coin toss results in a "Head" and nothing otherwise, they generally choose the guaranteed $1.00. Such risk aversion is accommodated in decision analyses by concave utility functions.” p. 242	(Yates, Jagacinski, & Faber, 1978)	9	(Yates et al., 1978)

*Mentions of this bias, based on Google Scholar per September/October 2019

Loss/Gain Lens in Planning and Implementation

No cognitive biases were classified into this category.

Loss/Gain Lens in Review and Feedback

Nr.	Cognitive Bias	Description	Managerial Axis	Psychological Axis	Reference	Mentions*	First mentioned
15.1	Choice-supportive bias	The tendency to recall past choices better than they actually were.	"People make choices throughout their lives. The way they remember these choices has implications for their well-being and their beliefs about themselves. For instance, remembering that the option one selected had many good features and that foregone options had many negative features should make one feel satisfied." p. 596	"Choice-supportive source monitoring may help avoid negative emotions such as regret or disappointment." p. 603	(Mather & Johnson, 2000)	290	(Mather & Johnson, 2000)

*Mentions of this bias, based on Google Scholar per September/October 2019

Appendix C: Authoritative Averaged References

Averaged References to Evaluate Written and Visualized Self-explanations in the IOED Experiments:

Blockchain - Text:

T(t)= (23+20+19)3= **20.7** = 100%

Blockchain - Visual:

A(v)= (19+14+21)3= **18** = 100%

E(v)= (8+7+7)3= **7.3** = 100%

C(v)= Mean (A(v), E(v))

Internet of Things - Text:

T(t)= (22+34+28)3= **28** = 100%

Internet of Things - Visual:

A(v)= (8+7+9)3= **8** = 100%

E(v)= (9+7+11))3= **9** = 100%

C(v)= Mean (A(v), E(v))

Augmented Reality - Text:

T(t)= (21+23+22)3= **22** = 100%

Augmented Reality - Visual:

A(v)= (13+17+26)3= **18.7** = 100%

E(v)= (13+14+8))3= **11.7** = 100%

C(v)= Mean (A(v), E(v))

Wireless Earphones – Text only:

T(t)= (32+24+20)3= 25.3 = 100%

Blockchain – Averaged Reference Text:

Summary:

T(t)= (23+20+19)3= 20.7 = 100%

Example 1:

Source: Wikipedia, https://en.wikipedia.org/wiki/Blockchain, accessed 16.6.2020

A **blockchain**, originally **block chain**, is a growing list of records, called *blocks*, that are linked using cryptography. Each block contains a cryptographic hash of the previous block, a timestamp, and transaction data (generally represented as a Merkle tree). By design, a blockchain is resistant to modification of the data. It is "an open, distributed ledger that can record transactions between two parties efficiently and in a verifiable and permanent way".

For use as a distributed ledger, a blockchain is typically managed by a peer-to-peer network collectively adhering to a protocol for inter-node communication and validating new blocks. Once recorded, the data in any given block cannot be altered retroactively without alteration of all subsequent blocks, which requires consensus of the network majority. Although blockchain records are not unalterable, blockchains may be considered secure by design and exemplify a distributed computing system with high Byzantine fault tolerance. Decentralized consensus has therefore been claimed with a blockchain.

Blockchain was invented by a person (or group of people) using the name Satoshi Nakamoto in 2008 to serve as the public transaction ledger of the cryptocurrency bitcoin. The identity of Satoshi Nakamoto remains unknown to date.

T(t)=23 Terms

Example 2:

Source: https://www.zdnet.com/article/blockchain-explained-in-plain-english/, accessed 17.6.2020

Blockchain is a Distributed Ledger Technology (DLT) that was invented to support the Bitcoin cryptocurrency. Bitcoin was motivated by an extreme rejection of government-guaranteed money and bank-controlled payments. The developer of Bitcoin, Satoshi

Nakamoto envisioned people spending money without friction, intermediaries, regulation, or the need to know or trust other parties.

Technically, the original blockchain is separable from Bitcoin, but this report will show that the blockchain design is so specific to Bitcoin that it's not a good fit for much else.

The central problem in electronic cash is Double Spend. Because pure electronic money is just data, nothing stops a currency holder from trying to spend it twice. Blockchain solves the Double Spend problem without a digital reserve fund or similar form of umpire.

Blockchain monitors and verifies Bitcoin transactions by calling upon a decentralized network of volunteer-run nodes to, in effect, vote on the order in which transactions occur. The network's algorithm ensures that each transaction is unique.

Several thousand nodes make up the Bitcoin network. Once a majority of nodes reaches consensus that all transactions in the recent past are unique (that is, not double spent), they are cryptographically sealed into a block. Each new block is linked to previously sealed blocks to create a chain of accepted history, thereby preserving a verified record of every spend.

The Bitcoin blockchain's functionality and security results from the network of thousands of nodes agreeing on the order of transactions. The diffuse nature of the network ensures transactions and balances are recorded without bias and are resistant to attack by even a relatively large number of bad actors. In fact, the record of transactions and balances remains secure as long as a simple majority (51 percent) of nodes remains independent. Thus, the integrity of the blockchain requires a great many participants.

T(t)= 20 Terms

Example 3:

Source: https://www.fundera.com/blog/blockchain-explained**,** accessed 17.6.2020

Blockchain is a technology that can allow individuals and companies to make instantaneous transactions on a network without any middlemen (if they are decentralized). Transactions made on blockchain are completely secure, and, by function of blockchain technology, are kept as a record of what happened. Cryptographic encryption algorithms ensure that no record of a transaction on blockchain can be altered after the fact.

A Visualization of How Blockchain Works

You can explain a blockchain as literally a chain of blocks. Those blocks represent data, held all together in a specific order. The data stored in the blocks includes information about a transaction (date, time, amount), who is participating in the transaction (via a "digital signature"), and information that distinguishes an individual block from other blocks in the chain. This information is expressed as a unique code called a "hash."

You can also imagine a blockchain as a ledger – because that's essentially how most blockchains function. Each block of data represents some new transaction on the ledger, whether that means a contract or a sale or whatever else you'd use a ledger for.

A blockchain is a record of transactions. Using blockchain, companies (or people!) can both make and verify these transactions. That's actually two very important concepts lumped together, so let's take a closer look.

T(t)= 19 Terms

Blockchain – Averaged Reference Visual

Summary:

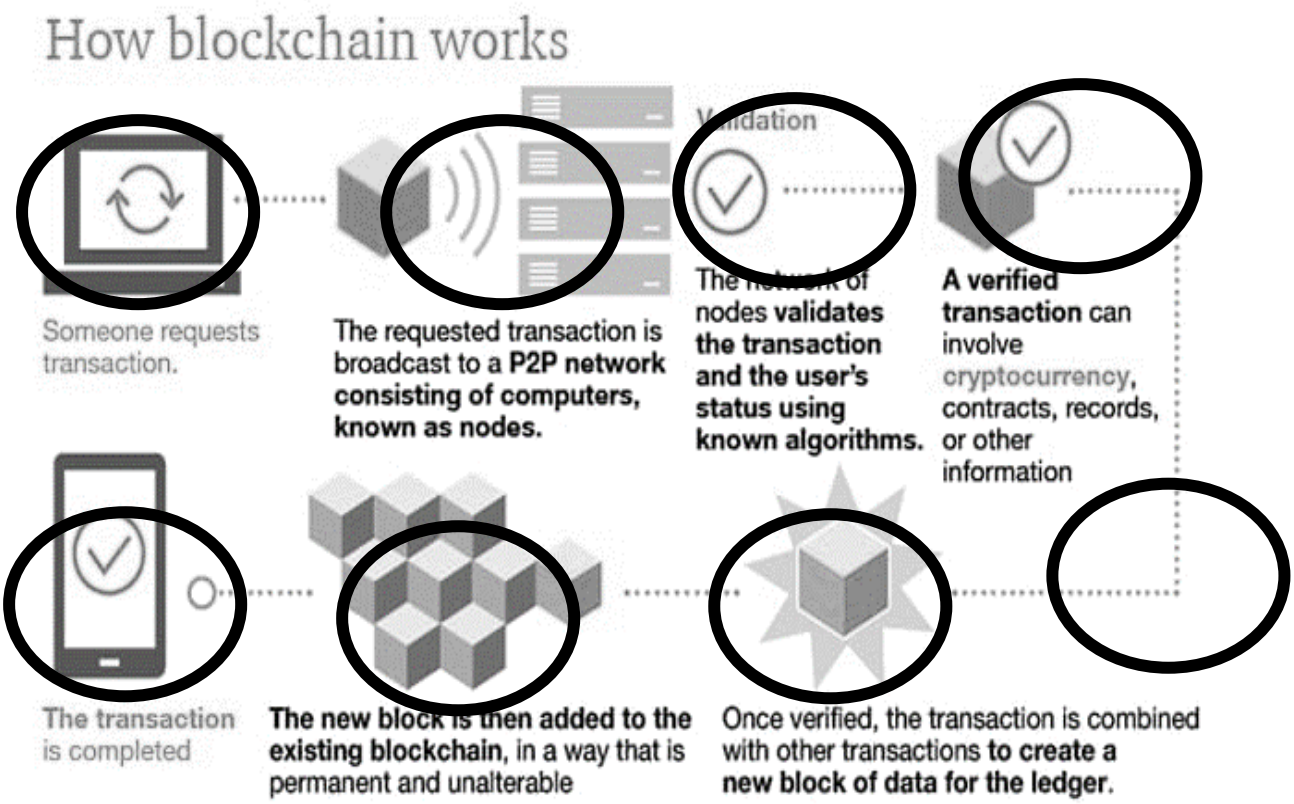
A(v)= (19+14+21)3= 18 = 100%

E(v)= (8+7+7)3= 7.3 = 100%

C(v)= Mean (A(v), E(v))

Example 1:

Source: https://www.pwc.com/us/en/industries/financial-services/fintech/bitcoin-blockchain-cryptocurrency.html, accessed 17.6.2020

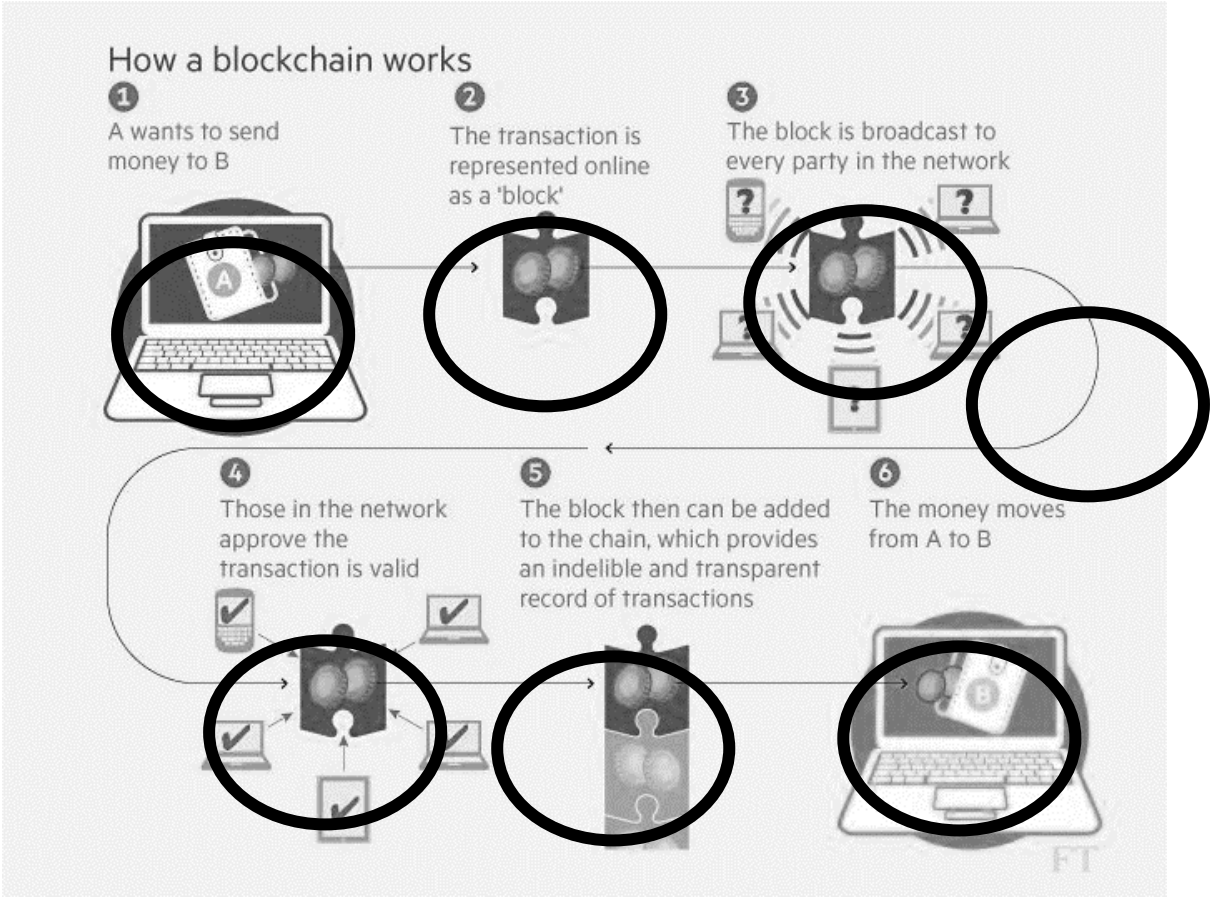


A(v) = 19 (blockchain, transaction, broadcast, P2P, network, nodes, validates, user's status, algorithms, verified, cryptocurrency, contracts, record, information, combined, ledger, permanent, added, unalterable)

E(v) = 8

Example 2:

Source: https://www.ft.com/content/eb1f8256-7b4b-11e5-a1fe-567b37f80b64, accessed 17.6.2020

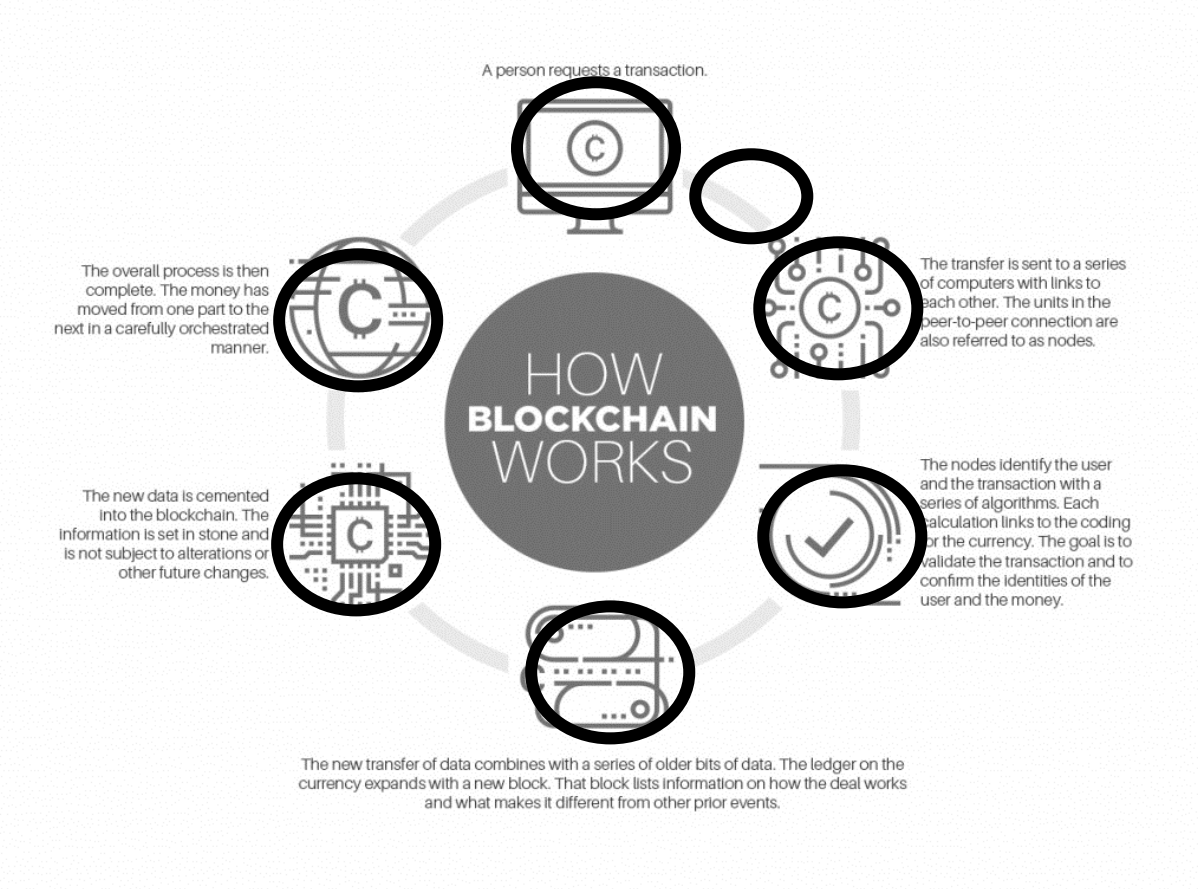


A(v) = 14 (blockchain, money, transaction, represent, online, block, broadcast, network, valid, added, chain, indelible, transparent, record)

E(v) = 7

Example 3:

Source: https://stockholm.bc.events/en/news/how-to-explain-blockchain-and-cryptocurrencies-in-simple-terms-91743, accessed 17.6.2020



A(v) = 21 (blockchain, transaction, transfer, linked computers, peer-to-peer, nodes, identify, algorithms, coding, currency, validate, confirm identity, combine, data, ledger, block, information, deal, prior events, set in stone/no alterations, process)

E(v) = 7

IoT – Averaged Reference Text:

Summary:

T(t)= (22+34+28)3= 28 = 100%

Example 1:

Source: https://www.ibm.com/blogs/internet-of-things/what-is-the-iot/, accessed 18.6.2020

What is the Internet of Things?

In a nutshell, the Internet of Things is the concept of connecting any device (so long as it has an on/off switch) to the Internet and to other connected devices. The IoT is a giant network of connected things and people – all of which collect and share data about the way they are used and about the environment around them.

That includes an extraordinary number of objects of all shapes and sizes – from smart microwaves, which automatically cook your food for the right length of time, to self-driving cars, whose complex sensors detect objects in their path, to wearable fitness devices that measure your heart rate and the number of steps you've taken that day, then use that information to suggest exercise plans tailored to you. There are even connected footballs that can track how far and fast they are thrown and record those statistics via an app for future training purposes.

How does it work?

Devices and objects with built in sensors are connected to an Internet of Things platform, which integrates data from the different devices and applies analytics to share the most valuable information with applications built to address specific needs.

These powerful IoT platforms can pinpoint exactly what information is useful and what can safely be ignored. This information can be used to detect patterns, make recommendations, and detect possible problems before they occur.

For example, if I own a car manufacturing business, I might want to know which optional components (leather seats or alloy wheels, for example) are the most popular. Using Internet of Things technology, I can:

- Use sensors to detect which areas in a showroom are the most popular, and where customers linger longest;
- Drill down into the available sales data to identify which components are selling fastest;
- Automatically align sales data with supply, so that popular items don't go out of stock.

The information picked up by connected devices enables me to make smart decisions about which components to stock up on, based on real-time information, which helps me save time and money.

With the insight provided by advanced analytics comes the power to make processes more efficient. Smart objects and systems mean you can automate certain tasks, particularly when these are repetitive, mundane, time-consuming or even dangerous. Let's look at some examples to see what this looks like in real life.

T(t)= 22 Terms

Example 2:

Source: https://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT, accessed 18.6.2020

The internet of things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

A *thing* in the internet of things can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low or any other natural or man-made object that can be assigned an Internet Protocol (IP) address and is able to transfer data over a network.

Increasingly, organizations in a variety of industries are using IoT to operate more efficiently, better understand customers to deliver enhanced customer service, improve decision-making and increase the value of the business.

How IoT works

An IoT ecosystem consists of web-enabled smart devices that use embedded systems, such as processors, sensors and communication hardware, to collect, send and act on data they acquire from their environments. IoT devices share the sensor data they collect by connecting to an IoT gateway or other edge device where data is either sent to the cloud to be analyzed or analyzed locally. Sometimes, these devices communicate with other related devices and act on the information they get from one another. The devices do most of the work without human intervention, although people can interact with the devices -- for instance, to set them up, give them instructions or access the data.

The connectivity, networking and communication protocols used with these web-enabled devices largely depend on the specific IoT applications deployed.

IoT can also make use of artificial intelligence (AI) and machine learning to aid in making data collecting processes easier and more dynamic.

T(t)= 34 Terms

Example 3:

Source: https://justcreative.com/2018/11/19/internet-of-things-explained/, accessed 18.6.2020

How Does IoT Work?

Since the mechanism of IoT devices is highly technical, so for many it's quite confusing how an IoT system actually works. Well, just like any other system has predefined steps and components to make it work, so the Internet of Things has its own. A complete IoT system is made up of four distinct components that work together to deliver the desired output. Let's look at each component and understand what it does.

Sensors/Devices

First of all, sensors or devices collect very minute data from the surrounding environment. The collected data could be as simple as a geographical location or as complex as health essentials of a patient. To pick up the most sensitive changes in data, one can bundle multiple sensors together to be a part of a device that is capable of doing more than just sense things. For instance, the mobile phone is a device with several built-

in sensors such as GPS, Camera, Accelerometer, without which the phone is not able to sense things.

Thus, be it a standalone sensor or a device having multiple sensors, the first step involves the collection of all the minute details from the surrounding environment.

Connectivity

Once the data is collected, it is sent to a cloud infrastructure aka an IoT platform with the help of a medium. That's where several wireless and wired networking technologies, such as Bluetooth, Wi-Fi, Cellular Networks, LPWAN, Ethernet, etc come into handy. While each of these connectivity options represents a tradeoff between power consumption, connection range, and bandwidth, choosing the best one to transmit data to the cloud solely depends on the complexity level and specific requirements of an IoT application.

Data Processing

Once the data gets to the cloud infrastructure, it is stored, analyzed, and processed securely using a Big Data Analytics Engine for better decision making. This analysis can be as simple as checking whether or not the temperature reading on an AC or heater is within an acceptable range, or as complex as identifying intruders in your house with the help of surveillance cameras. The processed data is then used to perform immediate, intelligent actions that turn our ordinary physical devices into exceptionally smart devices.

User Interface

The last step involves notifying the end user about the action through an email, text, notification, or alert sound triggered on their IoT application. Depending on the complexity of the IoT system, the user can then either leave the automatically performed action intact, proactively check in on their IOT system, or manually perform an action to backfire or affect the system. For instance, if the user detects some changes in a particular room, he can remotely adjust that room temperature via an IoT app installed on his phone.

T(t)= 28 Terms

IoT – Averaged Reference Visual

Summary:

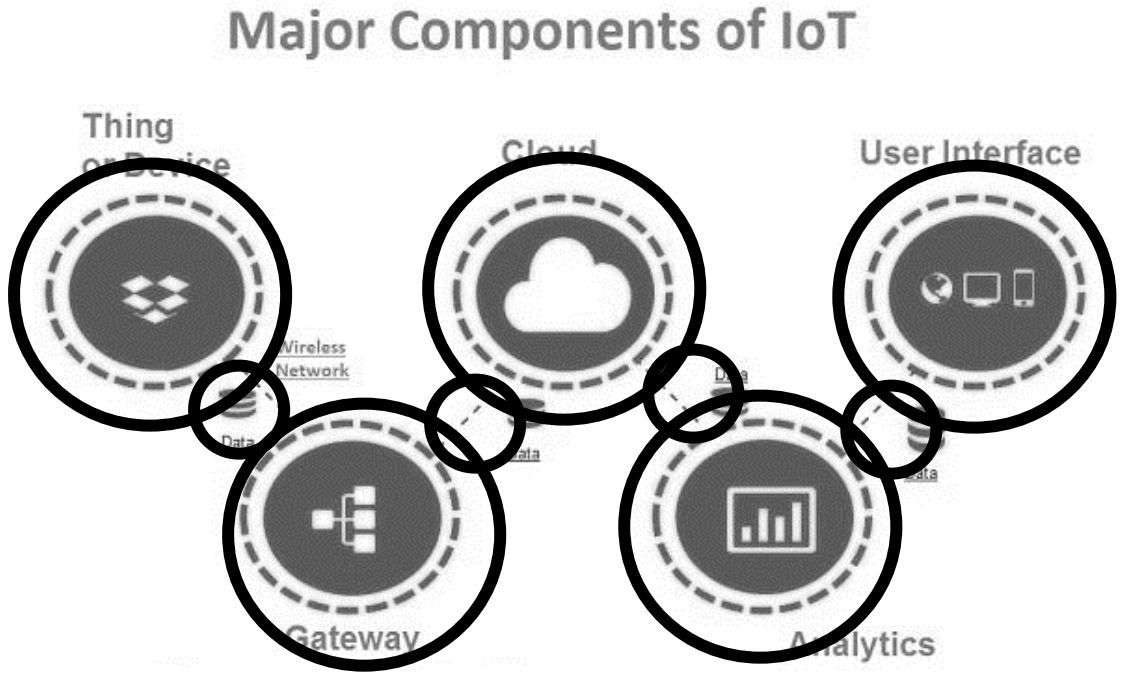
A(v)= (8+7+9)3= 8 = 100%

E(v)= (9+7+11))3= 9 = 100%

C(v)= Mean (A(v), E(v))

Example 1:

Source: https://www.rfpage.com/what-are-the-major-components-of-internet-of-things/, accessed 18.6.2020

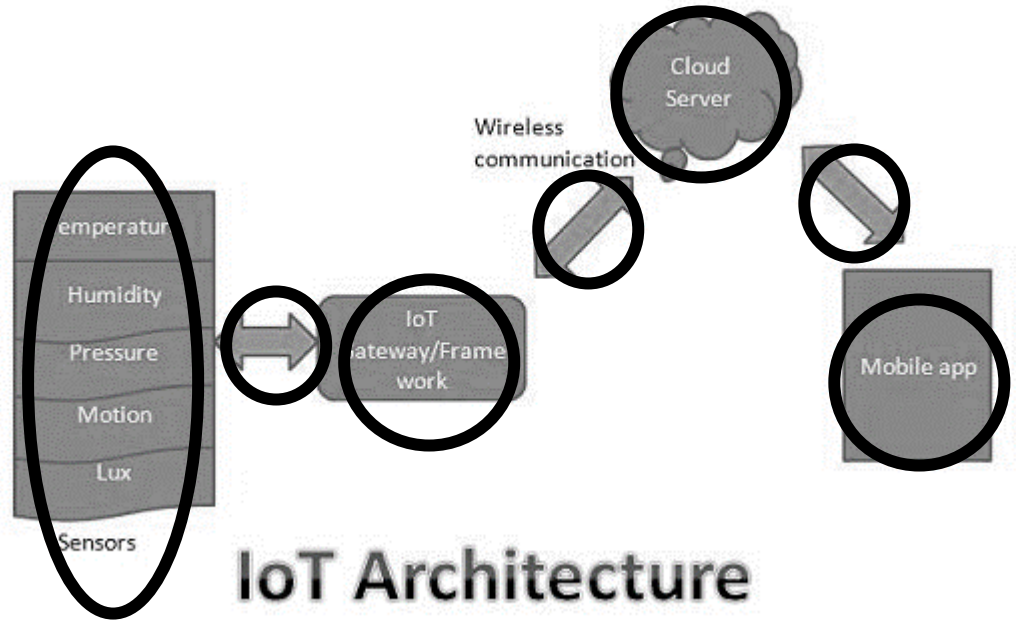


A(v) = 8 (thing, device, wireless network, data, gateway, cloud, analytics, user interface)

E(v) = 9

Example 2:

Source: https://iotdunia.com/iot-architecture/, accessed 18.6.2020

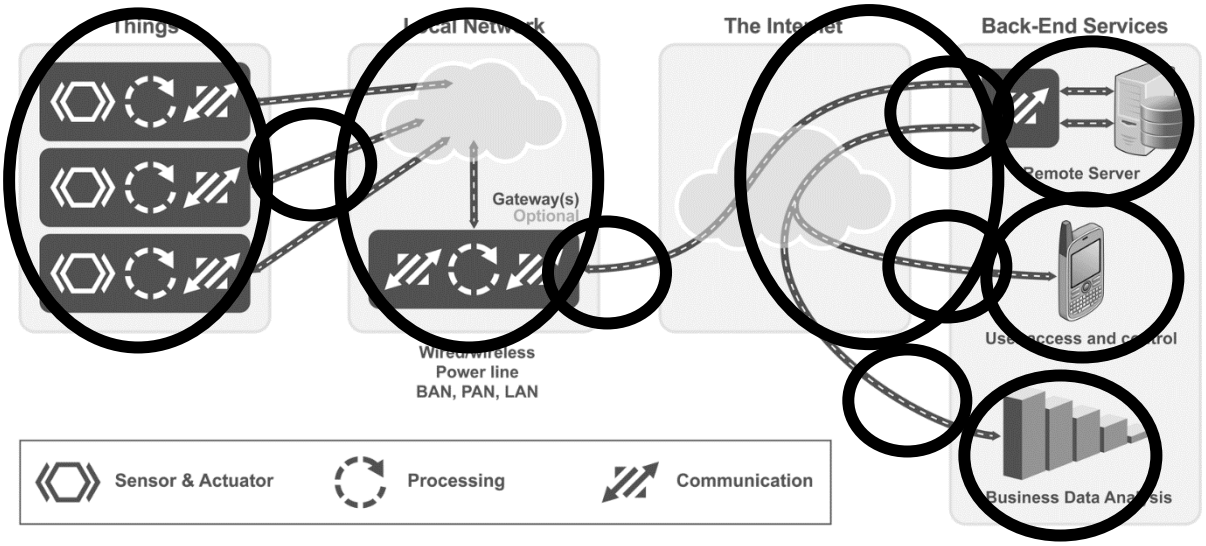


A(v) = 7 (sensors, iot, gateway, framework, wireless communication, cloud server, mobile app)

E(v) = 7

Example 3:

Source: https://www.micrium.com/iot/devices/, accessed 18.6.2020



A(v) = 9 (things, network, gateway, wired/wireless etc., internet, back-end services, remote server, user access and control, big data analysis)

E(v) = 11

Augmented Reality – Averaged Reference Text:

Summary:

T(t)= (21+23+23)3= 22 = 100%

Example 1:

Source: https://www.avrspot.com/augmented-reality-ar-work/, accessed 18.6.2020

Augmented reality (AR) adds digital elements onto a smartphone camera, creating an illusion that holographic content is a part of the physical world around you. In contrast with Virtual Reality (VR), you are not immersed in the whole artificial environment. AR alters the surroundings a bit by adding 3D objects, sounds, videos, graphics to it.

How Does Augmented Reality Work?

To show the relevant content to the user AR uses computer vision, simultaneous localization, mapping and depth tracking (sensor data calculating the distance to the objects). This allows cameras to collect, send and process data in order to show digital content relevant to what the user is looking at.

T(t)= 21 Terms

Example 2:

Source: https://www.blippar.com/blog/2018/08/21/what-is-augmented-reality-and-how-does-augmented-reality-work, accessed 18.6.2020

Augmented reality (AR) **adds digital content onto a live camera feed,** making that digital content look as if it is part of the **physical world** around you.

How does augmented reality work?

So now that you know the meaning of AR, how does it work? First, **computer vision** understands what is in the world around the user from the content of the camera feed. This allows it to show digital content relevant to what the user is looking at. This digital content is then displayed in a realistic way, so that it looks part of the real world - this is called rendering. Before breaking this down into more detail, let's use a concrete example to make this clearer. Consider playing an augmented reality board game using a real cereal box as the physical support like in the figure below. First, computer vision

processes the raw image from the camera, and recognizes the cereal box. This triggers the game. The rendering module augments the original frame with the AR game making sure it precisely overlaps with the cereal box. For this it uses the 3D position and orientation of the box determined by computer vision. Since augmented reality is live, all the above has to happen every time a new frame comes from the camera. Most modern phones work at 30 frames per second, which gives us only 30 milliseconds to do all this. In many cases the AR feed you see through the camera is delayed by roughly 50 ms to allow all this to happen, but our brain does not notice!

T(t)= 23 Terms

Example 3:

Source: https://en.wikipedia.org/wiki/Augmented_reality, accessed 18.6.2020

Augmented reality (AR) is an interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory. AR can be defined as a system that fulfils three basic features: a combination of real and virtual worlds, real-time interaction, and accurate 3D registration of virtual and real objects. The overlaid sensory information can be constructive (i.e. additive to the natural environment), or destructive (i.e. masking of the natural environment). This experience is seamlessly interwoven with the physical world such that it is perceived as an immersive aspect of the real environment. In this way, augmented reality alters one's ongoing perception of a real-world environment, whereas virtual reality completely replaces the user's real-world environment with a simulated one. Augmented reality is related to two largely synonymous terms: mixed reality and computer-mediated reality.

T(t)= 23 Terms

Augmented Reality – Averaged Reference Visual

Summary:

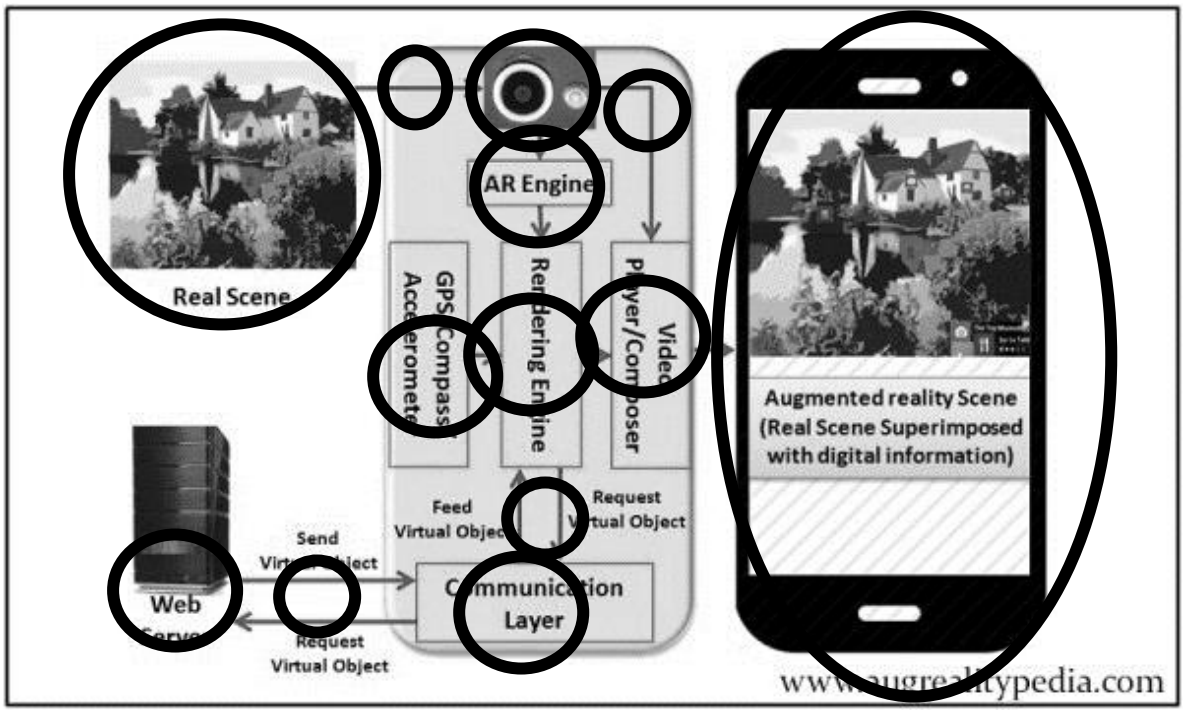
A(v)= (13+17+26)3= 18.7 = 100%

E(v)= (13+14+8))3= 11.7 = 100%

C(v)= Mean (A(v), E(v))

Example 1:

Source: https://www.augrealitypedia.com/7-amazing-facts-augmented-reality-tech/, accessed 18.6.2020

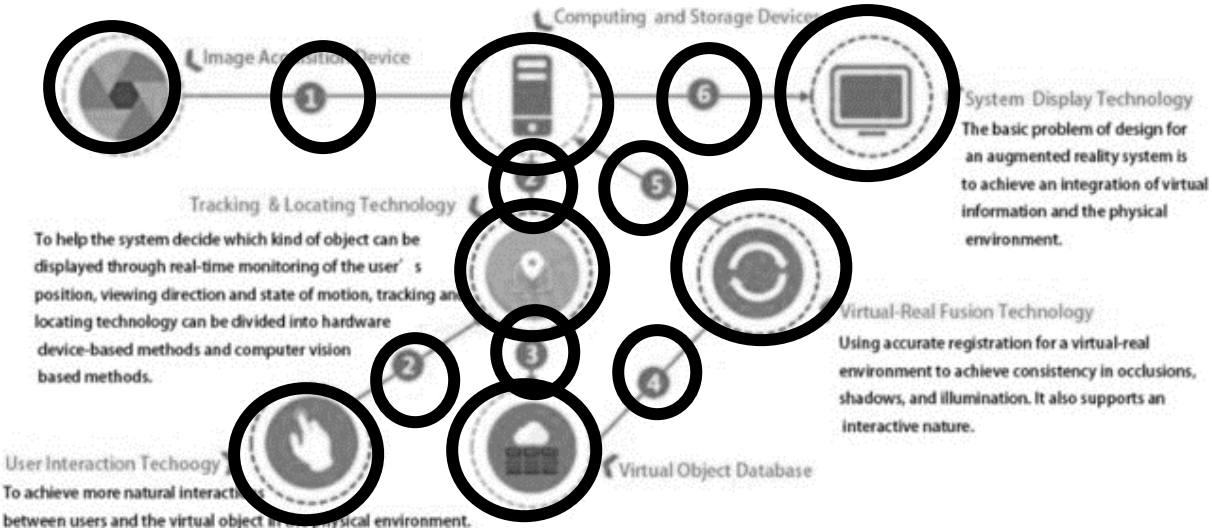


A(v) = 13 (real scene, AR engine, GPS etc, rendering engine, video player/composer, feed virtual object, request virtual object, communication layer, send virtual object, request virtual object, web server, augmented reality scene, superimposed with digital information)

E(v) = 13

Example 2:

Source: Cheng J., Wang Y., Tiondronegoro D. W., Song W. (2018), Construction of Interactive Teaching System for Course of Mechanical Drawing Based on Mobile Augmented Reality Technology, International Journal of Emerging Technologies in Learning (iJET) 13(02):126, DOI:10.3991/ijet.v13i02.7847

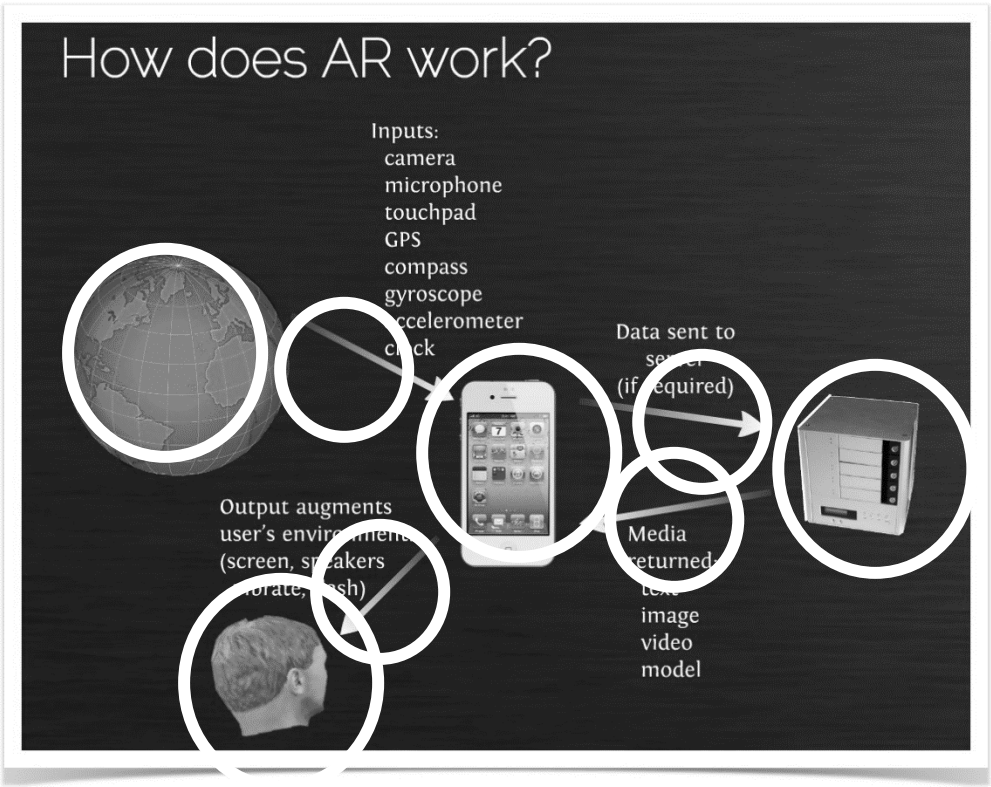


A(v) = 17 (image acquisition device, computing and storage device, system display technology, integration of virtual information and physical world, tracking, locating, real-time monitoring, user's position, viewing direction, state of motion, hardware, computer vision, virtual-real fusion technology, consistency, interactive nature, virtual object database, user interaction)

E(v) = 14

Example 3:

Source: https://wiki.mq.edu.au/display/ar/Augmented+reality+basics, accessed 18.6.2020



A(v) = 26 (AR, inputs, camera, microphone, touchpad, GPS, compass, gyroscope, accelerometer, clock, data, sent, server, media returned, text, image, video, model, output, augments, user's environment, screen, speakers, vibrate, flash)

E(v) = 8

Wireless Earphones – Averaged Reference Text:

Summary:

T(t)= (30+22+19)3= 23.6 = 100%

Example 1:

Source: https://cellularnews.com/mobile-accessories/how-do-wireless-headphones-work/, accessed 20.07.2020

The modern cornerstone of wireless technology is Bluetooth. So, let's start with it. This wireless tech connects devices within a short range by way of radio waves without the help of any cables or wires. The technology is used to send and receive information between Bluetooth-enabled devices like laptops, tablets, smartphones, etc. Hence, it requires a pairing handshake so that such gadgets are synced with each other. In Bluetooth headphones, they pair directly to your phone which provides you a wire-free experience. Depending on models, Bluetooth headsets have a range of up to 32 feet.

How is the sound or the music transmitted from the smartphone to headphones? The answer is via codec. Codecs are programs that compress data for faster transmission and then decompress it again upon reception. The codec compresses the digital audio signal on your phone. It is then transmitted over the air straight to your headphones. Audio players and headsets both possess audio codecs. You just have to make sure both devices you have support the same codec to work properly.

On the other hand, wireless headphones not running on Bluetooth use two other options: infrared and radiofrequency waves. Both require a base unit, a part that connects the wireless headset to the source device. Adapters and dongles are examples of a base unit. These connect to the device internally or externally and are still wire-free. Infrared waves work precisely like a television remote. The signal transmission range is limited to 7 meters or less. It also requires a clear line of sight to work. Alternatively, radiofrequency waves work like your old radio and are much more powerful than the infrared signal. This enables a better and farther range of up to 300 feet, still depending on your surroundings.

T(t) = 30

Example 2:

Source: https://mynewmicrophone.com/how-do-wireless-headphones-work-bluetooth-true-wireless/, accessed 20.07.2020

Wireless headphones, as the name suggests, receive their audio signals wirelessly rather than via headphone cables (often referred to as "hardwired" headphones).

Wireless headphones have built-in receivers that are designed to accept the wireless waves that carry the audio signal intended to drive the headphone drivers. This "wireless signal" is appropriately called the carrier wave.

Transmitters effectively encode the audio signal into a wireless format (the carrier wave) and propagate the wireless signal through the air.

The intended audio signal is referred to as the modulating signal. This modulating signal is encoded into a carrier wave that is transmitted wirelessly to the receiver.

The carrier waves used to transmit wireless headphone signals are either in the radio frequency range or the infrared frequency range. You can skip ahead to the sections of this article that explain these carrier waves in more detail by clicking the links in this paragraph.

It's important to note that the carrier wave is a single-frequency wave within the above-mentioned ranges. Audio signals are generally made up of frequencies within the audible range of 20 Hz – 20,000 Hz.

The wireless receiver is designed to read the carrier wave and decode the modulating signal (audio signal) from the wave. Wireless receivers must be tuned to accept the specified carrier wave frequency.

If the audio signal is digital, it is converted into an analog audio signal. The analog audio signal is then amplified to properly drive the headphone drivers.

It's important to note that, regardless of the specific type of wireless headphones, if the headphones are wireless, they are active. This means that they require power to function properly.

To maintain the “wirelessness” of the headphones, the power must be supplied by internal batteries. These batteries may be AA, AAA or batteries that are inserted into the headphones. However, it is more common to have built-in rechargeable batteries in today’s wireless headphones.

T(t) = 22

Example 3:

Source: https://wirelessheadphones.com/how-they-work/, accessed 20.07.2020

Wireless headphones work just the same with any wired headphone. However, these portable devices use low-powered radio signals for wireless transmission. No more cumbersome wires! You can freely go to a distance away from the audio source and enjoy freedom from messy wires.

Wireless headphones usually need two things in order to work. One is the headphone, and the other is its transmitter.

The transmitter in devices like smartphones, TVs, and speakers, usually comes in the form of a tiny chip that has the Bluetooth radio and software for pairing with other Bluetooth-enabled devices.

The headphone serves as the transducer of the radio signals and converts these audio signal output into a radio frequency. Then the radio frequency is transmitted over the air.

Wireless headphones are usually battery- operated. They have an integrated radio receiver which serves to accept the transmitted audio signals and convert it into its corresponding sound information. This sound information is what we hear once we use the headphones for playing our favorite tunes. This technology also lets you answer calls without the need of picking up your phone.

T(t) = 19

Curriculum Vitae

Christian Muntwiler,

born July 27., 1976 in Brugg, Switzerland

Citizen of Remetschwil, Aargau, Switzerland

Education

02/2018 – 02/2023	University of St.Gallen, Switzerland
	Conferral of a doctorate (PhD in Management)
10/1997 – 2/2002	University of St.Gallen, Switzerland
	Graduate Studies in Business Administration. Majoring in Media and Communication Management
08/1992 – 6/1996	Gymnasium Cantonal School, Baden, Switzerland

Working Experience

11/2018 - today	University of St.Gallen
	Executive Director ISP MBA
2017 - today	SGCM Consulting & Management AG
	Managing Director, Trainer, and Consultant
2004 - today	St.Gallen Business School, St. Gallen Management Institute, St.Gallen Management Program, and Others
	Lecturer and Consultant
2002 – 2016	St.Gallen Business School
	Director Corporate Seminars and Director of Studies

Further Experience

10/2019 – today	Municipality of Rehetobel (Appenzell Ausserrhoden)
	Elected Member of the Municipality Council