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Managerial and Entrepreneurial Decision Making
Emerging Issues

Edited by
Matteo Cristofaro, Maria José Sousa,
José Carlos Sánchez-García and Aron Larsson

MDPI

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Contents

About the Editors

Matteo Cristofaro

Post-doc Research Fellow in Management

Matteo Cristofaro work draws from the established concept of bounded rationality and tries to advance the strategic/managerial decision making literature leading to a new reconsideration of executives' actions as mostly based on cognitive errors, affective states and—in general—irrational forces. In this vein, he authored the recent Affect-Cognitive Theory of management decisions. His interests lie mainly in strategic decision making, behavioral strategy and organizational adaptation.

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Editorial

Contextualized Behavior for Improving Managerial and Entrepreneurial Decision-Making

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1. Introduction

Since the conceptualization of bounded rationality by Herbert Simon (1947), management scholars started investigating how people—managers and entrepreneurs—really make decisions within (and for) organizations. Taking into considerations the effect on organizational choices (e.g., new product development, market entry, merger and/or acquisition of other entities) and related performance (in organizational, economic, and social terms), a series of trends have flourished within this pivotal research area. Nowadays, the main important are: the biasing or beneficial role of heuristics (i.e., cognitive shortcuts of human mind) (Kahneman 2003), the influence of socio-demographic characteristics and personality traits (see the derived Upper Echelons Theory; Hambrick and Mason 1984; Abatecola and Cristofaro 2020), the impact of affective states (e.g., emotions, mood, temperament), the intertwinement between cognitive and emotional factors, the co-determinant role of the (micro-, meso-, and macro-) environment in the formation of choices with person-, group-, firm-specific variables, and the biasing or beneficial impact of technologies on managers' and entrepreneurs' rationality.

The aim of the proposed Special Issue is to deeply investigate these trends in conceptual and/or empirical terms, trying to provide new insights on how managers and entrepreneurs make decisions within and for organizations. Research direction followed were: (a) The analysis of the differential role of affective states in managerial and entrepreneurial decisions (Baron 2008; Zhang and Cueto 2017), as the emotions are a driver for motivation regarding goals achievement, and impacts the nature of the decision (Cristofaro 2019); (b) differential cognitive schemas of managers and entrepreneurs (Forbes 1999; Cristofaro 2020); (c) the features of new technologies (e.g., big data analytics) that help or undermine decision-making processes (Sundberg and Larsson 2017); (d) dilemmas of organizational culture regarding the possibility of reducing the negative influences of cognitive traps (Hammond et al. 1998; Bazerman and Moore 2013); (e) heuristics conditions that are beneficial for managers and/or entrepreneurs during the organizational development processes; (f) the stronger or weaker impact of the personality of managers/entrepreneurs on decisions respect to their affective states (Armstrong et al. 2012), (g) the role of competences and experiences in the learning and decisions paths (Sousa et al. 2019; Sánchez-García et al. 2017); (g) which heuristics are beneficial for "take the plunge decisions" of entrepreneurs; (h) the differences in emotions in individual and group decisions; and (i) the impact of cognition and/or affective states of stakeholders on the one of managers and entrepreneurs (Hodgkinson and Sadler-Smith 2018).

2. Managerial and Entrepreneurial Decision Making: Emerging Issues

The Special Issue of *Administrative Sciences* entitled "Managerial and entrepreneurial decision making: Emerging issues" received 16 submissions from March 2020 to October 2020. Among them, only 7 have been accepted to be published (acceptance rate 43%) after the one-blind peer-review process. Published manuscripts were considered having scientific soundness and originality, but, especially, leading to the advancement of managerial and entrepreneurial decision-making literature.

About the entrepreneurial decision-making process, the study of Arend (2020) entitled "Getting Nothing from Something: Unfulfilled Promises of Current Dominant Approaches to Entrepreneurial Decision-Making" makes a provokable debates on the value of two dominant models in the decision-making process in the entrepreneurial context: the creative school, and the logic of effectuation. In particular, departing from the weaknesses and failures of the of these two models, he then provides a series of alternative approaches for effectively studying the entrepreneurial decision-making. The first approach states that the origins of the resources are not identifiable; they are windfalls that occur at different stages of the process and with different possible effects. From this, the role that managers-entrepreneurs have in the identification of resources, as well as in their use, stands out. The second approach also considers heterogeneous factors as windfalls and explicitly recognizes that other companies are endowed with them as well, which should lead to progress through co-evolutionary action. This alternative provides more open roles for managers and more meaning for institutional policy purposes to support business decision-making. The third alternative they propose takes a different starting point. It is aimed at the premises of the formal theories that underlie the currently dominant approaches. Provided critiques offer the basis to identify spaces for improvement, to warn from applying prescriptions that rely on models' current weaknesses and flaws, and to outline the opportunities of three different alternative approaches in studying entrepreneurial decision-making.

As to extend the analysis of the entrepreneurial decision-making process, this was also investigated by a third party view, in particular, from the consultants' standpoint. Indeed, Nuijten et al. (2020), with their work entitled "Cognitive Biases in Critical Decisions Facing SME Entrepreneurs: An External Accountants' Perspective," examined biases in entrepreneurial decision-making from the perspective of SME accountants. To this aim, they conducted an empirical study by interviewing 14 accountants who can provide independent assessments of small medium enterprise (SME) decision-making regarding strategy, regulatory compliance, human resources, IT, and succession. Results show that the presence of a particular bias is highly dependent on decision domain as well as accountants showed four different approaches (warn, inform, intervene, and coach) when they encounter cognitive biases in entrepreneurial decision-making. In this study, therefore, the role of the context in which a decision is made emerges as pivotal because of the emergence of distinct biases. As to reduce the probability of falling in these biases, authors propose that accountants must intervene in highlighting the cognitive pitfalls to SME entrepreneurs as well as that extensive programs of feedback to combat biases should be implemented.

This conclusion is shared also by the work of Schettini et al. (2020) entitled "Enhancing Healthcare Decision-Making Process: Findings from Orthopaedic Field." In particular, they intended to analyze, through an interview-based explorative case study, whether and how cognitive biases occurring in "clinical reasoning" can affect orthopedists in decision-making regarding the follow-up after knee and hip arthroplasty. Results from the semi-structured face-to-face interviews conducted with three orthopedic surgeons attested the presence of four common biases (affect heuristic, anchoring, halo effect, saliency), and four others (groupthink, availability, overconfidence, confirmation) that come to light depending on the physicians' intrinsic working experience and/or working context (i.e., private or public hospital). From that, decision-making of physicians can be improved through the intervention of a third party that can evaluate the process according to the context in

which it is embedded. The amelioration of decision-making processes, therefore, may come through the involvement of a third party and practices of training and coaching.

Above results are also in line with the work by Goldsby et al. (2020), who proposed a conceptual paper entitled "Under Pressure: Time Management, Self-Leadership, and the Nurse Manager." The work advances a model to help mitigating time pressure on nurse managers and their frontline nurses based on the research regarding time pressure, psychosocial care, time management, and self-leadership. In particular, by the use of the metatriangulation methodology, authors propose three metaconjectures. First, it is proposed that time pressure will impede good decision-making and detract from the provision of quality psychosocial care by nurse managers. Second, research on time management and self-leadership leads authors to conjecture that when practices in these two areas are successfully implemented, the negative effect of time pressure on decisions related to care can be reduced. Third, the proper application of time management and self-leadership practices moderates the relationship between time pressure and psychosocial care by nurse managers. They conclude that deliberate and persistent use of time management and self-leadership practices, stimulated by training and coaching, may reduce the dissatisfiers that drain time and energy on the unit and open up more opportunities to find the little fixes that add marginal time savings as well.

However, biases in decision-making processes are just an effect of inner antecedents of decision-makers (e.g., personality traits, affective states, etc.,) and, because of that, another effective strategy to prevent cognitive biases is to understand their link with these precursory factors. In this regard, the study by Cristofaro et al. (2020) entitled "The Influence of Core Self-Evaluations on Group Decision Making Processes: A Laboratory Experiment" deals with the consideration of the personal trait called Core Self-Evaluations (CSE)—thus, the evaluations that individuals make about others, the world, and themselves—in decision-making processes. In particular, CSE of respondents was investigated with regard to: (i) the duality intuitive vs. reflective thinking, (ii) the connection with the overconfidence bias, and (iii) decision-making performance. To this aim, 120 graduate students—divided into groups of four—took part in a simulation game and were asked to make decisions acting the role of General Manager of a small-sized manufacturing firm. Results show that an average level of CSE is preferable to balance intuitive and reflective thinking, as well as avoiding overconfidence bias and reaching the best performance possible. This work suggests that there is a huge misattribution in considering a high level of CSE as being beneficial for decision-making processes and consequent performance and, because of that, managers should be aware of the level of CSE of each individual composing groups as to reach effective results.

In parallel to the study of the contextual features and personal characteristics that can lead to advent of biases in decision-making processes, other studies have been more focused on the actions to be implemented for anticipating undesired decision outcomes. In this vein, the paper by Splichalova et al. (2020) entitled "Managerial Decision Making in Indicating a Disruption of Critical Infrastructure Element Resilience," proposed a conceptual model to preventively indicate a potential disruption of the critical infrastructure elements' resilience before the actual occurrence of the adverse event. They identify the lack of managerial tools for the purpose of providing process support to decision-making in the selection of indicators for resilience disruptions, and contributes with a discussion on the need to further address resilience disruptions in the protection of critical infrastructure. In particular, they propose a model that consists of eight interconnected steps, providing the assessor with comprehensive instructions for the indication of a possible disruption of the resilience of critical infrastructure elements. This enables the assessment of the current level of the element's resilience to disruptive events evaluated according to the available methods.

With the same rationale of Splichalova et al. (2020), the work by Brous and Janssen (2020) entitled "Trusted decision-making: Data governance for creating trust in data science decision outcomes" provided a thoughtful model to understand the role of data governance

in creating trust in data science decision outcome. In particular, owing to the duality of technology lens and the adoption of two explanatory case studies in the asset management domain, authors are able to depict the interactions among the organization, decision-makers, and technology. Propositions of the model establish that organizations with an established data governance capability are more likely to: (i) have a well-functioning data science capability, (ii) to generate trusted data science outcomes, (iii) to ensure that organizational conditions of data science are met, (iv) and manage organizational and process changes introduced by data science outcomes. In synthesis, data governance here emerges as a boundary condition for managing the organizational consequences of data science outcomes.

3. Concluding Remarks

In total, this special issue covers the topic of managerial and entrepreneurial decision-making from a multitude of important perspectives that have flourished within the area. From the published papers it clearly emerges that the original concepts and theories, e.g., bounded rationality and the presence of cognitive biases in human decision-making processes, still play an important role in contemporary research (e.g., Shepherd and Rudd 2014; Artinger et al. 2015; Cristofaro 2017, 2020).

In this regard, from a systematic evaluation of the 7 published papers, the following can be stated: as to improve their decision-making process (i.e., by reducing biases and consequently improve related performance), executives and entrepreneurs should *contextualize their behavior*. Indeed, the works by Schettini et al. (2020) and Nuijten et al. (2020) demonstrate how decision-makers should be aware of the context in which they implement their actions; this is because the surrounding environment can drive to different biases for which the same preventive action cannot work. However, due to the strong influence of psychological factors for the elaboration of decisions, such as a high Core Self-Evaluation personality trait (see Cristofaro et al. 2020), executives and entrepreneurs should implement behavioral strategies, such as improving (through coaching and/or training) their own self-leadership (Goldsby et al. 2020) in order to adaptively act and react within organizations. In this regard, executives and entrepreneurs must be *ecologically rational*, thus be aware of the negative and positive effects that biases can have depending on the context and use them at their advantage (Gigerenzer et al. 1999).

In sum, it is here taken the position that behavior is the function of the strategies (e.g., heuristics) that individuals choose from the set of all possible ones (i.e., toolbox) according to the environment in which these strategies should be implemented (Todd and Brighton 2016). However, also planning and organizing activities—such as elaborating models that can prevent adverse organizational events (Splichalova et al. 2020) or defining activities that can help authority and control over the management of data assets (Brous and Janssen 2020)—can also help anticipating/avoiding undesired decision outcomes. From that, managerial and entrepreneurial decision-making emerge, even more, as phenomena that cannot be detached from the environment in which executives and entrepreneurs are embedded, claiming to establish new approaches to research (Arend 2020) that looks at decision-making as an individual/group/organization-environment dialectical and multi-level phenomenon.

References

Abatecola, Gianpaolo, and Matteo Cristofaro. 2020. Hambrick and Mason's "Upper Echelons Theory": Evolution and Open Avenues. *Journal of Management History* 26: 116–36. [CrossRef]

Arend, Richard J. 2020. Getting nothing from something: Unfulfilled promises of current dominant approaches to entrepreneurial decision-making. *Administrative Sciences* 10: 61. [CrossRef]

Armstrong, Steven J., Eva Cools, and Eugene Sadler-Smith. 2012. Role of cognitive styles in business and management: Reviewing 40 years of research. *International Journal of Management Reviews* 14: 238–62. [CrossRef]

Artinger, Florian, Malte Petersen, Gerd Gigerenzer, and Jurgen Weibler. 2015. Heuristics as adaptive decision strategies in management. *Journal of Organizational Behavior* 36: S33–S52. [CrossRef]

Baron, Robert A. 2008. The role of affect in the entrepreneurial process. *Academy of Management Review* 33: 328–40. [CrossRef]

Bazerman, Max H., and Don Moore. 2013. *Judgment in Managerial Decision Making*, 5th ed. New York: Wiley.

Brous, Paul, and Marijin Janssen. 2020. Trusted decision-making: Data governance for creating trust in data science decision outcomes. *Administrative Sciences* 10: 81. [CrossRef]

Cristofaro, Matteo. 2017. Herbert Simon's bounded rationality: Its evolution in management and cross-fertilizing contribution. *Journal of Management History* 23: 170–90. [CrossRef]

Cristofaro, Matteo. 2019. The role of affect in management decisions: A systematic review. *European Management Journal* 37: 6–17. [CrossRef]

Cristofaro, Matteo. 2020. "I feel and think, therefore I am": An Affect-Cognitive Theory of management decisions. *European Management Journal* 38: 344–55. [CrossRef]

Cristofaro, Matteo, Pier Luigi Giardino, and Luna Leoni. 2020. The influence of core self-evaluations on group decision making processes: A laboratory experiment. *Administrative Sciences* 10: 29. [CrossRef]

Forbes, Daniel P. 1999. Cognitive approaches to new venture creation. *International Journal of Management Reviews* 1: 415–39. [CrossRef]

Gigerenzer, Gerg, Peter M. Todd, and the ABC Research Group. 1999. *Simple Heuristics that Make Us Smart*, 1st ed. New York: Oxford University Press.

Goldsby, Elizabeth, Michael Goldsby, Christopher B. Neck, and Christopher P. Neck. 2020. Under pressure: Time management, self-leadership, and the nurse manager. *Administrative Sciences* 10: 38. [CrossRef]

Hambrick, Donald C., and Phyllis A. Mason. 1984. Upper echelons: The organization as a reflection of its top managers. *Academy of Management Review* 9: 193–206. [CrossRef]

Hammond, John S., Ralph Keeney, and Howard Raiffa. 1998. The hidden traps in decision making. *Harvard Business Review* 76: 47–58. [PubMed]

Hodgkinson, Gerard, and Eugene Sadler-Smith. 2018. The dynamics of intuition and analysis in managerial and organizational decision making. *Academy of Management Perspectives* 32: 473–92. [CrossRef]

Kahneman, Daniel. 2003. A perspective on judgment and choice: Mapping bounded rationality. *American Psychologist* 58: 697–720. [CrossRef]

Nuijten, Arno, Nick Benschop, Antoniette Rijsenbilt, and Kristinka Wilmink. 2020. Cognitive Biases in Critical Decisions Facing SME Entrepreneurs: An External Accountants' Perspective. *Administrative Sciences* 10: 89. [CrossRef]

Sánchez-García, José C., Elena Rodriguez-Gómez, Brizeida R. Hernández-Sánchez, and José Maniel Pérez-Díaz. 2017. Entrepreneurship Education as a Key Antecedent to Boost Nascent Entrepreneurs. In *Nascent Entrepreneurship and Successful New Venture Creation*. Edited by Antonio Carrizo Moreira, Dantas J. Guilherme Leitã and Fernando Manuel Valente. Hershey: IGI Global, pp. 58–84.

Schettini, Irene, Gabriele Palozzi, and Antonio Chirico. 2020. Enhancing healthcare decision-making process: Findings from orthopaedic field. *Administrative Sciences* 10: 94. [CrossRef]

Shepherd, Neil G., and John M. Rudd. 2014. The influence of context on the strategic decision-making process: A review of the literature. *International Journal of Management Reviews* 16: 340–64. [CrossRef]

Simon, Herbert. 1947. *Administrative Behavior*. New York: The Macmillan Company.

Sousa, Maria J., Manuel Carmo, Ana Cristina Gonçalves, Rui Cruz, and Jorge M. Martins. 2019. Creating knowledge and entrepreneurial capacity for HE students with digital education methodologies: Differences in the perceptions of students and entrepreneurs. *Journal of Business Research* 94: 227–40. [CrossRef]

Splichalova, Alena, David Patrman, Nikol Kotalova, and Martin Hromada. 2020. Managerial decision making in indicating a disruption of critical infrastructure element resilience. *Administrative Sciences* 10: 75. [CrossRef]

Sundberg, Leif, and Aron Larsson. 2017. The impact of formal decision processes on e-government projects. *Administrative Sciences* 7: 14. [CrossRef]

Todd, Peter M., and Henry Brighton. 2016. Building the theory of ecological rationality. *Minds and Machines* 26: 9–30. [CrossRef]

Zhang, Stephen X., and Javier Cueto. 2017. The study of bias in entrepreneurship. *Entrepreneurship Theory and Practice* 41: 419–54. [CrossRef]

Getting Nothing from Something: Unfulfilled Promises of Current Dominant Approaches to Entrepreneurial Decision-Making

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Abstract: We provoke. In this conceptual piece, we challenge the value of two dominant models of the entrepreneurial process that have existed over the past two decades—the creativity school and the logic of effectuation. We point out their weaknesses and their unfulfilled promises, and we argue for the field to move on forward with different ideas. We identify the lessons our field should learn so as to minimize the possibility of potentially detrimental model dominance in the future. We then outline three alternative approaches to modeling entrepreneurial decision-making that suggest further skills and policies required in improve the entrepreneurial process.

Keywords: entrepreneurial decision-making; resource-based view; opportunity identification; competitive advantage; critical assessments

1. Introduction

The research area of entrepreneurial decision-making remains important despite being bogged down over the last two decades by too few dominant approaches representing too few schools. Therefore, it is time to provoke. It is time to expose the weaknesses in those approaches to stop their persistence and to allow new ideas to breathe. Such an exercise is important in order to shift attention away from favored but flawed logics and towards alternative ideas that offer new models that address current weaknesses and explore fresh topics (Renwick et al. 2019). That is our intended contribution here.

That contribution is scientific. Every step in the progress of science entails an improvement to a field's knowledge base. That always entails suggesting (if not proving) errors in the current knowledge base (e.g., gaps, failures to consider interdependencies, incorrect assumptions, and so on). Often this critique of currently dominant ideas is done implicitly or indirectly, or framed in a positive light, as complementary. We are more blunt here. We expose the major weaknesses and failures of two currently dominant approaches in entrepreneurial decision-making in order to provide a basis to move forward, and then we suggest several alternative ways to do so.

We define entrepreneurial decision-making as choices made in the pursuit of differential value creation, appropriation and defense, necessarily against competing forces and beliefs (e.g., Westgren and Wuebker 2019). We see entrepreneurship research as the study of new value generation, often under conditions of relative uncertainty and resource scarcity, often through new products, processes and structures that address an *ex post* identifiable failure in a past market (Venkataraman 1997). Analyzing the phenomenon of entrepreneurship, in addition to the core of that process—decision-making—is vitally important because the majority of businesses in advanced economies are small, often new ventures, that have a disproportionate effect on both job creation and innovation. Therefore, when the model approaches are deficient, the non-beneficial effects from following their prescriptions, and from ignoring alternative approaches, can be significant.

Our plan in this paper for addressing those issues is the following: We first critically assess the two dominant approaches represented in the creativity school (e.g., Alvarez and Barney 2007) and in the logic of effectuation (Sarasvathy 2001), in addition to their epistemological basis. Then, we outline three alternative approaches that address some current flaws while building on a common underlying ambition to explain differentiated value generation. For each alternative, we discuss practical and academic implications. Finally, we summarize and conclude.

2. Critical Assessment of Dominant Approaches

Effectuation and the creativity school are two entrepreneurial decision-making model approaches that each have come to dominate the discussion since the early-to-mid 2000s (with their original articles being cited over 5300 and 2200 times in Google Scholar, and with numerous follow-on papers for each continuing into the present—e.g., Grégoire and Cherchem 2020; Mansoori and Lackeus 2019; Chandra 2017; McBride and Wuebker 2020, respectively). Below, we critique them and their epistemological base in order to suggest each is detrimental to the field. Each effectively exploited the weakness in then-current models in order to bolster a relative versus an absolute promise of improvement in understanding. Yet, each model is itself weak: each is incomplete (e.g., Ranabahu and Barrett 2019), based on questionable epistemology for the task, prescribes potentially detrimental behaviors, and does not fully recognize the ideas upon which it is built. Despite those issues, each approach has been seen in multiple publications in our top journals in a manner that took attention away from alternative approaches and reinforced limited perspectives. Table 1 summarizes our detailed critiques described below.

Given our definition of entrepreneurial decision-making, any model approach has to consider, at a minimum, the basis of differential value-creation. Without heterogeneity of a ventures' factors (e.g., their resources, capabilities, beliefs), then theoretically there is no new value to create. Without new value to create, there is no path to competitive advantage (CA) or sustained CA (SCA). This logic is clearly stated in the strategic management literature through the resource-based view (referred to as RBV henceforth—Barney 1986, 1989, 1991; Penrose 1959; Peteraf 1993; Wernerfelt 1984)[1]. Unfortunately, the RBV is deficient in explaining where resource heterogeneity originates—" . . . an important question in resource-based theory remains unanswered—where do heterogeneous resources come from" (Alvarez and Barney 2007, p. 22). Alvarez and Barney answered the question by connecting the RBV to entrepreneurial opportunity identification. They assert that the value of factors or products[2]

They were not the only ones pushing for a perspective on strategic decision-making in entrepreneurship based on creativity. While they did so from a questionable and esoteric metaphysical basis, others did it through a select-sample lab experiment inductive basis (Sarasvathy 2001), or from an old conceptual basis (e.g., bricolage—Levi-Strauss 1966). All promised ways to magically generate something from nothing—mostly by leveraging existing (read free, or mistakenly represented as costless) factors (both physical and social) that somehow all rival parties had missed. However, none explained either resource heterogeneity or the underlying market failures involved (e.g., Arend et al. 2015; Beugré 2017; Guo et al. 2018). Below, we consider these weaknesses and failures in more detail.

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[1] The RBV has also been proposed as a new theory of the firm (Conner 1991). Additionally, as with most recent theories, the RBV has received its share of critical analyses over time, across both fundamental empirical and logical issues. Critiques exist questioning how the RBV has been empirically tested. These suggest that the RBV has never been tested in its proposed complete form, but has only found support in loose and convenient statistically significant correlations between specific internal factors and performance outcomes (e.g., Arend 2006; Arend and Levesque 2010; Newbert 2007). Critiques also exist questioning its logic. These include concerns over the tautological nature of the value characteristic that defines focal RBV resources, a characteristic that has neither an independent definition nor a convincing origin story (Priem and Butler 2001).

[2] We use the term 'product' here in the broadest sense as an 'output' of entrepreneurial action—e.g., as a consumable product, as a new process, as a new business model, as a new form of organization, as a means to identify a new factor market, and so on. is exposed through entrepreneurial actions oriented by either discovery or creativity (e.g., Alvarez and Barney 2007)[3].

Table 1. Critical issues with dominant entrepreneurial decision-making approaches.

Issue Approach	Lack of Originality	Characteristics	Weaknesses	Failures	Something from Nothing	Uncertainty	Prescriptions
Creativity School	Venkataraman described opportunity creation and origins of one opportunity-generating market failure. RBV's inherit vs. build schools mirror discover vs. create schools. Discovery vs. invent debate ongoing in metaphysics for decades. Creativity school in entrepreneurship described by Bijkers in 1980s.	Based on contrast to a self-servingly narrowly defined 'discovery' school. A 'hook' of social constructivism—making an opportunity from nothing but belief. Timed to a spike in entrepreneurial activity and a disappointment with formal processes.	Ambiguous opportunity construct. Inapplicable to real entrepreneurs who see socially constructed (but socially objective) items, like money, as real, rather than something that they can influence others to believe in or not. Amoral—all selling is good (e.g., Theranos).	No explanation for origins of a market failure-producing opportunity. No explanation why creativity is harder than discovery. No explanation for origins for factor heterogeneity. No citing of previous metaphysics work on epistemologies involved. No citing of Bakelite case describing the creativity school	Effort, spunk, imagination and social manipulation alone can manufacture a profitable opportunity (even while others with more than that try to do the same).	Besides specifying Knightian uncertainty as a context, nothing more about which type or why it exists, is provided.	Training in social influence rather than in search and alertness.
Subjective Objectivity	Montuschi defines epistemological objectivity 13 years prior. Not cited, nor the relevant work of other metaphysics scholars.	Highly supportive of the creativity school. Tries to meet the need for social constructivists to find a measure of objectivity.	Prediction about un-hindering theorizing already proven wrong, given concepts needed to do so had existed for 13 years.			Knightian, without further specification (like that others facing it can be exploited).	Training in social influence/selling.
Effectuation	Experimentation, risk-sharing, bricolage, flexibility, arbitrage, and control already exist as concepts prior to their collection under this label.	Based on contrast to oddly-defined 'causation' logic. A 'hook' of sufficient constructivism—making value from any existing means. Timed to a spike in entrepreneurial activity and a disappointment with business planning.	Implicitly requires expertise (e.g., in who to partner with) to not be potentially detrimental. Five-part logic never holds holistically under testing.	Not a full theory (as argued previously). The core premise of means over goals, and a defining directive to not predict, are each contradicted by neuroscience Fails to explain how to be creative. Fails to prove that anyone can be an entrepreneur	Implies that any individual can be a successful entrepreneur, given the means they have, in a competitive marketplace, by following five rules that summarize what 27 experts did in a lab.	Implied Knightian, given the unpredictability assumption, but yet is a type one can locally control, can through partnering, and can react to better than others.	Training in leveraging available means and control; in risk-sharing; in conservative investment; in pivoting, rather than in planning.

3. Assessing the Creativity School's Approach

The first example of dominant work involves the creativity school of entrepreneurial activity (Alvarez and Barney 2007). Its thesis is that many opportunities are not discovered through physical search but created through social construction (i.e., where people work together to create artifacts). The contrast is to the pre-existing (economics-oriented) discovery approach based on scientific realism (i.e., the view that the universe is objective and mind-independent). Its prescriptions involve training entrepreneurs in selling their ideas in order to build (partner-based) upstream supply (of resources and funds) and downstream demand (from customers) related to their new products or services. The basis hook for this approach is metaphysical—based on the epistemology (i.e., the study of knowledge) and ontology (i.e., the study of reality) of social constructivism where what is known, if not what is real, about the opportunity is generated through interactions with other human beings.

This approach to entrepreneurial decision-making entails several weaknesses, starting with the opportunity construct they use. Alvarez, Barney, and Anderson (Alvarez et al. 2013, p. 302) define it in the following way: " . . . an opportunity exists when competitive imperfections exist in product or factor markets". That definition is based on Venkataraman (1997, p. 121) weak premise of entrepreneurship—which is his observation that there exist opportunities to enhance individual wealth by exploiting market inefficiencies that exist most of the time in most societies. Therefore, the definition is imprecise because opportunities exist almost always. Venkataraman (1997, p. 122) provides a better definition one page later—that opportunities exist because information is dispersed; however, the creativity school does not use it. Their chosen definition also imprecise because it does not actually state what an opportunity is but instead refers to when it exists. Furthermore, this approach offers no explanation for why the market imperfection exists; and, that matters because the source of that market failure (e.g., whether it be market power, an externality, a public good, technological infeasibility, or something else) does make a difference as to how, or even if, the market-failure-as-opportunity can be exploited at that time.

Besides being based on an imprecise definition of the core construct of opportunity, the approach is also based on a questionable contrast to a newly-labeled 'discovery' school. Like their definition of opportunities, Alvarez and Barney (2010) also source this label from Venkataraman (1997)[4]. Discovered opportunities involve relatively less effort and less path dependence than those that are 'created'. The main difference translates into the idea that 'discovery' implies that any venture lucky enough to stumble upon the market imperfection can exploit it, whereas 'creativity' implies that there are only a few ventures that could follow the unique path in that stumbling. The dividing assumption appears to be simply that discovery provides less protection from rivals than creativity. We question whether such a defining assumption is worthy of the dominance of this approach.

The creativity school fails to answer the origin questions of a strategic factor[5] (SF) or its value, although that is seemingly its main purpose. It simply kicks those questions down the 'regress road' by newly labeling the under-specified actions in factor markets from the RBV as being the behaviors of those following this school of entrepreneurial activity (Arend 2015). In that school, Alvarez and Barney (2007) provide descriptions of self-evident conditions relating to those behaviors (e.g., that path dependence is harder to imitate; that an uncertain context is harder to decide in than a risky one;

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[4]   While Venkataraman (1997) does state that opportunities can be discovered or created (Venkataraman 1997, p. 122), he also states that they are discovered and created (Venkataraman 1997, p. 136) or discovered, created and exploited (Venkataraman 1997, p. 120). However, given he does not detail the difference in discovery versus creation, the implication appears to be more likely that all opportunities are discovered and then must be acted upon through creation to be exploited, a process which does not actually suggest this dichotomy.

[5]   We use the term 'strategic factor' to include any resource, capability, asset, routine, organizational form or otherwise firm-accessible or—owned 'thing' that has the potential to provide the organization with a competitive advantage (i.e., if exploited efficiently, it is a source of SCA [super-normal economic rents]). Such strategic factors have been described in the RBV as having a particular set of characteristics often termed VRIO or VRIN—standing for Valuable, Rare, Inimitable, Organizationally appropriable, and Non-substitutable (Barney 1986).

and, so on) instead of addressing the focal origin story. The main origin explanation remains as the RBV's endowment story (i.e., the SF is a windfall found in a factor or production market). In other words, there is no new prescriptive value or potential for insight in their answer to the question of the origins of those heterogeneous resources[6] that can leverage opportunities.

The creativity school is unoriginal. It not only borrows heavily from the RBV but also from historic metaphysical debates, and without sufficient reference to the latter. To the former, the RBV also has two schools—inherit and build (Barney 1986, 1989, 1991; Peteraf 1993; Wernerfelt 1984). The inherit school describes auditing the firm for its discoverable SFs, but mostly focuses on the efficient leverage of them into competitive advantage. The build school describes actively participating in factor markets to arbitrage and generate the SFs that provide advantage in the product market (e.g., Barney 1986; Peteraf 1993). Such activity presumably entails social interactions where suppliers are underpaid for factors and partners and customers are then influenced and sold on the new value of those same factors [that may or may not have been newly combined or refined]. Essentially, the discovery school is the inherit school and the creativity school is the build school (Alvarez and Barney 2007).

These dichotomized schools are based on optimistic narratives. The first narrative, representing the inherit/discover school, involves a newly recognized windfall (e.g., identified through being alert—Kirzner 1973) that is easy to monetize. Often, it is a recent inventorying or enlightenment that detects factors (e.g., private information) that can be used to arbitrage a market in relatively few and relatively certain, well-understood steps (e.g., Wernerfelt 1984). The second narrative, representing the build/create school, involves a spark-like windfall that is hard to monetize (e.g., Alvarez et al. 2013). Often, it is in the form of an inspiration (or curiosity, or feeling, or insight) that leads to actionable beliefs that can be taken towards, in the best cases, uncovering further sparks to further actions that require many steps, many players, and many negotiations in order to build something that did not seem to be there (in that form) before, that now others value (e.g., Alvarez and Barney 2007). Additionally, that valuable thing can then be monetized in a process requiring relatively many steps that have less certainty (e.g., steps that are less proven, involving less confidence, less experience, and with more that can go wrong and also be more costly). In other words, there is not much new here; it is the RBV 2.0 (and 20 years on) with new language about epistemology and uncertainty added.

The added uncertainty, though, is poorly explained and also poorly supported. The creativity school bases itself on the notion of Knightian (Knight 1921) uncertainty and explicitly promotes that opportunities pursued under it must be done creatively, in the social constructivist manner. However, simple arbitrage does fulfill the definition of entrepreneurial action under Knightian uncertainty and is often conducted through what its most famous practitioners would describe as discovery activity focused on ontologically real entities. Furthermore, regarding the creation school's missing explanations of the precise uncertainties it involves, nowhere does it explain the role of uncertainty

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[6] It is realistic to acknowledge heterogeneity in entrepreneurship and strategic management: *all* firms and contexts do differ from each other (in space and time), and often in non-trivial ways. That said, it is common to assume homogeneity over most firm factors when theorizing in order to simplify the competitive context, as that allows more focus on the main drivers of performance (e.g., Bain 1954; Porter 1980; Venkataraman 1997). Homogenization is also done in practice so that heterogeneous factors can made to serve standardized functions in order to be of use in the firm's business model (e.g., unique people are trained to operate a welder on a mass assembly line). That homogenization provides several benefits, including improved skill applicability, larger scalability, greater share-ability, easier training, and more effective internal communication and coordination. Those benefits, in turn, generate higher production consistency, quality, and predictability. While heterogeneity is often homogenized so that the firm can do its business efficiently, heterogeneity is also often leveraged to protect how it does that business so that it is not imitated through external homogenization. That said, it is important to note that most heterogeneous firm factors are not potential sources of advantage (e.g., the heterogeneity of factors is usually not useful, or it is difficult to commercialize, or it is easy to imitate or to substitute for). Identifying what is and what is not a potentially advantageous heterogeneity is not a trivial exercise, and one that many firms do not attempt proactively for many reasons (including the difficulties in predicting uncertain possible futures—Hirschman 1958). We note that the creativity school does not identify either where advantageous heterogeneity originates or even how to identify any endowment of it. Instead, it implicitly assumes that the heterogeneity is there and that a plucky entrepreneur can take steps to identify and exploit its inherent potential value.

versus ambiguity versus ignorance in what an opportunity is, or in the origins of heterogeneous resources, or in how to be a more successful entrepreneur in practice.

The metaphysics hook used in the creation school is also borrowed. To be clear, metaphysics is its own field, with its own experts and its own history. Therefore, borrowing from it should be done in ways that honor its expertise and its record of research. That would include the acknowledgement that the discovery versus invention debate is well-trodden in metaphysics, and yet it appears to be the basis of the discovery versus creation dichotomy born in the mid-2000s. That original debate between scientific realists and social constructivists has been going on for a long time in the metaphysics field (see Bell 1994; Hacking 1999; and Winner, Simon, Kant, Nietzsche, and Plato for work decades and centuries before that). It has been a subject of the 'science wars' (Sokal 1996). A fantastic account of the creativity school appears in Bijker (1987) piece on Bakelite (which is uncited by the original entrepreneurship creation school authors some 20 years later). Yet, the idea that some entrepreneurial scholars newly invented such metaphysical concepts at the core of this school continues to this day.

4. Assessing the Metaphysics behind the Approaches

The same metaphysical hook is relied upon by both currently dominant approaches. Each relied upon social constructivism to contrast to the scientific realism that preceded it (e.g., the predictive-planning perspective prior to effectuation and in an alertness-search perspective prior to the creation school). We critique that hook by assessing a current example by authors in the creativity school now[7]. In their metaphysics-centered paper, McBride and Wuebker (2020) state that they untangle "the opportunity debate because there are now criteria for what makes an opportunity (or any social phenomena) objective" (p. 22); indeed, they claim that they have just provided "a novel perspective" that delivers a uniquely "clear understanding of social entities" (pp. 2–3) by newly defining the concept of epistemological objectivity. That is the new core contribution that they argue. However, unfortunately, previous metaphysics research had defined the same concept more than a decade prior.

Montuschi (2007, p. 177): "A philosophical distinction is normally referred to between two concepts of objectivity: an ontological concept . . . and an epistemological concept (objectivity is a property of the content of mental states and acts) . . . epistemological objectivity can be assessed in its own terms, that is the objectivity of our beliefs can be established by reference to other beliefs which may provide justifiable, coherent, intelligible, rational support . . . it is indeed on the basis of notions such as 'the way reality appears to us' . . . that epistemological objectivity can be at all ascertained." Clearly, the originally uncited Montuschi paper had already defined the criteria for what makes a social phenomenon objective.

They go on to predict that once entrepreneurship (as well as any other social science field) has seen their 'unique' answer to 'what is social objectivity' then the floodgates will open to significant advances in theorizing. They state "that getting the answer to the question about what makes any social phenomena objective might be the single most important piece of the foundation for the future success of the social sciences", so much so that the lack of that answer has hindered "advances in entrepreneurship theory" (p. 23) until just now. Unfortunately, given that answer has existed for over a decade, they not only have admitted that the creation school itself did not un-hinder entrepreneurial decision-making theoretical progress but they have also made the case that adding a 'core' metaphysical conceptualization has not either. This is all the more impactful because it comes from supporters of

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[7] Editorial discretion appears as one of the reasons for the persistence of these dominant models. When authors of these schools also act as editors for their co-author's and co-faculty's pieces that support and cite that work then several apparent conflicts of interest arise that should be, but are not, checked by our journals and our academies even when these appear to violate our ethics codes and the blindness in our reviewing processes that lies at the core of the legitimacy of the quality of research in our field.

the creation school and its social constructivist, subjective reality. This is why this example paper was chosen.

That is not to say that metaphysics is unimportant to research. Metaphysics provides the premises that act as the platform for theory-building (e.g., Dubin 1969). It does so by defining reality and knowledge together as a primary set of facts from which deduction can proceed and for how rational logic can work through induction. Theory-building abstracts from real phenomena, providing a small world model to capture its most important relationships in order to increase understanding, prediction and control of future similar events. However, the practice of entrepreneurship is a real and large world phenomenon involving many complexities, dynamics and, as with most social science targets, non-stationary relationships. It is quite far removed from the tiny world of metaphysics. Therefore, it should not be surprising that actual entrepreneurs do not care about the metaphysical arguments that money is socially constructed or not ontologically real; they conduct business as if it were, just as the academics studying them do.

Regardless of that tenuous connection between the tiny and large worlds related to entrepreneurial decision-making, supporters of the two dominant approaches argue for both a direct (through pedagogy) and an indirect (through the small world) influence of metaphysics (e.g., Sarasvathy 2001; McBride and Wuebker 2020). The direct influence involves the question of how best to teach entrepreneurs to obtain and exploit opportunities. Should they be taught to search for physically real objects (e.g., a new oil deposit) or to sell potential stakeholders on the mind-dependent objects that they make (e.g., a new social media platform)? However, this appears to be a forced choice on its face as all serious entrepreneurship textbooks embrace the requirement to cover both search skills (e.g., market research; reengineering) and creation skills (e.g., brainstorming; prototyping; sales and negotiations; team-building), either separately or through their explicit combination (e.g., in design thinking—Liedtka and Ogilvie 2011).

The indirect influence is via the small world, and accomplished by using the explicit modeling of the entrepreneurial process as the mediator. The argued premise is that the study of that process has to be conducted from one of two philosophies—scientific realism or social constructivism (Alvarez and Barney 2010). Most entrepreneurship scholars would absolutely disagree, given the very few studies that have ever referred to their epistemological choice, and the even fewer entrepreneurs who have raised it as an issue[8]. However, even when such a grand concept as epistemological objectivity is (re)discovered as it was in 2020, it is not used to provide new insights into the defining characteristics of entrepreneurial activity like uncertainties and the causes of the underlying market failures or, specifically, how to improve entrepreneurial decision-making[9]. Additionally, its impacts on even basic concepts like entrepreneurial opportunity also appear unclear, partly because such concepts themselves suffer from ongoing definitional disputes (e.g., Davidsson 2015). In fact, this metaphysics-based entrepreneurship stream provides no proof that specific gaps or mistakes in practitioner behaviors exist due to some lack of ontological or epistemological understanding by new venture founders or operators. While it is hard to deny that reality (ontology) and truthful knowledge (epistemology) do very much matter in today's unusual informational landscape, the final arbiters of how such issues affect innovation will not be the philosophers but instead will be the entrepreneurs who are on the ground finding ways to better satisfy human needs—both tangible and intangible[10].

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[8] It is worthwhile to note that all social science phenomena confront this metaphysical debate. Most have recognized it and moved on in the practice of *wissenschaft* in their fields where even the mind-dependent objects and events can be (and have been successfully) scientifically studied in the empirical and experimental traditions (Daston 2000).

[9] Consider the entrepreneurial activity of Warren Buffett: he represents the epitome of a Knightian entrepreneur despite the fact that he is squarely in the discovery school, searching for mispricing and exploiting it for profit, rather than creating anything new. He represents a blatant counter-example to the core metaphysical premises of the creation school. This is because even though he supposedly deals in that realm—as the entities he deals with are mostly mind-dependent, the uncertainties 'beyond risk', and the market failures mainly informational asymmetries—his data and models do not focus on any score of social objectivity but yet remain highly successful.

[10] Additionally, it remains unclear what social value there is to (re)defining epistemological objectivity alone. Prescribing greater attention be paid by entrepreneurs to selling the sizzle without any explicit assessment of quality of the steak is to

5. Assessing the Effectuation Logic

The other dominant model of entrepreneurial decision-making is effectuation logic (Sarasvathy 2001). While this model has been effectively critiqued elsewhere (e.g., Arend et al. 2015, 2016), it persists in its influence. Therefore, rather than repeating an analysis of its past exposed weaknesses, we will focus more on other issues.

We allege that effectuation's prescriptions have been shown to be detrimental to non-expert entrepreneurs (Baron 2009; Günzel-Jensen and Robinson 2017). Effectuation is based on a small set of (27) experts' observed behaviors in their entrepreneurial process as captured artificially in a lab setting with no new product created and nothing at stake. The obvious problem with any selective study—any study that selects subjects based on one common criterion—is that the criterion may be a necessary prerequisite for the behaviors to work properly. Therefore, it may well be that entrepreneurial expertise is a necessary attribute for successfully carrying out effectuation logic's prescriptions. Without such expertise, it may well be difficult to know what affordable loss is or whom to co-create with; in fact, it may well be that following the prescriptions as a novice may make outcomes worse (e.g., without expertise it is more likely that pursuing partners will result in the entrepreneur being taken advantage of).

We allege further concerns about effectuation related to its corruption of not only pre-existing ideas (e.g., bricolage, experimentation, ambidexterity) but also pre-existing words (e.g., causation). Such verbal re-definitions may have been an effective marketing move (Mehrpouya and Willmott 2018), but they raise concerns. Managerially important words like effectuate, causation, control, contingency, and isotropy[11] were suddenly redefined; and, seemingly without scientific justification. Not only did these established terms take on completely new meanings, over time somehow several became keyword choices for journal submission. We believe that doing so created unnecessary confusion for the field. It also appears a bad precedent to allow a proposed logic to so heavily draw on standard business tactics without fully crediting those who observed, analyzed and described those years prior. For example, effectuation's leveraging of existing means is akin to bricolage (Levi-Strauss 1966). Its risk-reduction strategies include then-known tactics such as staying local, experimenting cheaply, and beg-borrow-and-stealing (e.g., acting within affordable losses), and finding partners (e.g., co-creating). Expert entrepreneurs did not invent these behaviors, nor did effectuation newly generate them from lab observations. Therefore, it seems disingenuous to suggest otherwise. It also does nothing to improve entrepreneurial decision-making.

Further harms have occurred because effectuation's five-part logic has been distorted and those distortions have been exploited to offer empirical support. The metaphors in the effectuation's story have since been reengineered into a set of empirical measures. For example, while the story is presented as a holistic multi-part logic, the set of measures has not been supported as a consistent holistic construct empirically (Arend et al. 2015; Chandler et al. 2011; Welter et al. 2016). The distorted testing extends to where the story is assessed as well. The logic has most often been tested in less-than-chaotic contexts, where prediction is possible, and where the new ventures are not so new, nor the entrepreneurs so expert (Baron 2009; Skeat and Perry 2008). However, one issue with the distorted measures appears

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promote the next Theranos or Madoff. Making others believe deeper and wider about an idea does not alone make it worthy of pursuit let alone of social benefit.

[11] The dictionary definitions of these established words are clear, and clearly not what effectuation went on to cast them as: effectuate—to bring about, to cause to happen, to accomplish, to achieve (from latin, and having nothing to do with the five characteristics of the 'logic' described); causation—the action of producing, anything that produces an effect (from latin, and having nothing to do with the opposite of the 'logic', given causing and effectuating mean the same thing); control—to exercise restraint or direction over, to manage, to operate (from middle English, and having nothing to do with a lack of prediction or planning); contingency—dependence on chance or on the fulfillment of a condition (from 1560s English, and not being the 'opposite of knowledge'); isotropy—uniformity in all orientations (from Greek, and not being a type of real-world decision context because individual reality is not homogeneous given practical path-dependencies and neurobiological functioning). There is no scientific justification for re-defining existing words rather than naming possible new constructs that have very different meanings relative to those words. If terms have changeable meanings, involving changes that are not corrections, then any version of science allowing that is unsound.

to be a direct consequence of the way in which the original story was presented—as a relative logic. The logic relied on contrasts for definition as did the operationalizations that followed. But that has led to problems, as many of the contrasting characteristics do not define an opposite end of the given dimension. For example, prediction is not the opposite of control, chaos is. Goals are not the opposite of means, scarcity is. Market share is not the opposite of partnering, fighting is (which is more than simply competing). Contingency is not the opposite of knowledge, ignorance is. Additionally, there is no specification for what the opposite of affordable loss is to contrast to; however, it is certainly not maximizing expected value. Yet, these are the construct scales upon which rests whatever empirical support the logic has (Chandler et al. 2011; Perry et al. 2012). Worse, these scales are internally incongruous. Leveraging knowledge is consistent with leveraging existing means, and not inconsistent with leveraging contingencies given one needs knowledge to do so. Survey-style empirical studies have revealed that inconsistency (Chandler et al. 2011).

A flawed model that persists mainly based on distorted testing is not helpful for improving entrepreneurial decision-making. Furthermore, its core premise is simply wrong[12], and that is significant. Because, if we accept and advocate a logic that is factually wrong in its premises, then we really do not care about the science of business, but only the business of science.

Like the creativity school, effectuation has also persisted by offering a contrast to the overextended models that existed prior (e.g., those based on business planning), by offering a version of the entrepreneur as heroic and active, by exploiting social constructivism, by appropriating past ideas, and by offering (but not delivering on) some kind of new access to creativity (Arend et al. 2015). While it may have been refreshing to see such contrasting perspectives when they were first published well over a decade ago, the dominance of these models needs to end for our field to progress in understanding and improvement upon entrepreneurial decision-making[13].

6. Alternative Approaches

We have argued that the two dominant approaches to entrepreneurial decision-making should fade; but what should replace them? Scientific progress demands suggestions for new alternative approaches, approaches that can address the weaknesses exposed or explore new ground. These alternatives should also build on strengths. To that end, we outline three such alternative approaches below. We briefly describe the managerial, policy, and theoretical implications for each after their respective outlining.

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[12] Neuroscience-based experiments prove that effectuation's core premise is wrong. It is wrong to assert that the brain works without predicting the future regardless of uncertainties. It is wrong to assert that the brain makes decisions without goals, including immediate ones. Non-predictive control does not exist. Ignoring threats like competition does not happen. The brain is a 'real-world simulation' machine (e.g., Barrett 2017) that continuously predicts, in order to fulfill goals, considering available means, losses, risks, contingencies, and interactions with others.

[13] Each currently dominant approach enjoyed good timing, offering something different from the rational, planned, computed, search-optimizing, probability-based world of micro-economics that dominated previously. Effectuation and the creativity school promised a shift to divergent thinking as a contrast to the previous focus on analytical convergent thinking. However, neither substantively fulfilled that promise, and that is not surprising. If creativity could be boiled down to a repeatable and trainable process, it would not be creativity any more. Nowhere does effectuation actually explain how to be more creative; it is just supposed to occur at the right time and within the right budget. That promise of solving creativity is the core of the creation school, as well as many of its predecessors, like bricolage (e.g., Baker and Nelson 2005). These approaches push the idea that ex nihilo invention is possible. However, to be absolutely clear, at any metaphysical level, only nothing arises from nothing, period (Brecht 1978). Physical inventions are created from existing physical objects (by discovering new properties and uses). New beliefs are based on existing beliefs (even admitted to in the definition of subjective objectivity above). In other words, there is no way to generate something from nothing, regardless of one's metaphysical stance.

Each dominant approach also appeared to promise something like a full theory would emerge. In neither case has it. For example, effectuation remains a logic, or a process description, or some pragmatic advice, and does not rise to what it has proposed to be—a theory. Effectuation simply fails to meet the common standards for explanatory models, as has been explained in detail elsewhere (Arend et al. 2015, 2016). Despite references to ontology and epistemology, the creativity school is also not a theory, but instead simply an inconsistent and incomplete story involving social construction. In the end, neither provides a complete theory, nor new prescriptions for entrepreneurs. New prescriptions simply do not arise from only being descriptive of how real entrepreneurs were already not acting in accordance to the dominant models prior.

The first alternative approach we describe accepts the idea that the ultimate origins of heterogeneous resources are not identifiable and instead moves forward by analyzing them as windfalls that occur at different stages of the process to different possible effects. That acceptance addresses a weakness in both dominant approaches. This provides a role for entrepreneur-managers to identify those resources and then use them appropriately. This builds on the strong underlying logics for very actively leveraging such endowed heterogeneity recognized in the currently dominant approaches. Our second alternative approach also treats the heterogeneous factors as windfalls, but explicitly recognizes that other firms are also endowed with them, and that that should lead to progress through co-evolutionary action. This alternative provides more outward-facing roles for managers and more meaning for institutional-policy effects to support entrepreneurial decision-making. It addresses weaknesses in the dominant approaches related to what creativity is (i.e., it is luck- and learning-based in this alternative) and in social influencing (i.e., it is more co-evolving than unilateral in this alternative). Our third alternative takes a different starting point. It is aimed at the premises of the formal theories (e.g., the RBV) that underlie the currently dominant approaches. Two formal theories are analyzed to explore what occurs when their assumptions are broken in order to identify new entrepreneurial paths to economic value-creation, often based on viewing the venture not as one firm but instead as one part of a system of firms.

7. Alternative Approach No. 1—Focusing on Different Relevant Windfalls

Neither of the two dominant approaches identifies the ultimate origins of the SFs. In this alternative, that unidentifiability is explicitly acknowledged and such origins are simply taken as lucky windfalls. However, these windfall endowments can differ in ways that provide new insight. Here, we differentiate them by when they occur in the entrepreneurial process, and what they signify at those times, and that provides new implications for managers and researchers.

To proceed, it is worth revisiting the RBV as the current standard story of how heterogeneous factors (SFs) translate into possible SCA (Dyer and Singh 1998) given that story underlies each currently dominant approach. In the RBV, the SF is either given at the product market stage or it is obtained through factor markets just prior to the product market stage (e.g., Barney 1986; Peteraf 1993). There is a further heterogeneity assumption over whether the firm can efficiently and effectively leverage the SF in order to realize CA. This question over an execution endowment provides one explanation for why some firms with a product market SF can fail nonetheless, which allows the RBV to survive non-significant empirical results in testing. To those possible endowments of resources and capabilities, we add the one more possible windfall—that of a new opportunity.

Table 2 details the six cases of interest for entrepreneurial decision-making, comprised of the combinations of the four types of factor heterogeneity endowments identified above. An endowed pre-SF (e.g., a windfall of private information about a future technological breakthrough), occurring in the factor market, gives the firm the ability to identify a new opportunity, which then provides the value for the SF in that opportunity's product market. An endowed opportunity (e.g., as a windfall of being in the right place at the right time to spot a market failure, as in Airbnb's story of realizing a disconnected supply and demand for couch-surfing) gives the firm the ability to buy temporarily underpriced SFs prior to revealing the opportunity to the product market. An endowed SF in the product market (e.g., discovered in the firm's inventory as a dormant patent or managerial skill or social network connection that has unexploited value in a given product market, like for the rights for a particular piece of code or design feature or access to a newly important politician) gives the firm the ability to be more profitable in its current market. Additionally, an endowment of execution competence (e.g., emerging from a set of trusted employees based on a unique and fortunate path dependence) gives the firm the ability to realize any potential sources of value as SCA. We depict this entrepreneurial process as linear, proceeding naturally from a possible pre-SF to opportunity identification (where the value of the SF is defined) to a readily-exploitable product market SF to

execution on that to the attainment of CA. We leave for future work any feedback loops, as in where a product market SF creates a new opportunity for a different SF, and so forth.

New insights that can be gleaned from this alternative approach include the identification of the managerial skills needed to complement the different windfall types, and the meaning of what each windfall type has to entrepreneurship and RBV theories (e.g., in terms of what empirical support is expected for their logics). The skills the entrepreneur requires to be profitable under the endowment possibilities have some commonalities and differences. The main commonality is the necessity for SF exploitation skills in the product markets (e.g., efficient supply chain operations). The main differences arise from the type of endowment. With a pre-SF endowment, the focal skill concerns fully exploiting that advantage through identifying a new opportunity that adds new value to the product market SF (built on that pre-SF). Search skills (e.g., on where to apply the advantage), invention skills (e.g., on how the advantage can be combined with other factors), and sales skills (e.g., on getting partners to back investments in applications of the advantage) would all be important. With an opportunity endowment, the focal skill concerns arbitraging that knowledge to buy up then-underpriced to-be-SFs in the eventual associated product markets, especially those at bottlenecks and with the main technological complementarities (Teece 1986). Search skills, negotiation skills, signal-control/ informational-management skills, and prediction skills would all be important. With a product market SF endowment, the focal skill is about exploiting that advantage in the primary market and extending it through possible related diversification, tie-ins, and long-term supply-chain contracting.

Table 2. Cases implied by a deconstructed RBV-based on three endowment types.

	Opportunity Identification	Origin of SF (in Product Market)	Execution Competence	Expected Profitability	Implication for Observation/Policy
Pre-SF is endowed, guaranteeing an opportunity, and the value for the SF in the product market.	An opportunity is identified by actions (including search and social interaction) that leverage the pre-SF. That identifies the value of the SF.	SF emerges from the pre-SF endowment (it is indirectly endowed). It has value in the opportunity identified.	Assumed competent at execution of monetizing SF.	Guaranteed longer-term profitability (SCA).	Pre-SF and new opportunity related to SCA; invest in such firms.
			Assumed not competent at monetizing SF.	Profitability not guaranteed; inefficiencies reduce any realized advantage.	Weak, if any, link between pre-SF and CA; have policy to increase execution abilities.
Pre-SF is not endowed, allowing any or no firm to identify an opportunity.	Opportunity is endowed, guaranteeing an SF (through arbitrage—purchasing the undervalued factor prior to revealing its higher value in the opportunity).	SF emerges from arbitraging the endowed opportunity (it is indirectly endowed). It has value in the opportunity identified.	Assumed competent at execution of monetizing SF.	Guaranteed longer-term profitability (SCA).	New opportunity with SF related to SCA; invest in such firms.
			Assumed not competent at monetizing SF.	Profitability not guaranteed; inefficiencies reduce any realized advantage.	Weak, if any, link between opportunity (or SF) and CA; have policy to increase execution abilities.
	Opportunity is not endowed. Either the firm can identify it, a rival can, or no firm does.	SF is directly endowed. It has value in the firm's existing product market (not in any new opportunity).	Assumed competent at execution of monetizing SF.	Guaranteed profitability (CA).	SF related to CA; invest in such firms, encourage exploration activities longer-term.
			Assumed not competent at monetizing SF.	Profitability not guaranteed; inefficiencies reduce any realized advantage.	Weak, if any, link between SF and CA; policy to increase execution abilities.

The cases depicted range from providing expectedly strong to relatively weak to non-existent support of this RBV-based entrepreneurship process story. In the best cases, there is a consistent story moving from pre-SF endowment through to rent realization execution. However, in many cases, the profitability is not guaranteed, and the likely observations are not very supportive (nor may be the related policy recommendations very clear). That said, the cases indicate some new possibilities for which entrepreneurial decision-making skills to teach when.

From an academic perspective, this alternative highlights a challenge for the RBV and its effects on entrepreneurial activity. Market failures bracket the RBV (Peteraf 1993). That bracketing implies a

cycling through an extended sequence of opportunity-to-exploitation-to-new-opportunity. The RBV begins with an ex ante failure in the factor market, and we newly propose that that market imperfection can be the opportunity that potentially establishes the focal SF's value[14]. The RBV ends with an ex post failure in the product market that guarantees the potential appropriability of the SF's value because it ensures that its supply is restrict-able at a level below that of demand (Peteraf 1993). But, such a market failure also then identifies an opportunity for other firms to address via some form of activity (e.g., a dynamic activity—Teece et al. 1997; an entrepreneurial activity—Venkataraman 1997; a political activity—Arnold and Lange 2004; or, a disruptive activity—Christensen and Bower 1996).

This raises the question of whether those market failures arising from the RBV process differ from other competitive-market-imperfections-as-opportunities. If so, it is likely that each type of market failure should to be addressed differently (e.g., as some will likely be defended by current-SF-endowed firms and some will not). However, the creation school does not explicitly account for such issues like the attack and defense of those imperfections. That further weakness provides another reason to move on from it and consider alternatives that do address such issues. Furthermore, given the now-explicit daisy-chaining of the last market failure of the RBV process as being a source of opportunity for entrepreneurial activity (as implied by the definition used by Alvarez and Barney themselves Alvarez and Barney 2007), the RBV should no longer be considered as a finished theory. It is no longer a separable package, but instead only defines a waystation along a self-sustaining process that very much more puts into question the defendability of any realized competitive advantage theorized in the RBV[15].

8. Alternative Approach No. 2—A Co-Evolutionary Story

In this alternative, we also assume that the ultimate origins of SFs are unidentifiable and so model them simply as lucky endowments. The difference here is that we explicitly consider more types of such windfalls as well as more recipients of them. Instead of focusing solely inward at one specific firm, in this alternative we focus on the path to CA outwardly, arising through learning-based co-evolution (e.g., Abatecola et al. 2020; Breslin and Jones 2012).

This alternative shifts from the common RBV-based story of lucky endowments + super-rational decision-making + idealized supporting markets = competitive advantage for one firm to a new story of endowed variation + selection + retention = expected improvements in profitability and continuous new opportunity identification in an industry. Our new story is based on the assumption that firms can not only be endowed with SFs but also with other important heterogeneous factors and characteristics like a greater motivation-to-act (or more optimistic priors for acting), or a greater ability to observe the actions to other firms, or with a greater ability to learn from observations, and so on. Together, these items can generate a Darwinian evolution-like process (e.g., Breslin 2008) where the diversity of endowed (heterogeneous) 'stuff'—including motivations-to-act—are distributed in the population so as to get a (non-empty) subset of actors who do try to exploit their given factors in business ventures

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[14] We newly propose a connection of the RBV's definitional VRIO characteristics to the opportunity's definitional market failure by having the opportunity define the SF's value (i.e., the SF is valuable because it can be used to exploit a current competitive market imperfection). Therefore, a SF's value is no longer tautologically defined as being 'in demand' (Priem and Butler 2001), but instead arises from the potential of the SF to address an existing market failure (a condition that differs from simple demand).

[15] We believe that the future of the RBV-related decision-making research lies along several paths: One path separates out cases of certainty versus risk versus (forms of) uncertainty in specific, relevant decisions involving any firm factor-related path to competitive advantage. Another path separates out cases involving standard operating procedures versus tacit knowledge versus luck in specific, relevant process steps. Yet another path separates out ways to address asymmetric information for specific cases of arbitrage versus of legitimization versus of market creation. By focusing on understanding the constituent pieces of the RBV in terms of their separate possibilities, it will be easier to connect the SF-identification-exploitation-defense process backwards (e.g., to opportunities and new venture creation), forwards (e.g., to dynamic failure or reconstruction of past factor-based advantages), and sideways (e.g., to relation- or knowledge-based issues (Dyer and Singh 1998)). These connections can then be explained more clearly in what are likely to be behavior-focused, specific variants of an entrepreneurial RBV process.

(whether those turn out to actually be ex post SFs or not). When that occurs, even under the expectation that some firms will succeed and others will fail, as long as a sufficient number of others see those actions and outcomes and learn from them, then progress should be made towards new value creation by firms in an industry as a whole.

This alternative's story provides a more realistic way of getting from one state of business to a better state. In this story, the industry has firms that have been distributed with windfalls that may be initially hidden (or may involve sufficient uncertainty in their ultimate value) so as to stop an average firm manager's action to exploit it. However, that barrier can be broken when that average decision-maker can update her understanding of what the value of her endowment is and what the process to exploit it is, so as to gain the confidence to try acting on it; and that updating is made possible by other entrepreneurs acting first. Therefore, when the endowments also include differences in beliefs and motivations, others will indeed act first, and the rest will learn (e.g., updating their priors and their capabilities) so that the next set of firms then also act (with greater information), and so on towards better and better use of their endowments (e.g., Abatecola 2014; Abatecola et al. 2018; Cristofaro 2020).

As with the other alternative approaches, there are new implications for entrepreneurial decision-making, in terms of skills recommended, in terms of supporting policies and in terms of possible follow-on work. This alternative highlights the benefit of managerial skills in observation, in learning, in updating of beliefs, in increasing absorptive capacity (Cohen and Levinthal 1990), as well as in partnering to combine windfalls and shared alertness (Kirzner 1973, 1979). This alternative implies policies should be strengthened to increase diversity (e.g., policies that incentivize people to gain unique experiences, and to build on their varied endowments), to increase awareness of their inventories, and to increase action (e.g., policies that provide supporting micro-bets to make actions that are visible) in order to prime the relevant evolutionary machine's pump for entrepreneurial progress. The ideas in this alternative can be fleshed out in follow-on work, such as in computer simulations that test different model conditions (e.g., learning rates; visibility of success and failure), in human-subjects lab experiments (with different treatments of endowments and learning conditions), and in case studies of the co-evolution that occurred or is occurring in specific industries.

9. Alternative Approach No. 3—Breaking Theoretical Assumptions

The third alternative approach we outline takes a step back from entrepreneurial decision-making details (e.g., about endowment types and the mechanisms for their exploitation) to focus on the core assumptions underlying the theories in the currently dominant approaches in entrepreneurship and strategic management. In this alternative, we explore what occurs when the assumptions of a theory are broken, often because new technologies allow it, in order to discover new ways for ventures, often acting as a part of a system, to perform better in specific contexts.

Here we focus on two core theories—the RBV and transaction costs economics (TCE—Coase 1937; Williamson 1975, 1979, 1985). The difference in the premises of these two theories provides a way to break either one's assumptions in reasonable ways—we simply look to the other theory for alternative assumptions and for mechanisms that can break existing assumptions. Then we explore what occurs (for entrepreneurs) when we break each theory's assumptions. This approach provides new challenges for entrepreneurial decision-making, including the possibility for off-the-books (i.e., non-taxed) value to be leveraged among system partners (e.g., through bartering information, identity, contacts, and so on).

There are three main possibilities for 'assumption breaking' here. The first possibility involves TCE mechanisms breaking RBV premises. For example, the Relational View of the firm (Dyer and Singh 1998) proposes a hybrid transactional form that creates a unique joint capability that partners deploy to generate CA. A transaction creates a new resource across partners as with the VISA network, effectively breaking the assumption in the RBV that the focal factor is owned by only one firm. The second possibility involves RBV mechanisms breaking the TCE premises. For example, a firm's unique IT capability provides a new way to transact with customers (e.g., Priceline's patented reverse auction method). The third possibility involves the possible co-evolution of mechanisms and assumption-breaking

in the RBV and TCE, where each break affects the other's premise over time (e.g., where resources influence transaction options that influence new resource acquisitions, and so on).

The TCE and the RBV each provide a unique explanation for CA. TCE advantages involve governance choice and are efficiency-based, whereas RBV advantages involve scarce factor leveraging and are Ricardian-based. Figure 1 depicts how the theories and concepts fit together, with the TCE focused on the transactions, the RBV on the resources, and the relational view focused on the simplest system of resources–transactions–partners. Because choices over organizational forms, over partners, and over factor investments and uses are often interdependent, it is worthwhile to consider how CA can emerge through these choices collectively (as depicted in figure as a system-of-firms approach).
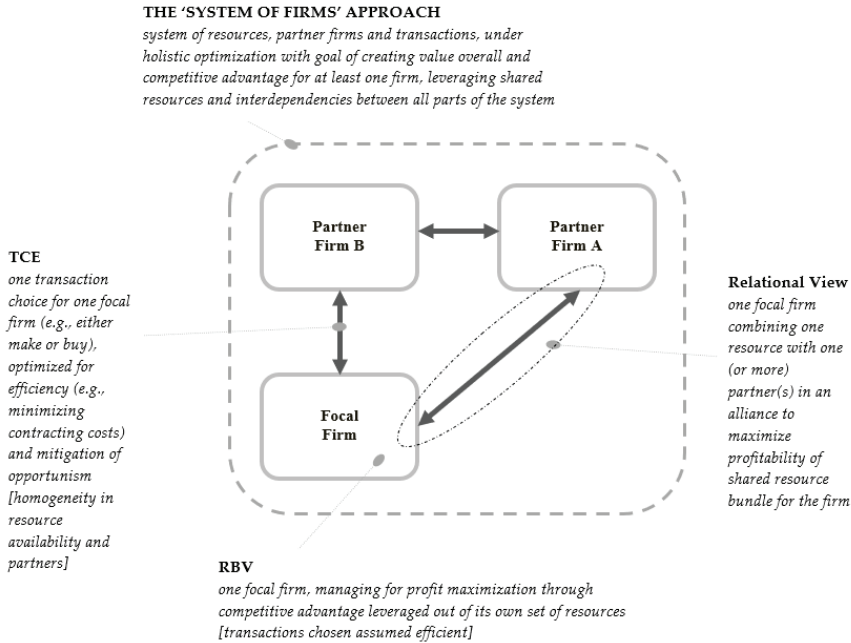
Figure 1. Domains of the relevant concepts and theories.

Resource- and Transactional-View Interdependence—As described above, this third alternative approach involves phenomena where the assumptions of one theory (RBV or TCE) are broken through the other theory's mechanisms. For example, the capabilities held by a firm can influence the availability or costs of the transactions it confronts. In this alternative, the effects of the two views are non-separable (i.e., the effects of some set of one theory's factors are interdependent on some set of the other theory's factors). For example, unique capabilities are created by an alliance, or a unique transaction form is created by one or more firm capabilities, or the capability and transaction forms co-evolve. This integration of the two theories assumes that the choice of organizational form that mitigates opportunism and economizes on incomplete contracting does influence the process of creating and exploiting capabilities, and that the capabilities that can generate competitive advantage do affect the choice of transactional forms (e.g., through the co-specialization of such capabilities with the factors made available through the transaction options).

In this alternative approach, the interdependence between the two theories involves TCE influencing RBV and RBV influencing TCE, sequentially or simultaneously. The first (TCE→RBV) has been addressed in the relational view (Dyer and Singh 1998). That view parallels the RBV, but focuses on factors as not being unique to a focal firm but instead being unique to a *set* of transacting firms.

In the relational view, there exist unique strategic capabilities that are only created by the combination of otherwise separate organizations. These capabilities then provide sustained competitive advantage to the organizations involved. In other words, the multi-firm organizational form directly affects the creation and exploitation of capabilities influencing each firm's performance; capabilities that would *not* otherwise be available in such valuable, rare and appropriable form to the partner firms independently. The other interdependencies (e.g., RBV→TCE) have not enjoyed such formal analyses. Such possible interdependencies involve new value creation with combinations of shared resources across often-novel transactional structures.

Therefore, what are the assumptions that can be broken by the factors in each view? In TCE, such assumptions include: the homogeneity of the firms involved (e.g., along their production mixes, and bargaining power over contracts); the homogeneity of the transaction options available; those options' costs and benefits and risks; and, that such governance choices are separable (both at a point in time, and across time). In the RBV, such assumptions include: that all firms choose optimal transaction forms for exploiting each resource; that firms know the value of all resources; that each firm needs to defend against the erosion of the value, rarity, inimitability (and non-substitutability); and the appropriability of its special resource base. Additionally, both the TCE and RBV assume optimization choices are separable. Table 3 depicts the assumptions of each theory that can be broken by the characteristics of the other theory.

Table 3. TCE-RBV interactions for systems and assumption breakings.

TCE Assumptions	Examples of Assumption-Breaking Effects of RBV
• Homogeneity of firms (along product mix, bargaining power, and so on) • Homogeneity of transaction options available (to each firm) • Homogeneity of each transaction option's characteristics (costs, benefits, and risks) for each firm • Separability of transaction choices (over time, space)	• technological capabilities affect the types of resources than can be exchanged • technological capabilities affect the information available to mitigate opportunism (e.g., through cheap monitoring) • technological capabilities affect the property rights available and enforceable • technological capabilities affect the ability to choose transactions that can mutually reinforce each other (e.g., in terms of cost synergies across a tight supply chain—JIT) • technological capabilities affect the types of transactions (e.g., oblique, based on data from customers) that are available to potential (new types of) partners (e.g., advertisers) • technological capabilities affect the homogeneity of transactions—making it easier to separate out partners and processes through real-time tracking, measurement of externalities, reduction of bounded rationality, minimization of contracting costs, automation of contract iteration, and new reputation-in-community based ways to address opportunism • technological and lobbying capabilities affect the market frictions to open up new markets to transact in • lobbying capabilities affect the types of transactions possible (through deregulation and changes to anti-trust law)
RBV Assumptions	**Examples of Assumption-Breaking Effects of TCE**
• Optimal choice of transaction to exploit each resource • Value of each resource is known, and is measured in monetary terms • Each firm needs to defend against VRIO erosion	• in a closed, stable system of partners, barter-transacting of valuable alternative resources (like access to consumers, and data) can occur without taxation • as in the relational view, new shared resources can be created through transactions • new property rights can be discovered through transacting • new VRIO protections can be based on transactions (e.g., with more parties defending those resources, and more causal ambiguity due to having more parties involved) • more accurate and complete valuation of resources can be possible through greater transactional activity
TCE-RBV Assumption	**Issue**
• Choices concerning transactions and resources are independent and separable	• in reality, resources and transactions are linked—cannot monetize without transacting, and cannot transact without resources being exchanged • resources are not homogeneous; transactions are not homogeneous

While the story of how the TCE can affect the RBV has been formally described in the relational view, the story of how the RBV can affect the TCE has not. Consider some of the ways it can involve managerial design capabilities that can generate new value for ventures. For example, such capabilities

could provide: cost-saving innovations in property rights (Alchian 1977); cost-saving innovation networking (Hagedoorn et al. 2006); reformulated property rights that generate new value (Barzel 1997; Foss and Foss 2005); a set of transactions that mutually reinforce each other (rather than where each transaction is handled separately—Nickerson 1997); a basis for a relationship strategy (Fuller and Lewis 2002); or simply a means to more effectively align production with supply (Brown and Cousins 2004).

It is not just that the RBV can break the TCE assumptions in theory, but it is that those assumptions are breakable in reality, as evidenced by the creation of new transaction forms (e.g., in hybrid governance forms, like virtual firms). New transaction form options can emerge from lobbying capabilities that result in the legislation for such new options to legally exist (e.g., through deregulation or changes to the anti-trust code). For example, the focal firm may then be able to access alternative suppliers in a newly opened market, or be able to consider options of alliances with newly available larger partner firms. New transactions may also emerge from new technological capabilities that allow new hybrid forms to become economically feasible (e.g., models based on web 2.0+ social-network knowledge transfers). For example, the focal firm may be able to use new internet community-based open-sourcing and crowd-sourcing transaction models. Or, the firm may exploit models that are based on users' content generation, or on free customer access subsidized through third-party advertising support, or on reverse auction mechanisms that leveraging real-time data, or on free brokerage across first and second parties but subsidized by third-party access to their information, and so on.

More specifically, RBV factors can break TCE assumptions related to the information asymmetries among transacting parties, the un-observability of agent actions, the risk aversion by agents, the externalities, the under-defined property rights, the vested interests, the bounded rationality, the uncertainty, the asset specificity, and the contracting costs involved in transactions. Asset specificity can be reduced by applying capabilities in asset construction (Jacobides et al. 2006). Information asymmetries can be reduced by applying capabilities in measuring and monitoring that are aimed at specific uncertainties and risks (e.g., capabilities like the managerial expertise for understanding hazards in complex environments described by Barney and Hansen 1994). Property rights and externalities of existing assets can be affected by applying capabilities in creating new goods from the by-products of assets being currently used. The bounded rationality in decision-making can be made less bounded by applying enhanced computing capabilities. Opportunism can be reduced by applying capabilities in human resource monitoring and incentivizing, or by applying capabilities that increase trust for supporting relational governance over formal contracting (e.g., Gulati 1995). The frequency of contracting can be reduced by applying capabilities that affect the length of transactions. Contracting costs may be decreased by applying capabilities that reduce hazards (e.g., the hazard-mitigating capabilities for market contracting of Delios and Henisz 2000). Risks for agents may be better insured and spread by applying capabilities in pooling and option-making. For example, Reuer, Zollo, and Singh's (Reuer et al. 2002) experience-based contracting capabilities may even alter the costs of transacting enough to open up new strategic transaction possibilities for the firms wielding them.

In this third alternative, the level of analysis switches to the unique set of resource-transaction combinations that create new value (e.g., through risk reduction; through the creation of new property rights for assets, and the associated discovery of their new uses; through product differentiation due to the uniqueness in the transaction; and so on). The mechanisms that preserve any value-creation advantages are drawn from the RBV and include: inherent heterogeneity, causal ambiguity (due to the complexity of, and art in, the combinations involved), time compression diseconomies, partner scarcity, resource indivisibility, resource scarcity, property rights, and asset stock interconnectedness.

In this third alternative, the entrepreneur's venture is part of a system of firms. The design of each system not only involves structuring each transaction, but also the portfolio of them, which involves choices of the partners and of the factors exchanged and their timing. Transactions are not just vertical (e.g., in the supply-chain) or horizontal (e.g., in lobbying alliances), but even oblique (e.g., with advertisers in a broadcast model, with complementors, and so on). The outcome is a unique system of partners–transactions–resources that may be based on one or more of the market,

hierarchical, alliance, or hybrid governance forms allowing the flow and use of shared synergistic resources from which the partners can gain value over others.

This alternative approach matters for two main reasons: (i) because it forms the basis of a theory of a system-of-firms; and, (ii) because it involves significant differences as a structure for doing business. In the TCE, the firm is a viable alternative structure to the spot market for transacting. In the RBV, the firm is a viable alternative structure for generating rents. In the relational view, the alliance is also a viable alternative structure to both the spot market and the firm for some transactions—transactions that are trust-based, more-than-temporary, and involve incomplete contracts (e.g., where parties exchange more than one item). Continuing such logic through combination and further extension to a system of firms, we argue that the system is a viable alternative structure for transactions and for rent generation for specific opportunities.

A system exists when it outperforms alternative forms of doing business. This system defines a structure entailing three differentiated characteristics. The first is the advantage from holistic optimization in the system. The second is the advantage from an ability to open up new markets by using the system and its shared capabilities in order to solve previously failed markets that were closed to alternative structures. The third is the advantage from an ability to exploit underregulated opportunities, where the system is ahead of policy-makers who have not yet addressed the complexities of system structures transacting in novel ways (e.g., Uber, Airbnb, and other brokers). Optimizing the whole system likely involves different decisions than optimizing each of its underlying pieces and connections. Such an approach builds upon the systemic and holistic thinking espoused by Zott and Amit (2010) and others. Such an approach also entails dealing with greater complexity, which may lead to new capabilities and new barriers to imitation, as well as new value. The new value emerges from the system's economies of scope (and variety), cross-synergies, cross-fertilization of ideas, added insights from the wider experiences across partners and from the holistic exposure itself. The system also entails an increase in complexity because it involves a network of more than one type of firm, exchange of more than one type resource, and the use of more than one type of role of the partner (e.g., where customer is also the supplier, in a community system like eBay or eHarmony). It is a shift to influencing the game that is played through interdependent choices. Such a challenge necessitates the use of a meta-level capability—where it is not just the firm's operations that need to managed, but also the system's, and further, doing that over time by knowing how to change how those are managed. Even further, the capability has to extend to using non-traditional influences (e.g., soft pressures) and to exchanging items of value (e.g., information; access to others) through barter, all under evolving issues of security and privacy.

This system approach is also unique in its potential to solve market failures that have closed markets to less-complex entities in the past, because such a system can represent more parties, can access more diverse resources and information, and can leverage an internal market that deals in non-monetary goods. Such a system is more likely to be able to alter regulations (e.g., to open up protected markets, or to open up new partner access), to be able to bring new types of partners together (e.g., casual, sporadic suppliers like Uber drivers), to be able to remove cost-prohibitive barriers in monitoring and enforcement through shared information, and so on. Once a new market is opened up, there emerges an unusual challenge to sustain the system's place in it, and even the system itself. That type of durability is required to compensate for the large up-front investment in making the right choices and piecing together carefully the right synergistic resources, across the right partners, with the right transactions, over time.

The goal is to create new value across the system in order to retain the (vertical, horizontal, and oblique) partners, pay the resource-holders at a rate above their opportunity costs, and minimize governance costs, all while protecting the system, and providing sufficient appropriation across stakeholders (in the payment forms that each values), while others are trying to do the same. Additionally, there is a need to do so while accounting for the type of value created (e.g., with value less embodied in physical and more in informational goods) and how that affects speed, feedback, scope,

globalization, data availability, and potential for leveraging those process characteristics. As such, entrepreneur-managers will need to be taught not just how to put themselves in their rival's shoes, but to be in several other shoes at the same time, the owners of which may take on conditionally competitive and cooperative roles as co-creators of new value-spaces[16]. Such an approach opens up several distinct paths of follow-on research that the dominant approaches have not while retaining the underlying logic they share in new value creation through the best use of available means, including those accessible from others.

10. Conclusions

We have used this forum to provoke because we care about the progress in our field. We believe that we need more debates over dominant approaches because challenges to long-standing models are simply not as prevalent as they should be (Renwick et al. 2019). Unchallenged dominance should not exist because it often turns theorizing into a business. To be a better field, we need the maintenance of its idea inventory to be as strong as initial gatekeeping. We should not require a fully-formed better model to displace a bad or outdated model; such an artificial hurdle simply stifles new ideas that are not yet fleshed out. We need to be better decision-makers ourselves in order to provide continuously improving and self-critical understandings of entrepreneurial decision-making so that those real entrepreneurs can also improve. Additionally, we need to more aggressively and more actively research rather than simply being content with reporting on what appear to be divergent or leading-edge behaviors.

Science requires the critique of dominant models. Such critiques offer the basis to identify places for improvement, to argue for proposed specific improvements, and to warn of concerns from applying prescriptions that rely on those models' current weaknesses and flaws. Such post-publication gate-keeping is crucial for a young field like entrepreneurship. We gate-keep to restrict the ideas that our field publishes, legitimizes, and hopes will positively influence practice. We do so because we believe that no benefit arises from accepting ideas that are unproven, false, misleading, incoherent, amoral, illogical, insufficient, poorly-explained, poorly-structured, trivial, repetitive, obvious, or useless. Unfortunately, we do not have a good (post-publication) mechanism for mitigating harms that could come from adhering to once-accepted ideas[17]. We have no formal process for 'theory removal' (and whatever it is that does exist is severely broken due to conflicts of interest—Arend 2019).

We have taken this opportunity to move our science forward by first critiquing two dominant approaches, and then by outlining three different alternative approaches (all of which that do what the dominant approaches do not while retaining the common underlying logic of differentiated value-creation). There are many further alternatives worth exploring that deserve the journal pages and follow-on testing and analysis more than the two approaches that have dominated over the last two

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[16] We suggest that the best way to manage the meta-challenges described is to: first, break it down into recognizable pieces—i.e., the resources, partners and transactions; second, consider these pieces in combinations, optimizing, and evaluating them as possible (and interdependent) sub-systems; and, third, do this over several possible dynamic, evolving future scenarios, where sequencing has effects.

[17] Failing to attend to the maintenance of the knowledge base of our field (e.g., by never removing ineffective or detrimental ideas) seems antithetical to a field's health, let alone its legitimacy. In fact, it is illegitimate for a younger field that has been improving its research quality to be rejecting new papers that do not live up to that higher quality while retaining old papers that also do not. The failure to put any effort into maintenance of the field's ideas is hypocritical given how very much effort we put into initial gatekeeping of ideas. We give peer editors and reviewers incredible power despite the potential conflicts of interest involved, despite the inexplicable utter lack of transparency involved (e.g., in how reviewers are assigned), despite an imperfect double-blind basis, and most often despite no guarantee that any underlying empirical data is valid (as most of it is primary and proprietary). We tolerate the standards imposed by the gatekeepers, regardless of the full knowledge that papers that should not have been accepted are and papers that should have been accepted are not. Yet, we balk at the mere suggestion that some entity should be responsible for correcting such errors or that peers should be held accountable for allowing them. Instead, we hold to the idea that the market will make the corrections naturally, even while we study a phenomenon that is only made possible due to market failures (Venkataraman 1997). Let us be clear, our 'market for ideas' is beset with failure. Call it Arend's Law—*that every self-regulated market will eventually drift towards corruption; and, that drift will accelerate as the market expands* (in the number of participants and the size of the stakes involved).

decades, and that remain flawed and incomplete. Our hope is that our peers, editors, and audiences interested in entrepreneurial decision-making research will push harder to realize that that diversity of thought is what makes us stronger.

References

Abatecola, Gianpaolo. 2014. Research in organizational evolution. What comes next? *European Management Journal* 32: 434–43. [CrossRef]

Abatecola, Gianpaolo, Andrea Caputo, and Matteo Cristofaro. 2018. Reviewing Cognitive Distortions in Managerial Decision Making. Towards an Integrative Co-Evolutionary Framework. *Journal of Management Development* 37: 409–24. [CrossRef]

Abatecola, Gianpaolo, Dermot Breslin, and Johan Kask. 2020. Do organizations really co-evolve? Problematizing co-evolutionary change in management and organization studies. *Technological Forecasting and Social Change* 155: 119964. [CrossRef]

Alchian, Armen Albert. 1977. Some Economics of Property Rights. In *Economic Forces at Work*. Edited by Armen Albert Alchian. Indianapolis: Liberty Press.

Alvarez, Sharon A., and Jay B. Barney. 2007. Discovery and Creation: Alternative Theories of Entrepreneurial Action. *Strategic Entrepreneurship Journal* 1: 11–27. [CrossRef]

Alvarez, Sharon A., and Jay B. Barney. 2010. Entrepreneurship and Epistemology: The Philosophical Underpinnings of the Study of Entrepreneurial Opportunities. *Academy of Management Annals* 4: 557–83. [CrossRef]

Alvarez, Sharon A., Jay B. Barney, and Philip Anderson. 2013. Forming and Exploiting Opportunities: The Implications of Discovery and Creation Processes for Entrepreneurial and Organizational Research. *Organization Science* 24: 301–17. [CrossRef]

Arend, Richard J. 2006. Tests of the Resource-Based View: Do the empirics have any clothes? *Strategic Organization* 4: 409–22. [CrossRef]

Arend, Richard J. 2015. Mobuis' Edge: Infinite Regress in the Resource-Based and Dynamic Capabilities View. *Strategic Organization* 13: 75–85. [CrossRef]

Arend, Richard J. 2019. Conflicts of interest as corrupting the checks and balances in the post publication oversight of academic business journals. *Journal of Management Inquiry* 28: 57–66. [CrossRef]

Arend, Richard J., and M. Levesque. 2010. Testing the Resource-Based View: Simulation Results for Violating VRIO. *Organization Science* 21: 913–30. [CrossRef]

Arend, Richard J., Hessamoddin Sarooghi, and Andrew Burkemper. 2015. Effectuation as ineffectual? Applying the 3E theory-assessment framework to a proposed new theory of entrepreneurship. *Academy of Management Review* 40: 630–51. [CrossRef]

Arend, Richard J., Hessamoddin Sarooghi, and Andrew C. Burkemper. 2016. Effectuation, not being pragmatic or process theorizing, remains ineffectual: Responding to the commentaries. *Academy of Management Review* 41: 549–56. [CrossRef]

Arnold, Beth, and Paul De Lange. 2004. Enron: An examination of agency problems. *Critical Perspectives on Accounting* 15: 751–65. [CrossRef]

Bain, Joe S. 1954. Economies of scale, concentration, and the condition of entry in twenty manufacturing industries. *The American Economic Review* 44: 15–39.

Baker, Ted, and Reed E. Nelson. 2005. Creating something from nothing: Resource construction through entrepreneurial bricolage. *Administrative Science Quarterly* 50: 329–66. [CrossRef]

Barney, Jay B. 1986. Strategic factor markets: Expectations, luck and business strategy. *Management Science* 32: 1231–41. [CrossRef]

Barney, Jay B. 1989. Asset stocks and sustained competitive advantage: A comment. *Management Science* 35: 1511–13. [CrossRef]

Barney, Jay B. 1991. Firm resources and sustained competitive advantage. *Journal of Management* 17: 99–120. [CrossRef]

Barney, Jay B., and Mark H. Hansen. 1994. Trustworthiness as a source of competitive advantage. *Strategic Management Journal* 15: 175–216. [CrossRef]

Baron, Robert A. 2009. Effectual versus predictive logics in entrepreneurial decision making: Differences between experts and novices. Does experience in starting new ventures change the way entrepreneurs think? Perhaps, but for now, "caution" is essential. *Journal of Business Venturing* 24: 310–15. [CrossRef]

Barrett, Léandre F. 2017. *How Emotions Are Made: The Secret Life of the Brain*. Boston: Houghton Mifflin Harcourt.

Barzel, Yoram. 1997. *Economic Analysis of Property Rights*, 2nd ed. Cambridge: Cambridge University Press.

Bell, David. 1994. Objectivity. In *A Companion to Epistemology*. Edited by Jonathan Dancy and Ernest Sosa. Oxford: Blackwell, pp. 310–13.

Beugré, Constant D. 2017. A Neurocognitive Model of Entrepreneurial Opportunity. *Intelligence, Sustainability, and Strategic Issues in Management: Current Topics in Management* 18: 17–42.

Bijker, Wiebe E. 1987. The social construction of Bakelite: Toward a theory of invention. In *The Social Construction of Technological Systems*. Cambridge: The MIT Press, pp. 159–87.

Brecht, Bertolt. 1978. *Brecht on Theatre*. Translated and Edited by John Willet. New York: Hill and Wang, Eyre Methuen.

Breslin, Dermot. 2008. A review of the evolutionary approach to the study of entrepreneurship. *International Journal of Management Reviews* 10: 399–423. [CrossRef]

Breslin, Dermot, and Colin Jones. 2012. The evolution of entrepreneurial learning. *International Journal of Organizational Analysis* 20: 294–308. [CrossRef]

Brown, Steve, and Paul D. Cousins. 2004. Supply and operations: Parallel paths and integrated strategies. *British Journal of Management* 15: 303–20. [CrossRef]

Chandler, Gaylen N., Dawn R. DeTienne, A. McKelvie, and Troy V. Mumford. 2011. Causation and effectuation processes: A validation study. *Journal of Business Venturing* 26: 375–90. [CrossRef]

Chandra, Yanto. 2017. A time-based process model of international entrepreneurial opportunity evaluation. *Journal of International Business Studies* 48: 423–51. [CrossRef]

Christensen, Clayton M., and Joseph L. Bower. 1996. Customer power, strategic investment, and the failure of leading firms. *Strategic Management Journal* 17: 197–218. [CrossRef]

Coase, Ronald H. 1937. The nature of the firm. *Econometrica* 4: 386–405.

Cohen, Wesley M., and Daniel A. Levinthal. 1990. Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly* 35: 128–52. [CrossRef]

Conner, Kathleen R. 1991. An historical comparison of resource-based theory and five schools of thought within industrial organization economics: Do we have a new theory of the firm? *Journal of Management* 17: 121–54. [CrossRef]

Cristofaro, Matteo. 2020. "I feel and think, therefore I am": An Affect-Cognitive Theory of management decisions. *European Management Journal* 38: 344–55. [CrossRef]

Daston, Lorraine, ed. 2000. *Biographies of Scientific Objects*. Chicago: University of Chicago.

Davidsson, Per. 2015. Entrepreneurial opportunities and the entrepreneurship nexus: A re-conceptualization. *Journal of Business Venturing* 30: 674–95. [CrossRef]

Delios, Andrew, and Witold J. Henisz. 2000. Japanese firms' investment strategies in emerging economies. *Academy of Management Journal* 43: 305–23.

Dubin, Robert. 1969. *Theory Building*. New York: Free Press.

Dyer, Jeffrey H., and Harbir Singh. 1998. The relational view: Cooperative strategy and sources of interorganizational competitive advantage. *Academy of Management Review* 23: 660–79. [CrossRef]

Foss, Kirsten, and Nicolai J. Foss. 2005. Resources and transaction costs: How property rights economics furthers the resource-based view. *Strategic Management Journal* 26: 541–53. [CrossRef]

Fuller, Ted, and Jennifer Lewis. 2002. 'Relationships mean everything': A typology of small-business relationship strategies in a reflexive context. *British Journal of Management* 13: 317–36. [CrossRef]

Grégoire, Denis A., and Naïma Cherchem. 2020. A structured literature review and suggestions for future effectuation research. *Small Business Economics* 54: 621–39. [CrossRef]

Gulati, Ranjay. 1995. Does familiarity breed trust? The implications of repeated ties for contractual choice in alliances. *Academy of Management Journal* 38: 85–112.

Günzel-Jensen, Franziska, and Sarah Robinson. 2017. Effectuation in the undergraduate classroom: Three barriers to entrepreneurial learning. *Education+Training* 59: 780–96. [CrossRef]

Guo, Zisheng, Jianqi Zhang, and Linrui Gao. 2018. It is not a panacea! The conditional effect of bricolage in SME opportunity exploitation. *Rand D Management* 48: 603–14. [CrossRef]

Hacking, Ian. 1999. *The Social Construction of What?* Cambridge: Harvard Univ. Press.

Hagedoorn, John, Nadine Roijakkers, and Hans Van Kranenburg. 2006. Inter-firm RandD networks: The importance of strategic network capabilities for high-tech partnership formation. *British Journal of Management* 17: 39–53. [CrossRef]

Hirschman, Albert O. 1958. *The Strategy of Economic Development*. New Haven: Yale University Press.

Jacobides, Michael G., Thorbjørn Knudsen, and Mie Augier. 2006. Benefiting from innovation: Value creation, value appropriation and the role of industry architectures. *Research Policy* 35: 1200–21. [CrossRef]

Kirzner, Israel. 1973. *Competition and Entrepreneurship*. Chicago: University of Chicago Press.

Kirzner, Israel M. 1979. *Perception, Opportunity, and Profit: Studies in the Theory of Entrepreneurship*. Chicago: University of Chicago Press, pp. 142–43.

Knight, Frank Hyneman. 1921. *Risk, Uncertainty and Profit*. Boston: Houghton Mifflin, vol. 31.

Levi-Strauss, Claude. 1966. *The Savage Mind*. Chicago: University of Chicago Press.

Liedtka, Jeanne, and Tim Ogilvie. 2011. *Designing for Growth: A Design Thinking Tool Kit for Managers*. New York: Columbia University Press.

Mansoori, Yashar, and Martin Lackeus. 2019. Comparing effectuation to discovery-driven planning, prescriptive entrepreneurship, business planning, lean startup, and design thinking. *Small Business Economics* 54: 791–818. [CrossRef]

McBride, Russ, and Robert Wuebker. 2020. Social Objectivity and Entrepreneurial Opportunities: Implications for Entrepreneurship and Management. *Academy of Management Review*. [CrossRef]

Mehrpouya, Afshin, and Hugh Willmott. 2018. Making a Niche: The Marketization of Management Research and the Rise of 'Knowledge Branding'. *Journal of Management Studies* 55: 728–34. [CrossRef]

Montuschi, Eleonora. 2007. 11 Real, invented or applied? Some reflections on scientific objectivity and social ontology. *Contributions to Social Ontology* 15: 177–91.

Newbert, Scott L. 2007. Empirical research on the resource-based view of the firm: An assessment and suggestions for future research. *Strategic Management Journal* 28: 121–46. [CrossRef]

Nickerson, Jack. 1997. Toward an Economizing Theory of Strategy: The Choice of Strategic Position, Assets, and Organizational Form. Ph.D. dissertation, University of California, Berkeley, CA, USA.

Penrose, Edith T. 1959. *The Theory of the Growth of the Firm*. New York: John Wiley and Sons.

Perry, John T., Gaylen N. Chandler, and Gergana Markova. 2012. Entrepreneurial effectuation: A review and suggestions for future research. *Entrepreneurship Theory and Practice* 36: 837–61. [CrossRef]

Peteraf, Margaret A. 1993. The Cornerstones of Competitive Advantage: A Resource-Based View. *Strategic Management Journal* 14: 179–91. [CrossRef]

Porter, Michael E. 1980. *Competitive Strategy: Techniques for Analyzing Industries and Competitors*. New York: Free Press.

Priem, Richard L., and John E. Butler. 2001. Is the resource-based "view" a useful perspective for strategic management research? *Academy of Management Review* 26: 22–40.

Ranabahu, Nadeera, and Mary Barrett. 2019. Does practice make micro-entrepreneurs perfect? An investigation of expertise acquisition using effectuation and causation. *Small Business Economics* 54: 883–905. [CrossRef]

Renwick, Douglas W., Dermot Breslin, and Ilfryn Price. 2019. Nurturing novelty: Toulmin's greenhouse, journal rankings and knowledge evolution. *European Management Review* 16: 167–78. [CrossRef]

Reuer, Jeffrey J., Maurizio Zollo, and Harbir Singh. 2002. Post-formation dynamics in strategic alliances. *Strategic Management Journal* 23: 135–51. [CrossRef]

Sarasvathy, Saras D. 2001. Causation and effectuation: Toward a theoretical shift from economic inevitability to entrepreneurial contingency. *Academy of Management Review* 26: 243–63. [CrossRef]

Skeat, Jemimah J., and Alison A. Perry. 2008. Exploring the implementation and use of outcome measurement in practice: A qualitative study. *International Journal of Language and Communication Disorders* 43: 110–25. [CrossRef]

Sokal, Alan D. 1996. A physicist experiments with cultural studies. *Lingua Franca* 6: 62–64.

Teece, David J. 1986. Profiting from technological innovation. *Research Policy* 15: 285–305. [CrossRef]

Teece, David J., Gary Pisano, and Amy Shuen. 1997. Dynamic capabilities and strategic management. *Strategic Management Journal* 18: 509–33. [CrossRef]

Venkataraman, Sankaran. 1997. The distinctive domain of entrepreneurship research. In *Advances in Entrepreneurship, Firm Emergence and Growth*. Edited by Jerome A. Katz. Oxford: Elsevier/JAI, vol. 3, pp. 119–38.

Welter, Chris, René Mauer, and Robert Wuebker. 2016. Bridging behavioral models and theoretical concepts: Effectuation and bricolage in the opportunity creation framework. *Strategic Entrepreneurship Journal* 10: 5–20. [CrossRef]

Wernerfelt, Birger. 1984. A resource based view of the firm. *Strategic Management Journal* 5: 171–80. [CrossRef]

Westgren, Randall, and Robert Wuebker. 2019. An economic model of strategic entrepreneurship. *Strategic Entrepreneurship Journal* 13: 507–28. [CrossRef]

Williamson, Oliver E. 1975. *Markets and Hierarchies: Analysis and Antitrust Implications*. New York: Free Press.

Williamson, Oliver E. 1979. Transaction-cost economics: The governance of contractual relations. *Journal of Law and Economics* 22: 233–61. [CrossRef]

Williamson, Oliver E. 1985. *The Economic Institutions of Capitalism*. New York: Free Press.

Zott, Christoph, and Raphael Amit. 2010. Business Model Design: An Activity System Perspective. *Long Range Planning* 43: 216–26. [CrossRef]

Article

Cognitive Biases in Critical Decisions Facing SME Entrepreneurs: An External Accountants' Perspective

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Abstract: Decisions by small and medium enterprise (SME) entrepreneurs are plagued by a variety of cognitive biases. Extant literature has mainly focused on a limited number of important biases (e.g., overconfidence) in a handful of important entrepreneurial decisions (e.g., start-up, market entry or exit). However, putting the spotlight on a few important biases and entrepreneurial decisions could leave other important biases and decisions underexposed. SME accountants are in a unique position to shed a broader light on this issue. SME entrepreneurs often seek advice of their accountants when they struggle with decisions that involve uncertainty and business risks in the domains of strategy, regulatory compliance, human resources, IT, and succession. In this study, we explore 12 different biases and analyze whether their importance can change across these decision domains. Interviews were performed with 14 SME accountants who provide an independent third-party view on decision making by over 3000 entrepreneurs. Our findings suggest that the importance of most of these biases varies from one decision domain to the other. We also identified four approaches (warn, inform, intervene, and coach) that accountants can take when entrepreneurs may fall victim to biases. We discuss the implications for research and practice of SME entrepreneurs and their accountants.

Keywords: SME entrepreneurs; accountants; cognitive biases; decision making; debiasing

1. Introduction

Entrepreneurial decision making is a challenging task. The context in which entrepreneurs make decisions is extreme in various ways: high uncertainties and ambiguities, high consequences, time pressures, emotional anticipation, and reactions (Shepherd et al. 2015). Theory on bounded rationality (Simon 1947) suggests that in these types of decision environments, rational decision-making processes (referred to as system 2 by Stanovich and West 2000) are often pushed beyond their capabilities. When system 2 gets overwhelmed, decisions are dominated by the experiential and intuitive decision-making processes (referred to as system 1). Unfortunately, these system 1 decisions are prone to cognitive biases that can cause irrational decision making. As one solution to cope with the limitations of bounded rationality in organizational decision making, Simon (1947) introduced the idea of the so-called 'administrative man'. The administrative man, or woman, is someone who helps to provide organizations with objective and unbiased information to support decision making.

In line with this, Kahneman et al. (2011) recommend that for critical decisions, such as the introduction of new products, organizational decision makers should seek advice from an external party. Such a third party could contribute to more rational decision making by challenging assumptions and by uncovering potential biases in the decision-making process. A third-party role could therefore be of pivotal value to identify cognitive biases in entrepreneurial decision making (Abatecola et al. 2018, p. 412). External accountants fulfil this role for many small and medium enterprise (SME) entrepreneurs. They are frequently sought for advice—and invited to challenge the entrepreneur—when entrepreneurs

face critical decisions (Bennett and Robson 1999; Berry et al. 2006; Blackburn and Jarvis 2010; Suddaby et al. 2002). Therefore, SME accountants are in a unique position to provide insight in the way SME entrepreneurs make decisions across a variety of domains for which they seek the advice of their accountant.

To the best of our knowledge, our study is the first to examine biases in entrepreneurial decision making from the perspective of SME accountants. Following a similar approach, in the business research domain of managing complex IT projects, insights from practitioners in a third-party role (i.e., information systems auditors) were used to shed light on cognitive biases (Keil and Robey 1999; Keil et al. 2000; Nuijten et al. 2019). In this study, we propose that this third-party view offered by seasoned SME accountants could similarly provide a contribution to extant literature on entrepreneurial decision making.

Results from interviews with 14 Dutch SME accountants, seasoned in this role and who combined have serviced over 3000 SME entrepreneurs over the years, provide a view from a third-party perspective on how these entrepreneurs make decisions. Following a deductive thematic analysis approach, we examine how 12 documented cognitive biases compare to each other in how important they appear to be in SME entrepreneurs' decisions. This comparative view across multiple cognitive biases contributes to the existing body of knowledge since many studies in this domain focus on one or two individual biases in isolation. While extant literature on cognitive biases in entrepreneurial decision making has predominantly focused attention on entrepreneurs' overconfidence, our results suggest that other biases could warrant more research attention as well.

Furthermore, the findings from our study suggest that the importance of many of those cognitive biases on entrepreneurial decisions varies across five decision domains for which entrepreneurs seek advice of their external accountants. These results contribute to the discourse since most of the extant studies depict entrepreneurial decisions as strategic investment decisions (start-up, market entry) or exit decisions. Our results however suggest that entrepreneurs might struggle with cognitive biases across a wider range of critical decisions that involve business risks (other than strictly financial).

Finally, our interviews showed four different approaches (warn, inform, intervene, and coach) that SME accountants take when they encounter cognitive biases in entrepreneurial decision making.

The remainder of our paper is organized as follows: In Section 2, we describe the theoretical background of our study. In Section 3, we discuss how the data for our study were collected and analyzed. Section 4 provides an overview of our research results. Finally, we conclude with a discussion of the implications of our study for both research and practice in Section 5.

2. Theoretical Background

2.1. Research on Cognitive Biases in Entrepreneurship

Research on cognitive biases in entrepreneurship has increased rapidly since its inception in the early nineties and in two decades it has become an important research area for entrepreneurship (Zhang and Cueto 2017). From their structured literature review of research on entrepreneurial biases, Zhang and Cueto (2017) also portray the research domain (in our words) as fragmented: a lack of consistent use of definitions, showing overlap and redundancy in biases (like *overconfidence* and *overoptimism*). The figures in their review, as well as their analysis, also indicate a very high representation of in-depth studies that put the spotlight on individual 'popular' cognitive biases (like *overconfidence*)[1]. Furthermore, after they defined a typology of cognitive biases to structure their assessment, Zhang and Cueto (2017) identified a need for research on relatively underexposed biases related to emotions (for example on *affect heuristic*) or biases related to the social context of the

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[1] The literature review by Zhang and Cueto (2017) shows that 33 out of 41 papers focused on one single cognitive bias, 5 papers examined two biases and no papers investigated more than four biases in one study. More than half of all papers examined *overconfidence* or *overoptimism*.

entrepreneur (environmental pressure). Since the literature review by Zhang and Cueto (2017), we are aware of only one paper (Abatecola et al. 2018), who examined a combination of multiple cognitive biases, (including one associated with *affect heuristic*), and how they are related.

The tables in the review by Zhang and Cueto (2017), show that a large portion of the research on entrepreneurial biases examined specific biases in the context of strategic investment decisions (start-up, market entry) or exit decisions (disinvestments). While there is no doubt that those financial decisions have been proven to be very good candidates to examine cognitive biases in entrepreneurial decision making, this spotlight approach could raise the issue whether other entrepreneurial decisions involving business risks and uncertainties might be underexposed. Furthermore, it could raise the issue whether the importance of specific biases in strategic investment decisions carries to other domains of entrepreneurial decisions as well.

In our attempt to supplement the many valuable spotlight studies in this domain, we aim to shed broader light on these issues. Therefore, we explore the importance of a series of (12) cognitive biases across a broader range of entrepreneurial decisions that involve business risks and uncertainties and for which decisions entrepreneurs seek external advice from their accountants. From their third-party role, accountants are in the position to have an overview of various types of decisions that entrepreneurs struggle with and seek advice for, as well as the cognitive biases that entrepreneurs may fall victim to in those decisions. Interestingly, a very recent conceptual study by Liebregts et al. (2020) confirms that people in the social context of entrepreneurs (like the accountants in our study) and who can observe entrepreneurs in their decision making processes, are in a unique position to examine cognitive biases and Liebregts et al. (2020) find this a promising avenue to advance our understanding of entrepreneurial decision making.

Before we further elaborate the literature background of the decisions and the cognitive biases that we included in our study, we first define the two concepts—biases and heuristics—that we put central. *Bias* refers to the systematic deviation from rational choice theory when people choose actions and estimate probabilities (Tversky and Kahneman 1974). *Heuristics* refer to simplifying shortcuts or principles that people use for problem solving and information processing (Baron 2007). Heuristics are fast and frugal, freeing people from making complete and systematic and effortful processing of information. As heuristics simplify information processing, they are associated with biases. Both biases and heuristics are part of what Stanovich and West (2000) referred to as experiential and intuitive decision-making processes (labeled as system 1). Although biases are portrayed as deviations from rationality, we do not take the position that biases are always bad. Moreover, while it has been documented that biases influence risk perceptions as well as decisions that involve risk, the desirability of biases should be considered in the context of the risk appetite (or desired risk-taking behavior) of the organization (Croce et al. 2020). We think this warrants the value of our study to explore whether cognitive biases are equally important across different domains of entrepreneurial decisions that involve business risk and uncertainties.

In the remainder of this section, we use the third-party stance of the SME accountant to develop our theoretical background. First, we describe for what kind of decisions entrepreneurs seek the advice from their accountants and we clustered those decisions to domains. Next, we determine a list of cognitive biases from literature that we can use for the purpose of our study and that allows us to exploit the unique position that accountants have to observe cognitive biases in entrepreneurial decision making in real-life situations.

2.2. Domains of Decisions for Which SME Entrepreneurs Seek Advice from Accountants

Table 1 provides an overview of literature and shows the various decisions for which SME entrepreneurs seek advice from accountants. Based on this overview of the existing literature, we have identified five decision domains that accountants are involved in as advisors. Table 1 shows how each of the various types of decisions from prior literature have been mapped to the following five decision domains:

i.   Strategy (e.g., advice on finances, business structuring, business transfers etc.)
ii.   Regulatory compliance (e.g., taxes, (ISO) compliance, health and safety etc.)
iii.   Human Resources (e.g., payroll, training and development, recruitment etc.)
iv.   Information Technology (e.g., information system implementation, security, IT system support)
v.   Succession planning (e.g., inheritance, ownership transfer etc.).

Table 1. Types of decisions in which entrepreneurs seek advice of accountants

Study:	Types of Decisions:
Gooderham et al. (2004)	**(i).*** business structure (company set-up), budgeting, marketing/sales, strategic planning, valuation of firms/mergers/demergers, **(iii).** pension schemes, management, organization, HRM, training and skills development, remuneration schemes, salary, **(iv).** implementation administrative routines, IT, **(v).** inheritance, generation transfer, owner transference
Berry et al. (2006)	**(i).** business advice, emergency advice, financial management, **(ii).** statutory services
Blackburn et al. (2006)	**(ii).** regulations and compliance, **(iii).** advice on employment and payroll
Van Teeffelen (2006)	**(v).** business transfers
Leung et al. (2008)	**(ii).** regulatory compliance, health and safety, environment
Doving and Gooderham (2008)	**(i).** closure of firms, **(ii).** tax/tax planning, type of company entity, **(iii).** recruitment
Devi and Samujh (2010)	**(i).** business formation, business plans, business valuation, due diligence, financing arrangement, liquidation/corporate recovery, mergers/ acquisitions, strategic planning, **(ii).** compliance, filing of tax returns, ISO standards internal control systems, forensic accounting, internal audit, statutory audit, **(iii).** loan application, payroll, recruitment, secretarial services, **(iv).** IT system implementation
Hasle et al. (2010)	**(ii).** health and safety, employment
Blackburn and Jarvis (2010)	**(i).** acquisition and new business advice, financial modeling, business structuring, purchase and sale of business, planning and forecasting, business strategy, financial advice, due diligence, investment strategy, **(ii).** forensic accounting, asset protection **(iii).** HR, payroll, company secretary, **(iv).** IT, **(v).** retirement planning, succession planning
Jarvis and Rigby (2012)	**(iii).** HR and employment issues
Ismail and King (2014)	**(iv).** IT system advice and support

* Roman numerals indicate to which of the five decision domains, described in the text above, each specific decision type has been assigned.

2.3. Cognitive Biases That Can Affect SME Entrepreneurs

To serve the purpose of our study, we selected a set of appropriate cognitive biases following an approach that is similar to the one that was followed by Cristofaro (2017). Since our research design required in-depth interviews with SME accountants, we decided that 60 topics would be our maximum (12 biases across 5 decision domains). Therefore, we limited ourselves to 12 biases so that it would remain possible to interview respondents in one interview.

Given the design of our study, biases should show in practice and must be recognized and easily distinguished by accountants from a third-party stance. We derived our set of biases from an initial literature review on SME entrepreneurial biases and we tested and refined the set of biases in our pilot with SME accountants. We also asked them whether important biases were missing.

At the time we set up our study, we were not familiar with the list of important biases that Zhang and Cueto (2017) derived from SME literature. Nevertheless, we have 8 out of 12 biases in common with their list. Four biases from their list are not in ours, and we think for good reason, since they appeared to be conceptually confusing for our respondents (too proximate with other biases we did include). From their list we did not have in ours: *law of small numbers* (could be confused with *representativeness bias*), *self-serving attribution* (is more hindsight to the decision, and could be confused with *confirmation bias* and *illusion of control*), *similarity* (could be confused with *confirmation bias* and *affect heuristic*), and *over-optimism* (could be confused with *overconfidence*).

Furthermore, we included four biases that were not in Zhang and Cueto's list. First, we included the more generic *confirmation bias*, that covered the more situated bias *similarity* in Zang and Cueto's list. Next, we included *groupthink* which blends well with Zhang and Cueto's call to examine biases related to the entrepreneurs' social context. The accountants in our pilot mentioned that many entrepreneurs participate in entrepreneurial network events from Rotary, Lions and alike. There they discuss and exchange business decisions to larger extent and get influenced by other entrepreneurs as well as some entrepreneurs get influenced by family members who are or have been involved in the SME. We also included two biases that were not in Zhang and Cueto's list but which blend well with their call to do further research on biases that are associated with SME entrepreneurs' emotions. We added *affect heuristic* that taps into the happiness emotion (proposed by accountants who told of entrepreneurs who felt in love with their products and company). And finally, our fourth added bias is *regret* that taps into the fear emotion of 'missing the boat', which was also mentioned by the accountants in our pilot. Following this approach, we arrived at the set of 12 cognitive biases and heuristics that we will briefly introduce.

2.3.1. Bias #1: Anchoring

Anchoring is a heuristic that influences one's intuitive judgment. Individuals subconsciously base their decisions on a reference point, the so-called anchor, and subsequently make adjustments to this initial anchor to come to their estimation or judgment. However, these adjustments are often insufficient causing the ultimate outcome to be biased towards the initial anchor, thereby limiting rational decision making (Tversky and Kahneman 1974). For example, in negotiations, the first offer made forms the anchor, causing the outcome of the negotiations to be strongly influenced by the first offer (Galinsky and Mussweiler 2001). Similarly, the entrepreneurial decision of whether to start a new venture has also been found to be subject to the anchoring bias (Barbosa and Fayolle 2007).

2.3.2. Bias #2: Availability Heuristic

The availability heuristic is a mental shortcut where prior examples that easily come to mind can receive disproportionate weight in decision making (Tversky and Kahneman 1973; Palich and Bagby 1995). As such, strongly positive or negative experiences, which come to mind easily, can strongly bias the decision-making process. Recent experiences have also been shown to come to mind more easily than experiences from a long time ago. In this context, entrepreneurs have been found susceptible to the availability heuristic in a study which showed that the decision of whether to found a new venture was strongly biased based on recent experiences (Barbosa and Fayolle 2007).

2.3.3. Bias #3: Confirmation Bias

The confirmation bias causes individuals to look for information that supports their opinion or decision, while disregarding information that is contradicting (Baron 2004). Entrepreneurs have been found to be prone to the confirmation bias, particularly when they have not experienced failure before. These entrepreneurs tend to overestimate their own previous successes, focusing on positive information and thereby rejecting disconfirming evidence (Carr and Blettner 2010).

2.3.4. Bias #4: Regret and Counterfactual Thinking

Counterfactual thoughts are thoughts that form an alternative to past events or situations, whereby one thinks about "what could have happened if . . . ". This can lead to forming alternative strategies for the future, which in turn can influence decision making processes (Baron 2013). Related to counterfactual thinking is the concept of regret, a counterfactual emotion, which is also strongly associated with decision making. Mullins and Forlani (2005) and Zeelenberg (1999) documented the regret effect in the field of new venture decisions and SME as the 'fear of missing the boat'. Family firms are more prone to regret in terms of family-based circumstances as well as business-related regret. The experienced regret in a family firm has been found to bias decision making (Hirigoyen and Labaki 2012).

2.3.5. Bias #5: Escalation of Commitment

Escalation of commitment occurs when decision makers overcommit to a previously chosen course of action, despite negative feedback indicating that this will not lead to success (Staw 1976). The longer people continue along the same path, the more difficult it generally becomes for them to change direction (Drummond 2004). Escalation of commitment in the context of SME's is primarily caused by a shortsighted vision as well as by the mixing of economic and personal interests (Drummond 2004). Furthermore, entrepreneurs are often highly dedicated to making their firm a success, which can hamper their ability or willingness to recognize that they, or their firm, are currently on a failing course of action. As long as this is not recognized, entrepreneurs are prone to escalation of commitment (Baron 1998).

2.3.6. Bias #6: Illusion of Control

The illusion of control bias occurs when people overestimate the amount of control that they have over a situation. It specifically constitutes an 'illusion' of control in the case where someone believes to have control even over those outcomes which are objectively outside of their control (Langer 1975). Entrepreneurs have been shown to be more inclined to overestimate the amount of control that they have. Due to this illusion of control they tend to underestimate risks, since they believe their own skills can prevent potential negative outcomes (Keh et al. 2002; Le Roux et al. 2006).

2.3.7. Bias #7: Overconfidence

In the context of our study, overconfidence comes in the form of the tendency to overestimate the correctness of an initial assessment in relation to complex situations (Busenitz and Barney 1997). Whereas the illusion of control relates to the false belief of having control over situations outside one's control, overconfidence relates to overestimating one's personal chances of success in any situation. Entrepreneurs have been found to show more overconfidence than managers in large organizations (Busenitz and Barney 1997; Forbes 2005). This has been related to differences in individual characteristics and the complexity and uncertainty that many entrepreneurs face, amongst others (Forbes 2005).

2.3.8. Bias #8: Planning Fallacy

The planning fallacy is associated with overoptimism in estimations about the amount of work that can be completed within a certain time period (Baron 1998; Kahneman and Lovallo 1993). This is often the result of assuming ideal circumstances or of underestimating or not accounting for events or risks that can add to the workload. The planning fallacy is more likely to occur in environments which are characterized by new and unique situations including a lot of uncertainty. These are also the types of environments that entrepreneurs operate in. Similarly, entrepreneurs have a more difficult time basing their estimations on prior experiences, an approach which has shown to reduce the planning fallacy (Kahneman and Lovallo 1993), due to the typically smaller size and younger age of the firm (Baron 1998).

2.3.9. Bias #9: Representativeness Bias

The representativeness bias can make decision makers falsely assume that limited experiences can be generalized and apply in all instances. Recognizing elements of past experiences in new situations can lead decision makers to incorrectly draw analogies and assume the same result will be achieved once more (Schwenk 1984). Busenitz and Barney (1997) conclude that entrepreneurs are more subject to the representativeness bias than managers in large organizations. Simon et al. (2000) argue that entrepreneurs are prone to the representativeness bias because they lack past examples on which to base estimations, forcing them to rely on the limited amount of data that they do have, which can lead to oversimplified analogies of complex situations. In line with this, Mehrabi and Kolabi (2012) show that representativeness negatively influences the quality of strategic decisions by entrepreneurs.

2.3.10. Bias #10: Status Quo Bias

The status quo bias is a tendency to stick to previously made choices and decisions, thereby sticking with and being unwilling to deviate from past decisions either made by yourself or by someone else, even if this is no longer rational (Burmeister and Schade 2007). Burmeister and Schade (2007) argue that entrepreneurs are not necessarily more prone to the status quo bias than other decision makers. However, they do argue that the status quo bias is more likely to occur in decisions or situation that the decision maker has a lot of experience with. Previous experience leads to a reduction in flexibility and a less varied range of potential choices (Burmeister and Schade 2007). In line with this, Gibbons and O'Connor (2005) found that the experience of SME CEO's was positively related to their commitment to the status quo.

2.3.11. Bias #11: The Affect Heuristic

Often, decisions are not made mostly based on the objective weighting of pros and cons but rather on how "good" or "bad" something feels, i.e., we buy the products, or hire that people, that we "like". This is referred to as the affect heuristic. Such affective reactions have been found to be important in decision making by entrepreneurs (Baron 2008) and entrepreneurs are often passionate people who follow their emotions (Cardon et al. 2009). In line with this, Nouri et al. (2017) describe that entrepreneurs may be particularly susceptible to the affect heuristic. For example, affect has been shown to have an influence on entrepreneurial opportunity evaluation (Foo 2011) and the pursuit of entrepreneurial ideas and even the decision to become an entrepreneur and start a business (Hayton and Cholakova 2012).

2.3.12. Bias #12: Groupthink

Whereas the previous biases are all focused on decision making by the individual, groupthink is a bias which can occur when people make decisions in a group. Groupthink originates from the human tendency to not want to go against the group. Groupthink occurs when "*the members' strivings for unanimity override their motivation to realistically appraise alternative courses of action*" (Janis 1972, p. 9). Groupthink tendencies in entrepreneurial teams can threaten entrepreneurial adaptation and renewal of the firm (Kor et al. 2007). In high-velocity environments (Bourgeois and Eisenhardt 1988), a free exchange of views among entrepreneurs is preferred to conformist thinking (Hambrick 1995).

3. Method

3.1. Research Design

In order to explore the importance of the 12 identified biases in each of the 5 decision domains, we performed in-depth interviews with 14 accountants who have experienced biases in SME decision making firsthand. In these structured interviews we collected both qualitative and quantitative data regarding the importance of each bias in the various decision domains. Following a deductive thematic analysis approach, we collected and analyzed these data as we will describe further in Section 3.3. Repeated Measures ANOVAs were performed to assess whether the importance of each bias differed across decision domains.

3.2. Interviewees

Fourteen experienced accountants were recruited to participate in the interviews. These SME accountants were recommended to us, by the Dutch association of Public Accountants, for their extensive experience with SME entrepreneurs. Prior to starting the interview, we first asked each accountant to what extent they had experience with the type of decisions involved in our study. Table 2 provides relevant characteristics of the interviewees, which they provided upon request. The Table lists the amount of years the respondents have been acting in this role, the sectors in which

their customers are active, and the number of SME entrepreneurs that have sought their advice. Our interviewees had an average of 20 years of experience and they advised 200 entrepreneurs on average. The combined experience of all 14 interviewees together reflects decisions made by more than 3000 SME entrepreneurs cumulated.

Table 2. Characteristics of our interviewees.

Accountant	Years of Working Experience with SME Entrepreneurs	Estimated Number of SME Entrepreneurs	Sectors in which the SMEs Were Active (Predominantly)
#1	21	>100	Trade, manufacturing, services
#2	18	>100	Hotel, catering, manufacturing, services
#3	11	>100	Building, transportation, manufacturing, wholesale
#4	22	300	Mostly flowers and food
#5	32	>300	Manufacturing, wholesale, retail, transportation, agriculture
#6	34	300	Construction, manufacturing, services, wholesale, retail, hotels
#7	20	100	Retail, manufacturing, construction, hotels and restaurants
#8	29	200	Services, manufacturing, wholesale, retail, restaurants
#9	15	>100	Construction, manufacturing, automotive, retail
#10	17	>300	Construction, agriculture, retail, manufacturing
#11	31	>300	Retail, manufacturing, automotive, wholesale
#12	34	250	Retail, wholesale, manufacturing, hotels and restaurants
#13	22	>300	All types of SMEs except agriculture
#14	37	>300	Retail, manufacturing, services, food

3.3. Materials Development and Pilot Testing

Interview materials were prepared to facilitate the collection of the intended qualitative and quantitative data. Since interviewees were asked to provide us with input on 12 different biases, we prepared plasticized cards with information on each of the biases. These cards contained the name of the bias, a brief description of the bias and an illustration associated with the bias. In this way, the interviewees could refer to the biases and their descriptions at any time during the interview. A pilot test with 3 accountants (who were excluded from our sample for the main study) was used to assess whether the descriptions and illustrations on these cards were clear and understandable to our target sample. Based on the pilot a few minor changes were made to the wording on the cards and to two of the illustrations.

In a similar way, we prepared 5 plasticized cards that represent the decision domains discussed in Section 2, i.e., strategy, regulatory compliance, human resources, information technology and succession planning. Each of these cards provided a brief description of the domain, as well as a few examples of decisions within this domain. These cards were also pilot tested with 3 accountants. The accountants recognized and validated the decision domains included in our study. Input obtained from the pilot test allowed us to make a few minor refinements to the wording on the cards prior to the subsequent 14 interviews.

3.4. Data Collection and Analysis

Our interview data were structured and analyzed using thematic analysis. Specifically, we performed a deductive, or theory-driven, thematic analysis approach (Boyatzis 1998; Braun and Clarke 2012). In doing so, we followed an approach similar to that of Cristofaro (2017), who also applied a theory-driven thematic analysis approach based on structured interviews in which the role of multiple cognitive biases in decision making on an organizational context was explored.

Prior to performing the interviews, a theoretical framework was developed. This framework consisted of descriptions of the 12 cognitive biases that can play a role in decisions for which

entrepreneurs ask for advice from SME accountant. The biases that formed the framework were identified in our analysis of the literature and subsequently validated via a set of pilot interviews.

As part of the thematic analysis, themes have to be identified which constitute "a pattern of meaning . . . across a dataset" (Braun and Clarke 2012, p. 57) and "a pattern in the information that at minimum describes and organises the possible observations" (Boyatzis 1998, p. 161). Given the deductive approach, the themes for our thematic analysis constituted the 12 predefined biases, and their corresponding descriptions.

Individual codes are associated with each theme, and each theme can contain a variety of codes (Braun and Clarke 2012). In deductive thematic analysis, these codes, like the themes, are typically predefined and theory-driven (Braun and Clarke 2012). The codes for our thematic analysis were developed with the intent to capture the importance of the biases in each of the 5 decision domains described in Section 2. As such, coding was performed using a predefined set of 60 codes, one for each unique combination of bias (12) and decision domain (5). These codes were applied to the input provided by the interviewees on the corresponding bias/domain combination. This input included the interviewees discussion of the importance of said bias in that specific domain: the score of the importance on the 5-point Likert scale, the supporting explanation, arguments, examples, and anecdotes.

Descriptions of the 12 themes, i.e., the biases, were provided during each interview. Each interviewee was asked to read this description aloud and to indicate whether this description was clear to them. A similar procedure was followed for each of the 5 decision domains. As such, we were able to clearly convey the meaning of each of the biases and decision domains and to verify whether interviewees understood these correctly. Based on this understanding, interviewees were able to accurately provide information in relation to each of the 60 codes included in our study.

The interviews were conducted in private and lasted between 90 and 120 min, in which each bias/domain combination was discussed. All interviews were recorded to accurately and completely capture interviewees' responses. Our data were stored in an electronic research database that contained: (1) the materials, i.e., cards and interview protocol, (2) audio files that captured our interviews, (3) a spreadsheet that contains for each respondent the validity test results and the input related to each of our 60 codes (including scores and brief explanations or anecdotes, completed with a time stamp that allowed a drill down to the corresponding text fragment in the audio file).

The data generated from the interviews were subsequently coded. Specifically, answers provided by interviewees were analyzed and assigned the corresponding code, where appropriate. The coded segments were gathered, analyzed, and compared across interviews. Findings related to individual codes were also grouped in the corresponding themes which formed the basis for the qualitative analysis of whether, or how, the importance of a specific bias differed across decision domains.

3.5. Data Quality Assessment

Before we further analyzed the results from our data collection, we assessed whether the quality of our data was sufficient to serve the purpose of our exploratory study. More specifically, we examined whether the data collected from these 14 interviewees formed a sufficient basis to draw conclusions. Therefore, we considered both the qualitative and the quantitative aspect of our data.

With regard to the question of whether 14 interviewees would be sufficient to draw conclusions from our qualitative data, we examined whether our data provides evidence of saturation. For that purpose, we assessed the rankings of each bias across the 5 decision domains. Specifically, we assessed whether the overall ranking of individual biases (from highest to lowest) changed when the number of interviews increased. Our data shows that after 12 interviews, no biases from the 7 (out of 12) highest ranked biases changed position when we moved to the 13th and 14th interviews. In those 2 last interviews, only very minor changes were found in the lower ranked biases which flipped places between 8th, 9th, and 10th position in the ranking. The lowest ranked biases (11th and 12th) no longer

changed positions after the 12th interview. We think this analysis provides evidence that we had reached saturation when we stopped collecting data after 14 interviews.

With regard to the question of whether 14 interviewees would be sufficient to draw conclusions from our quantitative data, we examined whether our data would allow hypothesis testing that biases vary (means are significantly different) across the 5 decision domains that we identified. With a Repeated Measures ANOVA, we tested whether the means of 5 cells with 14 observations are equal. Assuming that our N = 14 would be too low and would suggest that a type II error could exist in our data. In that case we would not find any significant effects from our hypothesis testing due to a lack of N. No such problem showed from the results, which we will present later in Table 3 and include the results of hypothesis testing, significance, and effect sizes.

Next to the number of interviewees, we also examined whether our data contained any indications that could question its reliability. More specifically, we questioned whether the interviewees themselves were biased in their observations of entrepreneurial decisions. From literature, we already knew that this would likely not be the case in observations from a third-party position. From the background and experience of our interviewees (as described in Section 3.2), the large number of SMEs that our interviewees discussed, the many anecdotes that were provided in our interviews, as well as the coherence of findings across the interviews, we have no reason to doubt the reliability of the data that we obtained from the 14 interviews.

Taken this together, we found that the data from the 14 interviews provided a sufficient basis to draw the conclusions that we did in the context of this exploratory paper. With our study we do not attempt to generalize to a population, like many survey studies in this domain do. Our contribution with this explorative study is to obtain a more rich and coherent insight on cognitive biases in entrepreneurial decision-making across 5 different decision domains in which SME entrepreneurs seek advice from their external SME accountant. We assessed that the quality of our data serves that purpose. The results of our analyses are discussed extensively in Section 4.

4. Analysis & Results

4.1. Overview of the Importance of Each Bias across Decision Domains

Table 3 provides an overview of the overall scores of the biases across decision domains. The rows of the table represent the biases and the column represents the decision domains. Each cell provides information of the mean score from the fourteen interviewees on the importance of a specific bias in a certain decision domain. Furthermore, each cell also provides a relative ranking (from highest to lowest) of the mean score of that bias compared to the mean scores of the other biases in that domain.

As can be seen from looking at the individual rows of Table 3, the mean scores and the relative rankings of a bias can vary strongly across the five decision domains. For example, the *affect heuristic*, which is rated by the interviewees to be the second most important bias in the HR decision domain with a mean score of 3.86, is actually rated as the least important bias in the law decision domain, with a mean score of just 2.14. The *affect heuristic* is, however, not the only bias for which scores differ across domains. For nine of the biases, the difference between the highest ranking and the lowest ranking across the five domains is at least six places (e.g., highest ranking as 1st and lowest ranking as 7th).

Table 3. Rankings and mean scores of each bias across decision domains.

Bias	Strategic Decision Domain	Regulatory Compliance Decision Domain	HR Decision Domain	IT Decision Domain	Succession Planning Decision Domain	Bias Mean Score (Scale 1–5)
Planning fallacy	2nd * 4.14 ^	5th 3.07	9th 3.14	1st 4.00	3rd 4.11	3.69
Escalation of commitment	4th 3.89	9th 2.46	3rd 3.71	2nd 3.82	4th 3.86	3.55
Status quo bias	3rd 4.00	8th 2.50	5th 3.57	4th 3.50	1st 4.18	3.55
Overconfidence	1st 4.32	6th 2.79	4th 3.64	3rd 3.64	7th 3.18	3.51
Availability heuristic	8th 3.50	3rd 3.32	1st 3.96	5th 3.46	6th 3.21	3.49
Affect heuristic	6th 3.75	12th 2.14	2nd 3.86	7th 3.32	2nd 4.14	3.44
Regret	7th 3.64	11th 2.32	9th 3.14	9th 3.14	5th 3.71	3.19
Confirmation bias	4th 3.89	10th 2.39	6th 3.50	11th 3.00	9th 2.93	3.14
Groupthink	12th 2.71	1st 3.43	11th 3.07	6th 3.43	8th 3.07	3.14
Illusion of control	9th 3.46	2nd 3.36	12th 3.04	12th 2.93	10th 2.79	3.11
Representativeness bias	11th 3.14	3rd 3.32	6th 3.50	9th 3.14	12th 2.07	3.04
Anchoring	10th 3.43	7th 2.64	8th 3.21	8th 3.29	11th 2.54	3.02
Domain mean score	3.66	2.81	3.45	3.39	3.32	3.32

* Rankings of scores of the 12 biases within a specific decision domain (column), from highest to lowest. ^ Mean of the scores provided by the 14 interviewees on a 5-point Likert scale ranging from 'not at all important' (1) to 'very important' (5).

4.2. Testing for Significant Differences in Bias Scores across Decision Domains

To test whether the differences, depicted in Table 3, are significant and in order to determine empirically whether the importance of these biases differs across decision domains, Repeated Measures ANOVAs were performed. In this test, the score assigned by each of the respondents to the bias across conditions (i.e., the five decision domains) is compared and is tested against a null hypothesis that this score does not differ across conditions. An outcome of $p < 0.05$ indicates that the null hypothesis is rejected and that the scores assigned to the bias differ significantly across conditions.

One advantage of this method is that it compares scores assigned to a bias in one domain with scores of the same bias in other domains assigned by the same interviewee. Comparing scores by the same interviewee allows the analysis to account for, and filter out, individual characteristics and differences between respondents. Furthermore, this method of analysis enabled us to test each bias individually, rather than the set of 12 biases as a whole and allowed us to test whether scores differed significantly across conditions for each bias separately.

Prior to interpreting the results, the assumptions for performing a Repeated Measures ANOVA were tested for each of the 12 biases across decision domains. First, boxplots were generated for each bias for each decision domain to detect possible outliers. A small subsample of observations was flagged as potential outliers. Note, however, that all observations constitute scores on a 5-point Likert scale and, as such, it would be unusual to classify any score on such a scale as being an outlier which can significantly disturb our research findings. Nevertheless, robustness checks were performed by running the same set of the Repeated Measures ANOVAs a second time with these potential outliers

removed from the dataset. The observed effects were almost identical, and in fact slightly stronger, with the outliers removed.

Second, tests of normality of the distribution of the dependent variable were performed via Shapiro-Wilk's tests and inspection of Q-Q plots for each bias in each decision domain. For some specific combinations of bias and decision domain the Shapiro-Wilk's test was significant, indicating a potential violation of normal distribution. Note, however, that Likert scale data typically is not perfectly normally distributed. In addition, Repeated Measures ANOVAs are quite robust to violations of normal distribution. Further investigation of the Q-Q plots revealed no sign of patterns deviating from normality.

Third, the data sample for each of the 12 biases was tested for sphericity using Mauchly's tests. *Regret* was the only bias for which Mauchly's test was significant. As a result, the *p*-value related to the Repeated Measures ANOVA for the bias *regret* was corrected to account for this using a Greenhouse-Geisser correction. Both the uncorrected and the corrected results were significant at the $p < 0.05$ level. After performing the testing of the assumptions, the Repeated Measures ANOVAs were performed.

Table 4 shows the results from the Repeated Measures ANOVAs. For most of the biases, the mean scores differ significantly across decision domains, indicating that these biases, and their importance, is indeed dependent on the decision domain. The rightmost column depicts the relative effect sizes for each of the biases. While there were differences in mean scores across decision domains for the *anchoring* effect, the *availability heuristic*, *groupthink* and the *illusion of control*, as shown in Table 4, these differences were not statistically significant. This suggests that for these biases, unlike the other eight, the importance is more or less the same across decision domains. For example, the anchoring effect was generally rated as a relatively unimportant bias across decision domains and never ranked in the top 5. Similarly, the illusion of control ranked between 9th and 12th place for all but one decision domain.

Table 4. Results of Repeated Measures ANOVAs.

Bias	Does the Importance of the Bias Differ Significantly across Decision Domains?	Significance	Effect Size (Partial Eta-Squared)
Planning fallacy	Yes	$p = 0.012$ *	0.215
Escalation of commitment	Yes	$p = 0.001$ **	0.302
Status quo bias	Yes	$p = 0.000$ ***	0.359
Overconfidence	Yes	$p = 0.006$ **	0.241
Availability heuristic	No	$p > 0.2$	0.069
Affect heuristic	Yes	$p = 0.000$ **	0.424
Regret	Yes	$p = 0.028$ *	0.220
Confirmation bias	Yes	$p = 0.009$ **	0.227
Groupthink	No	$p > 0.2$	0.098
Illusion of control	No	$p > 0.2$	0.084
Representativeness bias	Yes	$p = 0.008$ **	0.230
Anchoring	No	$p = 0.109$	0.129

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, two-tailed.

4.3. Which of These Biases Are Considered to Be the Most Important in Each Decision Domain?

Our findings not only imply that the importance of individual biases can differ across decision domains, but also that, for each decision domain, different biases are important. When comparing the columns of Table 3, one can see that the top three, or the top five, most important biases out of the set of 12 biases included in our study, differ greatly across decision domains. For example, none of the biases appear in the top 3 for more than two decision domains, with the sole exception of the *planning fallacy*,

which appears in 3. Indeed, the top 3's for the different decision domains contain 8 out of 12, different biases. Furthermore, the bottom row of the table shows that, overall, biases are considered to be more important in some decision domains than in others. In this subsection of the paper, we provide further insight into the most important biases for each decision domain, based on the qualitative findings from the interviews.

4.3.1. The Importance of Biases in the Strategic Decision Domain

According to the interviewees, biases are most important in the strategic decision domain, as illustrated by the domain mean score across all biases of 3.66/5 that is higher compared to the other domains. The respondents indicated that strategic decisions can have a big impact on the SME but are simultaneously subject to much uncertainty. These factors could fuel biases.

Out of all biases, *overconfidence* was considered to be the most important, with a mean score of 4.34 out of 5. The consensus amongst interviewees was that SME entrepreneurs are prone to overoptimism about their capabilities and chances of success. Multiple interviewees argued that *overconfidence* is typical for entrepreneurs, e.g., "*otherwise they would not have become entrepreneurs*". Our respondents shared several anecdotes of entrepreneurs who exhibited overconfidence in their capabilities and started risky adventures far beyond their domain of expertise.

The second highest rated bias is the *planning fallacy* (mean: 4.14/5). According to the interviewees, SME entrepreneurs often underestimate the time needed for the implementation of the strategic decisions. As a result, strategic plans are often unrealistic since they don't sufficiently account for potential setbacks and delays.

The status quo bias was rated as the third most important bias (mean: 4.00/5) As one interviewee explains: "SME entrepreneurs discuss with me about strategic changes and they visualize new products. Nevertheless, they often find it difficult to take a distance from and end the old products. It sometimes seems as if they visualize a happy future with a new girlfriend, but that they are happily married to the old products as well."

4.3.2. The Importance of Biases in the Regulatory Compliance Decision Domain

In stark contrast to the strategic decision domain, the importance of biases is considered to be the lowest overall in the regulatory compliance decision domain (mean: 2.81/5), as can be seen in Table 3. Multiple interviewees argued that this decision domain leaves less room for interpretation, as you either comply or you do not. There is less room for uncertainty or subjective views, thus limiting the overall importance of biases. However, even in this decision domain, there are individual biases which are considered to be important.

While *Groupthink* was considered the be the least important bias in strategy decisions, it is ranked as the most important bias in the regulatory compliance decision domain (mean: 3.43/5). It was argued that, for these decisions, entrepreneurs are easily influenced by their peers. As one interviewee describes: "*When I discuss these topics with my clients, they often refer to what their peers from Rotary or Lions clubs say or do. It is clear to me that for law and regulation decisions, entrepreneurs compare themselves to others: they don't want to be best in class, but they don't want to be discordant to their peers either.*"

The second most important bias, according to the respondents, is the *illusion of control* (mean: 3.36/5). SME entrepreneurs are believed to sometimes overestimate their chances of "*not getting caught*" if they were to violate law and regulation requirements. This is closely related to *availability heuristic*, which was also considered to be important (mean: 3.32/5). During our interviews this was illustrated as follows: "*When I discuss law or regulatory decisions with my customers, it makes a huge difference whether or not they have previously experienced a visit by inspectors or have received a penalty for noncompliance. They always immediately mention such an experience that they had themselves, or one of their closely related family members or peers. Other customers, who do not have such an experience, are quicker to think that this won't happen to them and that they may not get caught if they don't comply with regulations.*"

4.3.3. The Importance of Biases in the Human Resources Decision Domain

Table 3 shows that biases are considered to be fairly important in the HR decision domain (mean: 3.45/5). According to the respondents, HR decisions involve many subjective aspects such as assessing peoples' competencies, personal preferences, and relationships. This leaves much room for subjective interpretations and biases. These biases may be especially important in family-owned SME's since personal relations and experiences may promote biases there.

The *availability heuristic* is ranked as the most important bias in this decision domain (mean: 3.96/5). SME entrepreneurs are heavily influenced by preconceptions and former experiences that they had with people or with other people that they deem to be similar (in age, background, etc.). For example, one interviewee described that: "*When I discuss HR decisions with my customers, such as hiring new staff, they often bring easily to the table any former experiences, such as problematic dismissal procedures, and other problems they had with people from a certain age or background.*"

The second most important bias for HR decisions, is the *affect heuristic* (mean: 3.86/5). A positive or negative first impression of a person can strongly influence SME entrepreneurs' assessments of the qualities of that person. Prior affective reactions to a person, e.g., due to them being a family member, can similarly lead SME entrepreneurs' to (falsely) assume that the person also will do well in the family business.

Escalation of commitment was ranked as the third most important bias (mean: 3.71/5). The following quote is illustrative for the importance of this bias: "*I often see that my customers stick to their choices regarding people and sometimes stay loyal to specific employees far beyond what I would find reasonable. This often applies to certain family-members who don't function properly, but who are hardly criticized and even get protected by the SME entrepreneur.*"

4.3.4. The Importance of Biases in the IT Decision Domain

Cognitive biases were also considered to be fairly important in the IT decision domain (mean: 3.39/5). Our respondents argued that IT decisions involve complexity and that SME entrepreneurs, often due to a lack of personal expertise on the subject, can be prone to make their decisions based on 'beautiful pictures' presented by IT-suppliers and consultants who may not always act in the SME's best interests.

For IT decisions, the planning fallacy is ranked as the most important bias (mean: 4.00/5. From the accountants' experiences, SME entrepreneurs especially tend to heavily underestimate the time and effort needed to implement or replace an IT system, such as ERP systems, or computer hardware. The following quote is exemplary of the kind of comments made with regards to this bias: "*My customers often do not see nor understand what it takes to implement a new IT-system. SME entrepreneurs sometime use phrases like 'How difficult can it be? In my home, I can get software up and running in a few minutes. So why would it take so much time to implement a system at the office?', that illustrate how much they underestimate time and complexity of IT implementations in the business environment.*"

The second most important bias is escalation of commitment (mean: 3.82/5). Amongst others, it appears to be difficult for SME entrepreneurs to admit that a challenged or failing implementation of a system should be redirected or stopped. This seems to be especially difficult if the entrepreneurs themselves previously tried to convince their employees of the value of the system, because they may not want to lose face in front of their employees and would rather continue with the (troubled or failing) chosen course of action.

Surprisingly, our respondents ranked *overconfidence* as the third most important bias (mean: 3.64/5). Although SME entrepreneurs are typically aware that they have limited knowledge of IT, they often do think they are very capable to select and find the right person or organization to provide IT services to them, as one interviewee explains: "*Some of my customers tell me that they 'sense' which IT person or organization they should hire or not. I sometimes find it curious that they make such claim without having the IT knowledge necessary to make such decisions.*"

4.3.5. The Importance of Biases in the Succession Planning Decision Domain

Biases were considered to be fairly important in the succession planning decision domain, as shown in Table 3 (mean: 3.32/5). Respondents indicated that the succession decisions have such large consequences (i.e., pensions, stakeholders) that dedicated accountants are often involved, who can help the SME entrepreneur to make well-informed, rather than biased, decisions. At the same time, these decisions involve many of the same subjective considerations that play a role in the HR decision domain, as well as the high level of uncertainty and impact that is present in the strategic decision domain. In addition, these decisions have a big impact on the SME entrepreneur personally. These factors may all increase the likelihood of biases occurring, for example, in relation to the assessment of one's own capabilities and those of the potential successor(s). This may especially hold true for family-owned SME's since family relations are often intertwined with positions in these firms.

The *status quo bias* was ranked as the most important bias (mean: 4.18/5). Our respondents provided many examples of SME entrepreneurs who found it very difficult to detach from the company that had been part of their lives for so many years and who often postponed the difficult decision to make such drastic changes in a situation that existed for so long. As such, they often stayed at the helm for longer than was desirable, or rational.

The *affect heuristic*, the second most important bias in this decision domain (mean: 4.14/5), played a similar role. The interviewees argued that their customers are often emotionally attached to their organization, citing SME entrepreneurs who talk about 'this beautiful company', 'these wonderful people', and 'our unique products'. This too, can be a barrier to leaving the company, even if this is the best course of action. The *affect heuristic* can also bias the assessment of who would make the best example—for example one of the children.

Our respondents ranked *planning fallacy* as the third most important bias (mean: 4.11/5). Entrepreneurs often underestimate the time and effort that is needed to prepare for and implement the succession. Additionally, since they may have postponed the succession decision for too long, due to the aforementioned biases, there is often not enough time left to make proper arrangements.

4.4. Actions That SME Accountants Could Take When Faced with These Biases

In addition to information about the importance of these biases across the five decision domains, our interviewees also provided us with insights about actions that SME accountants could take when faced with these biases by SME entrepreneurs. In this subsection, we will discuss and categorize these proposed actions.

The accountant is in a unique position to guard SME entrepreneurs from the harm to the enterprise that may result from irrational and biased decision making. The information provided in our paper can help SME accountants to recognize the most prominent biases in each of the decision domains. However, while awareness and recognition of such biases is a necessary precondition for dealing with them, recognition alone does nothing to stop the harmful effects of biases. Prior research has shown that external advice, i.e., from someone outside the organization, can be valuable. Such external advice has been found effective in reducing the *illusion of control* bias, for example. Internal advice was shown to be less effective and in fact even increased the bias (Meissner and Wulf 2016). Similarly, the seeking of outside advice has shown to reduce *escalation of commitment* (Hammond et al. 2006).

Reducing the effects of biases is also called *debiasing* (Fischhoff 1982). Debiasing by an outsider—such as the accountant—can be achieved in several ways, such as by giving warnings, information, by intervening, or by providing coaching or mentoring. The debiasing approaches emerged from the question to our interviewees what actions they would recommend to their peer accountants when they deal with an SME entrepreneur who falls victim to biases. The four approaches are discussed in more detail in the following paragraphs and we briefly reflect on them from debiasing literature. Which debiasing approach is most appropriate and successful according to our interviewees, depends, in part, on the specific relationship that the SME accountant has with the SME entrepreneur.

4.4.1. Debiasing by Giving Warnings

Our interviewees suggested that the accountant can warn SME entrepreneurs of important biases in a specific decision domain, prior to them occurring. While a warning in advance may prevent the entrepreneur to fall victim to a bias, it is important that the warning is given by the right person, in the right way and at the right time. Another bias, the deaf effect, where receivers of messages irrationally do not hear, or listen to, warnings, can manifest itself otherwise. In some cases, such warnings may even be counterproductive (Keil and Robey 1999; Nuijten et al. 2016). The accountant could be the right person to give such a warning, but only if the specific relationship that the accountant and the SME entrepreneur have is suitable for it. Prior literature has shown that such warnings are effective if the messenger is perceived to be a partner, who is giving the message with the intention to help, but less effective otherwise (Nuijten et al. 2016). Thus, this approach is suitable specifically when the SME entrepreneur perceives the SME accountant in such a way and if their relationship allows for the giving of such well-intended advance warnings. The findings from our study may be valuable to accountants in this role since they provide insight into which biases are most important in a specific decision domain. As such, the accountant could focus on providing warnings for those biases which are most important for the decision at hand.

4.4.2. Debiasing by Giving Information to Help Recognize or Reduce the Impact of Biases

This approach focuses on reducing the effects of a bias by providing information that can help reduce the bias, and promote rational decision making, at the right time. This can be effective at the time when an SME entrepreneur is considering his decision and the accountant suspects that a bias might play a role. Some interviewees suggested that, to aid in the decision-making process, the accountant could provide information about the most relevant biases that apply to these types of decisions as well as information on the impact of these biases or how to recognize them (i.e., symptoms of the bias). With this information, the SME entrepreneur may realize that they have fallen victim to this bias, or, they may recognize symptoms of these biases if they risk falling victim to them in the future. On multiple occasions, this was referred to during the interviews as 'holding up a mirror'. Similarly, several interviewees mentioned that it was important for accountants to inform the SME entrepreneurs of the risks and impact associated with a specific decision, if it seemed that the entrepreneur was not fully aware of them. The information provided in our study can aid accountants by identifying which specific biases they should look out for and should discuss with the SME entrepreneur.

Furthermore, the accountant and entrepreneur could agree on the usage of checks for these biases, specific critical questions that an accountant can routinely ask prior to making the final decision aimed at detecting potential biases in the decision-making process. They can also discuss potential actions that are advisable of signs of a bias are detected. One interviewee indicated that the use of such protocols by accountants can be helpful and several interviewees also discussed the importance of the accountant providing the right information but also of asking the right questions.

This suggestion aligns with what is known about reducing biases from literature. For example, prior research has established that the *status quo bias* can be reduced by explicitly thinking about, and taking into consideration, alternative courses of action and by critically considering whether the status quo will actually help achieve them (Hammond et al. 2006). Other studies have shown that drafting a checklist of information relevant to the decision, prior to making the decision, can help ensure that decisions are based on the right information and are not biased by the *availability heuristic* (Kahneman et al. 2011). The accountant could advise the entrepreneur to consider such aspects in their decision.

As stated, the effectiveness of this approach depends on the nature of the relationship that the SME entrepreneur and accountant have. This approach seems to fit especially when the entrepreneur needs an accountant who is mainly focused on business support of the entrepreneur with interpretation of figures and provides insight into the impact of choices.

4.4.3. Debiasing by Intervening when an SME Entrepreneur Falls Victim to a Bias

This is a reactionary approach, where the accountant responds when they have strong suspicions that an SME entrepreneur has fallen victim to a bias. This response could take the form of trying to make the entrepreneur aware of the bias that they have fallen victim to, warning them of the potential negative consequences of the bias, and advising them on actions that could be taken to reduce the impact of the bias. For example, prior research suggests that the effects of *anchoring* can be reduced by challenging the decision maker to consider an alternative point-of-view. This can reduce the effect that an anchor has on the decision (Mussweiler et al. 2000; Galinsky and Mussweiler 2001). Such a perspective taking has been shown to be an effective strategy in reducing biases in general (Kahneman et al. 2011).

This situation is of course precarious because the accountant should not want to be perceived as sitting in the entrepreneur's chair. As such, the relationship that the accountant and SME entrepreneur have should be suitable for performing such interventions. As such, this approach is likely most appropriate for an entrepreneur who values an accountant who is sometimes willing to take on the additional role of a 'strict friend'.

4.4.4. Debiasing by Coaching and Mentoring

The approach of coaching implies a more extensive program of feedback to combat biases in practice (Fischhoff 1982). This constitutes a more holistic approach which utilizes elements from the previously described approaches, where and when appropriate, depending on the specific context and the relationship with the SME entrepreneur. As with the first approach, the accountant can share knowledge about the most important biases in specific decision domains with clients from the SME practice, illustrated with anonymized examples from practice, prior to biases occurring. This could not only help prevent entrepreneurs falling victim to these biases later, but it can also create a basis for future discussion about the subject of biases with these clients. Thus, making it easier to give warnings (approach #2) or intervene (approach #3) at a later time, if the accountant is concerned about the entrepreneur falling victim to a specific bias. Furthermore, prior research has shown that such group discussions or group decision making can reduce the effects of biases (Hammond et al. 2006). Of course, not every SME entrepreneur will desire or appreciate their accountant taking on the role of a coach of mentor. Additionally, even if they do desire it, this cannot be forced—such a relationship must develop over time.

5. Discussion & Implications

5.1. Implications for Research

While SMEs have been a subject of investigation of cognitive biases for decades, our exploratory study has three main contributions. To our knowledge this study is the first to examine cognitive biases in entrepreneurial decision making from the perspective of SME accountants. SME entrepreneurs often seek the advice of their accountants when they struggle with critical decisions that involve uncertainty and business risks (Bennett and Robson 1999; Berry et al. 2006; Blackburn and Jarvis 2010; Suddaby et al. 2002). This can involve a large variety of decisions regarding strategy, regulatory compliance, human resources, IT, and succession. It is acknowledged that involving a third party could contribute to more rational decisions, since someone in that position can challenge assumptions and uncover potential biases in the decision-making process (Kahneman et al. 2011). A third-party role therefore could be of pivotal value to identify cognitive biases in entrepreneurial decision making (Abatecola et al. 2018, p. 412). External accountants fulfil this role for many small and medium enterprise (SME) entrepreneurs. Therefore, SME accountants are not only in the position to help SME entrepreneurs make more rational decisions, but they could also serve as a valuable source of information for research in the domain of entrepreneurial decision making. They are in the position to directly observe how entrepreneurs make decisions in real-life situations and they could identify

cognitive biases when they occur. Direct observation of entrepreneurial decision making could be a fruitful way to study cognitive biases (Liebregts et al. 2020). SME accountants who are external to the SME and advise hundreds of entrepreneurs over a long period of time, therefore could offer valuable insights of how cognitive biases affect SME entrepreneurial decision making. Although our study is exploratory by nature, we think it confirms the value of using SME accountants as a source of information.

The second contribution of our study exploits the use of SME accountants who are consulted by entrepreneurs for a variety of decisions. This allowed us to shed a broader light on an issue that is related to how the research stream on cognitive biases in entrepreneurial decision making has unfolded. A literature review by Zhang and Cueto (2017) shows that research in the domain of entrepreneurial decision making has emphasized a number of important biases (e.g., overconfidence) in a handful of specific and important entrepreneurial decisions (e.g., start-up, market-entry or exit). However, putting the spotlight on a few specific biases and entrepreneurial decisions could leave other important biases and decisions underexposed. Since the SME accountants in our study advised in total over 3000 entrepreneurs on a variety of decisions, they allowed us to compare the importance of 12 different cognitive biases and analyze whether their importance can change across five decision domains for which entrepreneurs seek advice of accountants: strategy, regulatory compliance, human resources, IT, and succession. Results from our analysis showed that for most of these biases, the importance differs significantly across decision domains. This indicates that considering the decision domain is important when studying these biases. In addition, our analysis allowed us to compare the 12 different biases to each other. In doing so, we provide some insight into which of these 12 biases are most important, both in general, as well as for each of the individual decision domains. In line with our other findings, this analysis showed that the biases that were considered to be the most important differed greatly across decision domains. We think this offers a small but valuable contribution, since it sheds a broader light on the issue whether some cognitive biases and decisions might be over-emphasized or under-emphasized and thus might be of help to researchers to determine which biases and decisions to focus on.

A third contribution of our study comes from the willingness of our interviewees to share with us and with other accountants what approach they follow in situations that SME entrepreneurs fall victim to cognitive biases. We identified four debiasing approaches (warn, inform, intervene, and coach) SME accountants take to help SME entrepreneurs avoid or reduce biases.

5.2. Implications for Practice

As more and more SME accountants extend their services from traditional bookkeeping towards advisory services and coaching, they are faced with both a great opportunity and a great challenge of adding value to SME entrepreneurs who struggle with their decisions. Those external accountants are in a unique position to provide added value by aiding the identification and prevention of cognitive biases. However, there are several challenges in doing so. Prior literature has identified many different cognitive biases, and these have often been studied in isolation. This makes it difficult for SME accountants to be informed of all these biases. Furthermore, it was unclear how important these biases are in these decision domains. Our study provides insights from various experienced SME accountants who have encountered these biases with SME entrepreneurs in practice. As such, our study provides other accountants with insight into how important these biases are across five decision domains.

Furthermore, based on our analysis, we were able to identify which of these biases were considered to be the most important in each of the five domains. We consider such information to be valuable to practitioners since it allows them to focus on those biases, amongst the ones studied, that are most important given the decision at hand, and it allows them to better recognize them from the role that they can play in that decision domain. As such, accountants need not have to look out for 12 different cognitive biases in each decision, without knowing how important each of these may be.

Knowledge of which of these biases is the most important in the specific decision domain at hand can also provide an effective means to leverage the influence of the accountant and have a positive impact on the quality of the decisions that SME entrepreneurs make. The SME accountant can do so either by helping prevent these biases before they occur, or by counteracting them if an SME entrepreneur has fallen victim to them already. The insights generated from our interviews with SME accountants experienced in this role yielded suggestions for four different approaches that an SME accountant could adopt to achieve this result: by giving pre-emptive warnings, by giving the right information and asking the right questions, by challenging the SME entrepreneur when a bias occurs, or by mentoring and coaching the SME entrepreneur.

5.3. Limitations

As is the case with all research studies, our work is subject to limitations. One limitation is that we restricted our study to five decision domains for which SME entrepreneurs seek the advice of their accountants. So, SME decisions that would not lend themselves for any involvement of the accountants, were excluded from our scope. We are not aware of relevant SME decisions that could be prone to biases and which are not included in our scope, other than the decision of choosing an accountant. At the same time, we cannot rule out that there may be other such decisions in which biases could play a role.

Another limitation is that our study was not longitudinal and therefore we relied on the accountants' recollection of biases in order to reconstruct how SME entrepreneurs made their decisions. We did not independently measure or verify the consequences of such biases, beyond the information that was provided by the interviewees. Therefore, we could not entirely eliminate the existence of cognitive biases from the end of the accountant in our data collection. However, the unique third-party position (Kahneman et al. 2011) that accountants have, offers them a very good stance to observe biases in the decisions that entrepreneurs make. On a related note, from the way we measure the importance of biases to entrepreneurial decisions, our results cannot distinguish between (1) how frequently a bias occurs as a percentage of the decisions that are taken, and (2) how strongly the bias affects the decisions. Both contribute to the importance that cognitive biases have in entrepreneurial decision making and serve the purpose of our study.

A final limitation is that our study was restricted to 14 Dutch SME accountants who had advised in decisions by over 3000 entrepreneurs in the Netherlands over a period of two or three decades in total. Of course, some of our findings may have been influenced by the particularities of Dutch culture. Therefore, we are cautious to generalize our exploratory findings to a larger population nor can we make any claims for similarities with other countries. However, we do know that our list of decision domains for which SME entrepreneurs seek advice of the external accountant as well as our list of biases are derived from international literature and were confirmed by our Dutch interviewees. So, at least there is a certain level of similarity of the Dutch context to other countries.

5.4. Directions for Future Research

Our study suggests several avenues for future research. First, it would be useful to conduct longitudinal studies and interpret the effects of cognitive biases over time for the various types of decisions that we identified. Some types of decisions (e.g., HR decisions) are taken more frequently than others (e.g., succession planning) and such differences could shape the pattern of chance and impact of biased decisions.

Next, the results of our exploratory study could warrant further use of accountants as a source of information to examine entrepreneurial cognitive biases. Future research on this avenue could address the limitations of our study and expand to other countries, to a larger number of participants, and adopt a further refined instrument to measure and compare the importance of a series of cognitive biases on entrepreneurial decision making (in line with Keil et al. 2000).

In addition, there is a need to conduct research to test and verify the effectiveness of the actions that were suggested by the SME accountants to cope with these biases. Prior literature on the deaf effect, for example, suggests that the approach of giving warnings may only be successful under certain circumstances (Nuijten et al. 2016). Even though several of the approaches mentioned by the interviewees may have been successful for them, and are in line with literature on debiasing strategies, we believe it to be important to investigate such potential negative side-effects of the approaches that are described in this study.

Finally, while extant research has focused on entrepreneurs and accountants separately and considered individual biases, we believe that more work is needed that takes a holistic approach on these biases, the entrepreneurs, their accountants, and their relationships. We encourage other scholars to further develop our understanding of this important field.

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References

Abatecola, Gianpaolo, Andrea Caputo, and Matteo Cristofaro. 2018. Reviewing cognitive distortions in managerial decision making. *Journal of Management Development* 37: 409–24. [CrossRef]

Barbosa, Saulo D., and Alain Fayolle. 2007. Where is the risk? Availability, anchoring, and framing effects on entrepreneurial risk taking. *Frontiers of Entrepreneurship Research* 27. Available online: https://ssrn.com/abstract=1064121 (accessed on 4 November 2020).

Baron, Jonathan. 2007. The study of thinking. In *Thinking and Deciding*, 4th ed. Edited by Jonathan Baron. Cambridge: Cambridge University Press, pp. 54–58.

Baron, Robert A. 1998. Cognitive mechanisms in entrepreneurship: Why and when entrepreneurs think differently than other people. *Journal of Business Venturing* 13: 275–94. [CrossRef]

Baron, Robert A. 2004. The cognitive perspective: A valuable tool for answering entrepreneurship's basic "why" questions. *Journal of Business Venturing* 19: 221–39. [CrossRef]

Baron, Robert A. 2008. The role of affect in the entrepreneurial process. *Academy of Management Review* 33: 328–40. [CrossRef]

Baron, Robert A. 2013. Counterfactual thinking and venture formation: The potential effects of thinking about "what might have been". *Journal of Business Venturing* 15: 79–91. [CrossRef]

Bennett, Robert J., and Paul J. A. Robson. 1999. The use of external business advice by SMEs in Britain. *Entrepreneurship & Regional Development* 11: 155–80.

Berry, Anthony J., Robert Sweeting, and Jitsuo Goto. 2006. The effect of business advisers on the performance of SMEs. *Journal of Small Business and Enterprise Development* 13: 33–47. [CrossRef]

Blackburn, Robert A., and Robin Jarvis. 2010. The role of small and medium practices in providing business support to small- and medium-sized enterprises. In *A Report for the International Federation of Accountants*. New York: IFAC, pp. 1–32.

Blackburn, Robert A., Will Eadson, Rock Lefebvre, and Philip Gans. 2006. SMEs, regulation and the role of the accountant. In *Research Report No. 96*. London: ACCA.

Bourgeois, L. Jay, III, and Kathleen M. Eisenhardt. 1988. Politics of strategic decision making in high-velocity environments: Toward a midrange theory. *Academy of Management Journal* 31: 737–70.

Boyatzis, Richard E. 1998. *Transforming Qualitative Information: Thematic Analysis and Code Development*. Cleveland: Sage Publications.

Braun, Virginia, and Victoria Clarke. 2012. Thematic analysis. In *APA Handbook of Research Methods in Psychology, Vol. 2. Research Designs: Quantitative, Qualitative, Neuropsychological, and Biological*. Edited by Harris Cooper, Paul M. Camic, Debra Long, Abigail T. Panter, David Rindskopf and Kennet J. Sher. Washington: American Psychological Association, pp. 57–71.

Burmeister, Katrin, and Christian Schade. 2007. Are entrepreneurs' decisions more biased? An experimental investigation of the susceptibility to status quo bias. *Journal of Business Venturing* 22: 340–62. [CrossRef]

Busenitz, Lowell W., and Jay B. Barney. 1997. Differences between entrepreneurs and managers in large organizations: Biases and heuristics in strategic decision-making. *Journal of Business Venturing* 12: 9–30. [CrossRef]

Cardon, Melissa S., Joakim Wincent, Jagdip Singh, and Mateja Drnovsek. 2009. The nature and experience of entrepreneurial passion. *Academy of Management Review* 34: 511–32. [CrossRef]

Carr, Jon C., and Daniela P. Blettner. 2010. Cognitive control bias and decision-making in context: Implications for entrepreneurial founders of small firms. *Frontiers of Entrepreneurship Research* 30: 2.

Cristofaro, Matteo. 2017. Reducing biases of decision-making processes in complex organizations. *Management Research Review* 40: 270–91. [CrossRef]

Croce, Annalisa, Elisa Ughetto, and Marc Cowling. 2020. Investment motivations and UK business angels' appetite for risk taking: The moderating role of experience. *British Journal of Management* 31: 728–51. [CrossRef]

Devi, Susela S., and Helen Samujh. 2010. Accountants as providers of support and advice to SMEs in Malaysia. In *Research Report 118*. London: Association of Chartered Certified Accountants.

Doving, Erik, and Paul N. Gooderham. 2008. Dynamic capabilities as antecedents of the scope of related diversification: The case of small firm accountancy practices. *Strategic Management Journal* 29: 841–57. [CrossRef]

Drummond, Helga. 2004. 'See you next week'? A study of entrapment in a small business. *International Small Business Journal* 22: 487–502. [CrossRef]

Fischhoff, Baruch. 1982. Debiasing. In *Judgment under Uncertainty: Heuristics and Biases*. Edited by Daniel Kahneman, Paul Slovic and Amos Tversky. Cambridge: Cambridge University Press, pp. 422–44.

Foo, Maw D. 2011. Emotions and entrepreneurial opportunity evaluation. *Entrepreneurship Theory and Practice* 35: 375–93. [CrossRef]

Forbes, Daniel P. 2005. Are some entrepreneurs more overconfident than others? *Journal of Business Venturing* 20: 623–40. [CrossRef]

Galinsky, Adam D., and Thomas Mussweiler. 2001. First offers as anchors: The role of perspective-taking and negotiator focus. *Journal of Personality and Social Psychology* 81: 657–69. [CrossRef]

Gibbons, Patrick T., and Tony O'Connor. 2005. Influences on strategic planning processes among Irish SMEs. *Journal of Small Business Management* 43: 170–86. [CrossRef]

Gooderham, Paul N., Anita Tobiassen, Erik Doving, and Odd Nordhaug. 2004. Accountants as sources of business advice for small firms. *International Small Business Journal* 22: 5–22. [CrossRef]

Hambrick, Donald C. 1995. Fragmentation and the other problems CEOs have with their top management teams. *California Management Review* 37: 110–27. [CrossRef]

Hammond, John S., Ralph L. Keeney, and Howard Raiffa. 2006. The hidden traps in decision making. *Harvard Business Review* 84: 118–24.

Hasle, Peter, Bo Bager, and Lise Granerud. 2010. Small enterprises—Accountants as occupational health and safety intermediaries. *Safety Science* 48: 404–9. [CrossRef]

Hayton, James C., and Magdalena Cholakova. 2012. The role of affect in the creation and intentional pursuit of entrepreneurial ideas. *Entrepreneurship Theory and Practice* 36: 41–68. [CrossRef]

Hirigoyen, Gérard, and Rania Labaki. 2012. The role of regret in the owner-manager decision-making in the family business: A conceptual approach. *Journal of Family Business Strategy* 3: 118–26. [CrossRef]

Ismail, Noor A., and Malcolm King. 2014. Factors influencing the alignment of accounting information systems in small and medium sized Malaysian manufacturing firms. *Journal of Information Systems and Small Business* 1: 1–20.

Janis, Irving L. 1972. *Victims of Groupthink: A Psychological Study of Foreign-Policy Decisions and Fiascoes*. Boston: Houghton Mifflin, ISBN 0-395-14002-1.

Jarvis, Robin, and Mike Rigby. 2012. The provision of human resources and employment advice to small and medium-sized enterprises: The role of small and medium-sized practices of accountants. *International Small Business Journal* 30: 944–56. [CrossRef]

Kahneman, Daniel, and Dan Lovallo. 1993. Timid choices and bold forecasts: A cognitive perspective on risk taking. *Management Science* 39: 17–31. [CrossRef]

Kahneman, Daniel, Dan Lovallo, and Olivier Sibony. 2011. Before you make that big decision. *Harvard Business Review* 89: 50–60.

Keh, Hean T., Maw D. Foo, and Boon C. Lim. 2002. Opportunity evaluation under risky conditions: The cognitive processes of entrepreneurs. *Entrepreneurship Theory and Practice* 27: 125–48. [CrossRef]

Keil, Mark, and Dan Robey. 1999. Turning around troubled software projects: An exploratory study of the de-escalation of commitment to failing courses of action. *Journal of Management Information Systems* 15: 63–87. [CrossRef]

Keil, Mark, Joan Mann, and Arun Rai. 2000. Why software projects escalate: An empirical analysis and test of four theoretical models. *MIS Quarterly* 24: 631–64. [CrossRef]

Kor, Yasemin Y., Joseph T. Mahoney, and Steven C. Michael. 2007. Resources, capabilities and entrepreneurial perceptions. *Journal of Management Studies* 44: 1187–212. [CrossRef]

Langer, Ellen J. 1975. The illusion of control. *Journal of Personality and Social Psychology* 32: 311–28. [CrossRef]

Le Roux, Ingrid, Marius Pretorius, and Sollie M. Millard. 2006. The influence of risk perception, misconception, illusion of control and self-efficacy on the decision to exploit a venture opportunity. *Southern African Business Review* 10: 51–69.

Leung, Philomena, Jean Raar, and Greg Tangey. 2008. *Accounting Services and SMEs: An Australian Study*. London: Association of Chartered Certified Accountants.

Liebregts, Werner, Pourya Darnihamedani, Eric Postma, and Martin Atzmueller. 2020. The promise of social signal processing for research on decision-making in entrepreneurial contexts. *Small Business Economics* 55: 589–605.

Mehrabi, Rosa, and Amir M. Kolabi. 2012. Investigating effects of entrepreneur's personal attributes and cognitive heuristics on the quality of entrepreneurial strategic decision making. *Global Business and Management Research: An International Journal* 4: 178–92.

Meissner, Philip, and Torsten Wulf. 2016. Debiasing illusion of control in individual judgment: The role of internal and external advice seeking. *Review of Managerial Science* 10: 245–63. [CrossRef]

Mullins, John W., and David Forlani. 2005. Missing the boat or sinking the boat: A study of new venture decision making. *Journal of Business Venturing* 20: 47–69. [CrossRef]

Mussweiler, Thomas, Fritz Strack, and Tim Pfeiffer. 2000. Overcoming the inevitable anchoring effect: Considering the opposite compensates for selective accessibility. *Personality and Social Psychology Bulletin* 26: 1142–50. [CrossRef]

Nouri, Pouria, Narges Imanipour, Kambeiz Talebi, and Mohammadreza Zali. 2017. Heuristics and biases in entrepreneurial marketing: Some new insights. *International Journal of Entrepreneurship* 21: 1–9.

Nuijten, Arno, Mark Keil, and Harry R. Commandeur. 2016. Collaborative partner or opponent: How the messenger influences the deaf effect in IT projects. *European Journal of Information Systems* 25: 534–52. [CrossRef]

Nuijten, Arno, Mark Keil, Gerrit Sarens, and Mark van Twist. 2019. Partners or opponents: Auditor-manager relationship dynamics following the deaf effect in information system projects. *Managerial Auditing Journal* 34: 1073–100. [CrossRef]

Palich, Leslie E., and Ray D. Bagby. 1995. Using cognitive theory to explain entrepreneurial risk taking: Challenging conventional wisdom. *Journal of Business Venturing* 10: 425–38. [CrossRef]

Schwenk, Charles R. 1984. Cognitive simplification processes in strategic decision-making. *Strategic Management Journal* 5: 111–28. [CrossRef]

Shepherd, Dean A., Trenton A. Williams, and Holger Patzelt. 2015. Thinking about entrepreneurial decision making: Review and research agenda. *Journal of Management* 41: 11–46. [CrossRef]

Simon, Herbert A. 1947. *Administrative Behavior*, 1st ed. New York: Free Press.

Simon, Mark, Susan M. Houghton, and Karl Aquino. 2000. Cognitive biases, risk perception, and venture formation: How individual decide to start companies. *Journal of Business Venturing* 15: 113–34. [CrossRef]

Stanovich, Keith E., and Richard F. West. 2000. A psychological point of view: Violations of rational rules as a diagnostic of mental processes. *The Behavioral and Brain Sciences* 23: 681–83.

Staw, Barry 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: 27–44. [CrossRef]

Suddaby, Roy, Royston Greenwood, and Christopher R. Hinings. 2002. Theorizing change: The role of professional associations in the transformation of institutionalized fields. *Academy of Management Journal* 45: 58–80.

Tversky, Amos, and Daniel Kahneman. 1973. Availability: A heuristic for judging frequency and probability. *Cognitive Psychology* 5: 207–32. [CrossRef]

Tversky, Amos, and Daniel Kahneman. 1974. Judgement under uncertainty: Heuristics and biases. *Science New Series* 185: 1124–31.

Van Teeffelen, Lex. 2006. Involvement of accountants and bankers in SME transfers: Perspectives and witnessed difficulties. Paper presented at the RENT XX Conference, Brussels, Belgium, November 22–24.

Zeelenberg, Marcel. 1999. Anticipated regret, expected feedback and behavioral decision making. *Journal of Behavioral Decision Making* 12: 93–106. [CrossRef]

Zhang, Stephen X., and Javier Cueto. 2017. The study of bias in entrepreneurship. *Entrepreneurship Theory and Practice* 41: 419–54. [CrossRef]

Enhancing Healthcare Decision-Making Process: Findings from Orthopaedic Field

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Abstract: In the healthcare field, the decision-making process is part of the broad spectrum of "clinical reasoning", which is recognised as the whole process by which a physician decides about patients' treatments and cares. Several clinicians' intrinsic variables lead to this decisional path. Little is known about the inference of these variables in triggering biases in decisions about the post-discharge period in the surgical field. Accordingly, this research aims to understand if and how cognitive biases can affect orthopaedists in decision-making regarding the follow-up after knee and hip arthroplasty. To achieve this goal, an interview-based explorative case study was run. Three key-decisional orthopaedic surgeons were interviewed through a quality control tool aimed at monitoring the causes and effects of cognitive distortions. Coherently with the literature, eight biases come to light. All the interviewees agree on the presence of four common biases in orthopaedic surgery (Affect heuristic, Anchoring, Halo effect, Saliency). The other biases (Groupthink, Availability, Overconfidence, Confirmation), instead, depending on specific physicians' intrinsic variables; namely: (i) working experience; (ii) working context. This finding contributes to the debate about the application of cognitive tools as leverage for improving the quality of clinical decision-making process and, indirectly, enhancing better healthcare outcomes.

Keywords: clinical decision-making process; clinical reasoning; cognitive biases; orthopaedics; follow-up decision; healthcare decision

1. Introduction

Decision-making is a complex and progressively unpredictable process that relies on precise information availability (Simon 1947; Sousa et al. 2019).

In healthcare, the decision-making process called the "clinical decision process" (Higgs et al. 2019) is a part of a more complex process named "clinical reasoning". According to Norman (2005), the topic of clinical reasoning has been studied for more than 30 years and three fields of research have characterised it. They are related to (i) Understanding the process of clinical reasoning; (ii) Knowledge and memory related to clinical reasoning; and (iii) Mental representation of clinical reasoning.

Up to now, there is no unique definition of clinical reasoning, there are several definitions that differ a lot from each other (Durning et al. 2013). For clearness, in healthcare literature often clinical reasoning and clinical decision-making have been used as synonyms to define "the process by which a healthcare practitioner decide what to think and do with a patient" (Christensen et al. 2017, p. 176), but Durning et al. (2013, p. 446) provides a precise definition of clinical reasoning as "the mental process and behaviours that are shared (or evolve) between the patient, physician, and the environment". In this manuscript, according to Higgs et al. (2019), we refer to clinical reasoning as the whole process of a physician's thinking during her/his practice, where clinical decision-making is a step of it, provided in order to emphasize the outputs or decisions. Towards the analysis of every decision-making process, it should

be noted that this is a human process and it is not exempt from human characteristics such as several biases, that is, deviations from human rationality, due to human nature (Kahneman 2011). Most of the literature on clinical reasoning (both articles and reviews) leads to bias-triggered diagnostic errors (Cooper and Frain 2016) concerning emergency medicine (Croskerry 2003; Rubio-Navarro et al. 2020; Antonacci et al. 2020); just a few studies, however, regard biases in the clinical and therapeutic decision process (day by day decisions). This first literature gap would deserve to be further investigated; especially, some scholars have stated that clinical outcomes may be improved through recognising, understanding, and modifying those decisions affected by biases. (Antonacci et al. 2020).

Moreover, some authors outside the healthcare field (Baron 1998; Haley and Stumpf 1989; Rashid and Boussabiane 2019) have studied the connection between decision-makers' personal variables and the decisional output. In line with this literature, Wu et al. (2017) stated that the personal features of managers together with characteristics of their working environment could influence the decision-making process and operating choice. According to the author, the main decision-maker influencers are: (i) the manager's international experience; (ii) the specific task/role; (iii) the number of team members with which the manager works; (iv) the working atmosphere and pressure. In other words, Wu et al. (2017) recognise that working experience/role and working context play a crucial role in influencing business decisions. Nevertheless, within the healthcare management field, a literature gap was also noted about the specific analyses of the linkage between intrinsic human variables of clinicians and the decisional biases connected to the clinical reasoning. Actually, this second aspect still remains understudied.

This is in accordance with what Ashoorion et al. (2012) have stated. By analysing the correlation between physicians' personal variables and clinical reasoning on medical students, authors have claimed the need for future studies to confirm their results in other fields. With regards to the working context, only a study by Elvén et al. (2019) has defined those variables as able to effectively influence clinical reasoning. Nevertheless, their sample study has referred only to the physical therapist students and not to physicians; thus, also this aspect would deserve to be further investigated.

Accordingly, this article would like to contribute to filling the two above-mentioned gaps arisen from the literature, with a specific reference to the decision-making process in the surgical field. To achieve this goal, the inquiry intends to analyse both features of decisions in the orthopaedic context and physicians' personal variables which would trigger cognitive biases and, in turn, mistakes in clinical choices.

Starting from this precondition, this study wants to understand which kind of errors are made by orthopaedic surgeons during their clinical decision process related to the follow-up of hip and knee arthroplasty. As a secondary endpoint, consequent to the main one, this study intends to verify the effective contribution of cognitive tools in recognising biases in the orthopaedic field, whose investigation would improve the quality of clinical decision-making path.

For the sake of clarity, the orthopaedic surgical field is chosen due to its standardised process and its considerable impact on healthcare systems' expenses. Mainly, the choice of the hip and knee arthroplasty (the most common joint reconstructions) is exactly due to the high frequency and demand that characterise the two surgery procedures (Ministero della Salute 2016). In fact, as reported by Bcc Research (2020) estimates, the world market relating to joint reconstructions should reach a value of 26.81 billion dollars by 2025, with a number of interventions equal to 5198.38 million. These two procedures, for example, represent the largest expense of implant costs in the USA. (Robinson et al. 2012).

Actually, the goal of a healthcare institution is creating higher value for patients at lower costs (Porter 2009); thus, the availability of information about the effectiveness and efficiency of the treatments at every stage of the patient value-chain (from hospital admission to follow-up) becomes fundamental. In order to address this challenge, managers of healthcare organisations need solutions that would allow them to improve decision-making and business processes together with communication among doctors, patients, and administration, as well as effective access to different data (Olszak and Batko 2012).

For this study aim, however, it is fundamental to specify the concept of follow-up to which we refer: "a check on someone who has been examined before in order to assess the process of a disease or the results of treatment" as defined by Dictionary of medical terms (Collin 2009). The moment of the follow-up decision was choosing to analyse a different aspect of clinical decision-making. Most studies tended to focus on clinical decision making within the hospital and in an emergency situation (Flynn et al. 2012; Lo and Katz 2005; Hess et al. 2015); on the contrary, we want to analyse the process related to the long term management of the patients and clinical decision-making process that condition the continuum of care (Jette et al. 2003) in hip and knee arthroplasty.

To sum up, the aim of the study, in relation to the decision-making process of orthopaedic surgeons about the follow-up of hip and knee arthroplasty, is twofold:

- To analyse possible decisional biases by the use of a cognitive tool;
- To understand if some decision-maker features influence cognitive biases.

To achieve these goals, the work follows three main stages. First of all, an analysis of the theoretical background on decision-making and its criticalities and connections with the healthcare and surgical fields was carried out. Second, it was run an interview-based qualitative case study on the field of orthopaedic surgery; the interviewees are well-informed physicians representing a good cross-section of the Italian orthopaedic landscape.

Lastly, besides verifying those consolidated biases in healthcare decision-making, the analysis of qualitative findings demonstrates a connection between some specific biases and two features of decision-makers: working experience and working context. This last issue, particularly, represents an aspect of healthcare decision-making still understudied; this would pose the study as a novelty in the field.

The paper proceeds with the following outline: after this introduction, the second section focuses on the main theoretical background. The third section reports the methodology of the study, while the fourth one presents the research findings. Section five discusses the results obtained and provides some considerations about the endpoints of this study. The last section includes the final remarks.

2. Theoretical Background

The clinical decision process is a complex dynamic and under pressure process including a choice between options as categories and diagnosis (Hausmann et al. 2016; Higgs et al. 2019); its complexity is due to the involvement of more people and the gap between information availability and those necessary. Hence, clinicians, often have to face uncertainty and make decisions without definitive information, taking into account the so-called "imperfect information" (Higgs et al. 2019, p. 504) that is available at the early stage of the clinical encounter (Cooper and Frain 2016). At this stage of the decision process, physicians can be satisfied only in deciding what kind of information has to be collected and which aspects of the situation have to be pointed out (Higgs et al. 2019). Thus, they are able to provide only a potential diagnosis.

In this context, the use of big data surely improves clinical output (Atoum and Al-Jarallah 2019); in particular, data availability (Sun and Scanlon 2019) would represent an information source which is able to sustain the decision-making process, by making it more aware (and bias-free) as based on concrete findings drawn from similar clinical situations (Yan et al. 2017).

Within the clinical reasoning sphere, however, it is crucial to refer to a personal understanding of the patient's condition by the physician and to his/her ability to make a decision. Within this path, indeed, the physician has to evaluate several elements concerning the patient history (e.g., findings from clinical examination, test results) and, above all, they have to make a decision under time pressure that can considerably condition the whole process (Cooper and Frain 2016; Goldsby et al. 2020). According to Del Mar et al. (2006) "*doctors have to be good at interpreting, at prioritising, at making compromises, at seeing what matters*" (p. vi), with the aim to managing complications and health crisis in a timely way; in a complex environment, in fact, it could often happen that "*what seems right in theory would be damaging*

in the flesh" Del Mar et al. (2006, p. vi). In particular, from Zavala et al. (2018) we learned that clinical decision-making can be influenced by factors which increase complexity and uncertainty depending on the specific case; thus, factors which complicate the healthcare context can be summarised as the following: unpredictable workflows, non-replicable conditions, pressures, organisational systems, workload, teamwork, human interactions, and patient complexity.

Moreover, it should also be noted that within the clinical decision process the state and the action spaces of physician (decision-maker) are strictly influenced by the patient. There is a sort of interdependence between the two actors that can lead the entire process and its results (Lippa et al. 2017). In particular, more is the clinician's self-efficacy in her/his patient management abilities more is the patient reliance on that clinician's approach (Sizer et al. 2016).

In addition, the clinical decision process could be influenced by several factors like external context (Robinson et al. 2020), environment, the complexity of the task (Higgs et al. 2019) and by the capabilities, confidence, and emotions of the practitioner (Smith et al. 2007). Actually, it is impossible to analyse the clinical decision process without considering the context or situation in which it occurs, as reported by several authors (Cooper and Frain 2016; McBee et al. 2015; Fargen and Friedman 2014) context characteristics or interactions between physician, patient, and environment are fundamental to understanding the whole process of clinical reasoning and can modify it in several ways, sometimes bringing errors.

Hughes and Nimmo (Cooper and Frain 2016) in particular have identified five types of errors that can occur in the diagnostic process and are related to:

1. Missing information
2. Lack of supervision
3. Physicians' knowledge
4. Misunderstanding of a diagnostic test
5. Cognitive errors

According to Simon, there are several restrictions on human cognition related to the social environment in which decisions occur; in the author's opinion, an individual has a "bounded rationality" and thus people make "satisficing rather than optimal decisions" (Cristofaro 2017b, p. 172).

Moreover, according to Kahneman (2011), there are two modes or systems of thinking:

- System one, or the intuitive system, is characterised by quick thinking, unawareness, and little effort;
- as a contrast, system two, or reflective system is characterised by slow thinking, awareness, deductive reasoning, and more concentration.

By using system one, people incur cognitive shortcuts that can affect the decision-making process (Cristofaro 2017a). Biases are very common in every human situation, so in clinical practice too; knowledge and experience cannot avoid the possibility to make these errors: they are "subconscious deviations in judgement leading to perceptual distortion, inaccurate judgement and illogical interpretation", in Cooper's opinion (Cooper and Frain 2016, p. 26); these errors can be related to both systems of thinking.

To help decision-makers to avoid these biases and improve the decision-making process, Kahneman et al. (2011) identified the checklist: a tool to improve the quality of decisions finding defects in the process. This tool provides a set of 12 questions aimed at identifying errors in thinking (biases). To use this tool, a third person is required, independent from the analysed group; indeed, people cannot recognise their own errors as a third person (Kahneman et al. 2011).

Specifically, in the healthcare field, (Antonacci et al. 2020) identifies a twofold direction between (i) biases in emergency care; (ii) biases in clinical and therapy medicine.

Emergency physicians are required to make decisions under an extremely high level of uncertainty, and they have to consider plenty of factors (Croskerry 2003). Indeed, during their decision-making process in an emergency room or similar situation, physicians have to consider not only the physical

patient condition (choosing which treatment to exclude, which one has to be initiated and when) but also patients' preferences, resources availability, cost and time (in particular time and resources are limited in this context) (Hausmann et al. 2016). Another aspect that is important to underline is that in the emergency decision-making process, clinicians have to choose how to allocate their time and effort and which patient to prioritise. This factor along with limited knowledge of the patient's personal history by the physician makes the emergency room a "natural laboratory of error" (Croskerry 2003; Antonacci et al. 2020; Hausmann et al. 2016). According to Croskerry (2003, p. 776), moreover, "nowhere in medicine is rationality more bounded by relatively poor access to information and with limited time to process it". Accordingly, emergency medicine is an area full of heuristics (Abatecola 2014): a method of solving problems by finding practical ways of dealing with them, learning from past experience (Oxford Dictionary 2012).

Regarding the clinical decision process related to therapy and clinical medicine, there are several studies that can explain which kind of factors may lead this process in different fields; listed below there are some sample factors that can modify the decision-making process in some medicine fields:

- In internal medicine, there are contextual factors, interactions, and how information is collected and acquired (McBee et al. 2015).
- In physical therapy: situational circumstances, the perspective of the client, reasoning strategies, knowledge, and experience (Elvén et al. 2019; Wainwright et al. 2011).
- In dentistry: age of physician, number of dependents, perception of practice loans, and place of initial training. (Ghoneim et al. 2020).

Furthermore, medicine literature has identified and described more than one hundred cognitive biases (Cohen and Burgin 2016), listed below there are some of the major biases of other medicine fields:

- Anaesthesiology: Anchoring, Availability bias, Premature closure, Feedback bias, Confirmation bias, Framing effect, Commission bias, Overconfidence bias, Omission bias, Sunk costs, Visceral bias, Zebra retreat, Unpacking principle, Psych-out error (Stiegler et al. 2012).
- Neurology: Framing Effects, Anchoring, Availability, Representativeness, Blind Obedience (Vickrey et al. 2010).
- Medical imaging: Availability Bias, Alliterative Bias, Anchoring Bias, Framing Bias, Attribution Bias, Blind Spot Bias, Regret Bias, Satisfaction of Search, Scout Neglect Bias, Hindsight Bias (Itri and Patel 2018).
- Dermatology: Anchoring, Availability bias, Representativeness restraint (Dunbar et al. 2013).
- General surgery: Anchoring, Availability Bias, Commission Bias, Overconfidence Bias, Omission Bias, and Sunk Costs (Vogel and Vogel 2019).

Moreover, some scholars recognised the ownership of a Hospital Institution as able to directly/indirectly influence the clinical decision process in surgery. The main difference between public and private hospitals in the surgical field regards the type of healthcare intervention provided to users/patients; public-access hospitals carry out more traumatic and emergency interventions on acute patients; private hospitals, instead, tend to provide mostly elective and planned surgery (Ierano et al. 2019).

As a consequence, another significant difference between public and private hospitals is about physician autonomy in decision-making. Accordingly, Ierano et al. (2019) stated that "autonomy was perceived to be greater in the private hospital setting than in the public hospital setting". In their study, the interviewed nursing staff noted that private surgeons had the capability to "dictate their own practice" irrespective of the guidelines or the hospital policy, as the private physicians were "doing their own thing and renting the space".

Concerning the field of this study, orthopaedic surgery, it is important to underline that it focuses on both the emergency and clinical/therapy medicine fields; therefore, the orthopaedic surgery field can be led both by "emergency bias" (mostly heuristics) and by the "clinical biases", depending on

which kind of healthcare services we focus on. Particularly, Sizer et al. (2016) proposed a model to drive the clinical decision process in the orthopaedic field: the "evidence-supported practice wheel" that poses the clinician's expertise and the patient at the centre of the problem, it makes the physician more flexible to adapt to the patient's needs and context, still relying on scientific literature. According to the author, some technical factors influence decision-making in orthopaedic surgery; Sizer defines the biomedical information on the patient that has to be taken by the physician in order to provide an aware decision-making process.

In addition, as stated by Grove et al. (2015), orthopaedic surgery is characterised by high professionalisation based on long-training and proven practical experience. In this field, according to the author, an elite group of surgeons (usually grouped per different countries and regions on the base of specialist surgery) is recognised as the reference key-opinion leaders able to influence (ordinary) surgeons in decision-makings through their researches and case study reports developed in their working experience. In our opinion, these circumstances could affect the orthopaedist's decision-making with cognitive biases (as identified by Kahneman), which might display the guidelines from the key-opinion leaders as always valid, without any further in-depth consideration of the patient case.

Moreover, some scholars belonging to the industrial field state that the working context and job experience are also able to influence the decision-making sphere (Hendrick 1999; Kobus et al. 2001). Accordingly, the expectation of this manuscript, for the healthcare field, is to understand how patient information together with physicians' variables would impact personal thinking as a base of the decision-making process.

3. Materials and Methods

Qualitative research (Patton 2002) was a better fit for the types of study that we conduct and for the state of prior research and theory we refer to (Edmondson and Mcmanus 2007). Accordingly, qualitative descriptions allow the researchers to stand by the data and provide factual summaries of participants' experiences and perceptions (Neergaard et al. 2009). Given the above, to analyse different scenarios of the orthopaedic surgery world, three semi-structured "face to face" (El Said 2017) interviews with three different orthopaedic surgeons from different working contexts in Italy were conducted. In particular:

- the head of a public "trauma-centre" hospital and university professor/director of a "Postgraduate School in Orthopaedics", with more than 20 years of experience; (SD)
- the head of several orthopaedic surgery teams, working in private hospitals, with more than 15 years of experience (SP);
- the Coordinator of the orthopaedic emergency team in a public "trauma-centre" hospital, with less than five years of experience (SH).

The respondents work in Italy, in different regions.

Even if only three, in the authors' opinion, these interviewees represent a quite good depiction of the orthopaedic landscape in Italy (Torre et al. 2017); the Italian healthcare, according to Spano and Aroni (2018) is based on public-access hospitals/health authorities (which mostly provide free of charge services as responses to emergencies and scheduled surgeries) and private organisations (which exclusively sell scheduled services).

Accordingly, considering respondents belonging to different ownerships (public and private) of healthcare organisations with different roles and experience means estimating the main variables concerning the physician job: working experience and working context. Particularly, the respondents' sample (even if small) considers:

- a high-experienced physician, working in a public context (SD);
- a high-experienced physician, working in a private context (SP);
- a law-experienced physician, working in a public context (SH).

Please, note that all the three interviewees have the responsibility of their working team, and they are the main coordinators of the decision-making during their specific work-shifts and surgical activities. Accordingly, they could be considered as key-expert-informants (Yin 2004, 2017) for the aim of this study, given also its explorative-goal (Scapens 1990) based on critical case study sampling (Patton 2002) design. This explains why it would not make sense to interview a law-experienced physician, working in a private context, whose contribution to the decision-making process would be surely considered as secondary.

Hence, in order to contextualise and define the topic, a definition of follow-up was required by all respondents. Thus, to achieve this study goal, Kahneman's checklist (as the quality control tool aimed at monitoring causes and effects of cognitive distortions) was submitted to the three respondents; on the basis of their expertise, interviewees were asked to highlight and explain those biases recognised on their current decision-making, with specific reference on hospital discharges (Jette et al. 2003).

Kahneman's checklist aims, in fact, to find those biases related to the possibility that decisions can be distorted by cognitive mistakes/biases.

Thus, according to Cristofaro (2017a), the checklist was adjusted to make it suitable for the healthcare context and in particular it was focused on the intellectual process regarding the decision-making about patient's follow-up (Jette et al. 2003) after knee or hip arthroplasty.

Table 1 reports the adjusted checklist submitted to interviewees, modified to be suitable for this study's aims. The last column of Table 1 contains the link between each checklist question and the related control question(s), separately listed at the end of the table.

Table 1. Adjusted checklist and biases which it refers to.

Factors That Can Lead to Distortion	Bias/Code	Adjusted Checklist Questions	C.Q. *
Own interest of decision-maker	Self-interest	*1. In your choice of the patient's follow-up path, do you think there is any reason to think that the personal motivations of the clinical operator (orthopaedic doctor) influenced the prescription (number and frequency of checks)?*	*A* *F*
Preference of decision-maker about one alternative	Affect heuristic	*2. Is it possible that the choice of a specific follow-up path has been made on the basis of consolidated practice, rather than on the specific analysis from the context in reference to the specific contingencies of the patient?*	*A*
Team communication or absence of communication among team members	Groupthink	*3. Are decisions regarding follow-up made at the operating team/ward level or at the individual doctor's (orthopaedic patient's) level?* *3a. If conflicting opinions emerge, are they sufficiently examined? How are any "conflicts" resolved?*	*A* *C* *D*
Past success	Saliency	*4. In your opinion, how much is the choice of a specific follow-up path influenced by the experience of the clinical operator regarding similar past situations?*	*A*
No full evaluation of other alternatives	Confirmation	*5. When choosing a follow-up path, are different credible and reliable alternatives considered?*	*A*
Information availability	Availability	*6. What clinical information is used to make decisions about the patient follow-up process? If you could have other information (non-clinical) which would you need?*	*A* *B*
Information base	Anchoring	*7. Which source provides you with the data referred to in the previous question?*	*A*
Connection between alternatives or situation and decision-maker	Halo effect	*8. When choosing a follow-up path, is it possible that the decision was made (or influenced) on the basis of similar decisions made by other departments or other clinical contexts?*	*A*
History or past events	Sunk-cost fallacy	*9. When choosing a follow-up path, how does the patient's medical history influence your decision?*	*A*

Table 1. *Cont.*

Factors That Can Lead to Distortion	Bias/Code	Adjusted Checklist Questions	C.Q. *
Excessively optimistic	Overconfidence optimistic	10. When choosing a follow-up path, do you usually consider extremely positive implication scenarios regarding the patient's specific contingencies?	A E
Excessively pessimistic	Disaster neglect	11. When choosing a follow-up path, do you always consider a realistic scenario regarding the patient's specific contingencies?	A E
Excessively conservative	Loss aversion	12. When choosing a follow-up path, do you usually consider extremely negative implication scenarios regarding the patient's specific contingencies?	A E
n		*** Control questions (C.Q.)**	
A		*What do you mean by the follow-up process?*	
B		*What else?*	
C		*What does it happen if something happened during the surgery and a doctor thinks he wants to see that patient again? Is this kind of decision made by the group?*	
D		*Do you decide only on your own, without discussing with your team?*	
E		*What do you mean by a positive or negative scenario?*	
F		*What other kinds of interest can bring you to define different timespans for follow-ups?*	

Source: Authors' elaboration inspired by Kahneman et al. (2011), Cristofaro (2017a), Stylianou (2008). The * it is referred to the text in the twelfth line. For this reason, the text in that line begins with *.

As stated by Stylianou (2008), a control question is defined as a probe question "that controls an independent variable in the participant's thinking for verification and exploration purposes" (p. 242). Particularly, control questions should be used in situations in which "the substantive theme contains multidimensional concepts or complex causal structures" (Stylianou 2008, p. 242) that need to be disentangled.

As in our case study, control questions allow the interviewer to monitor that the questions protocols were respected and that all the inquiry issues have been understood by interviewees in coherence with the study goals.

Thus, as included in the previous Table 1, the control questions were provided for the following reasons, concerning the understandability of the qualitative results detected:

a. C.Q. **A** was to verify if the interviewees agree on the concept of follow-up.
b. C.Q. **B** was to understand which "non-clinical" information is considered as "necessary" in decision-making development.
c. C.Q. **C** was to examine in depth how decisions are undertaken within a group of orthopaedists and if the group tends to review some decisions taken by a member.
d. C.Q. **D** was to understand what it would mean for an orthopaedic surgeon to always take decisions without any discussions/debates with the team.
e. C.Q. **E** was to analyse what would be considered a positive or a negative scenario in the orthopaedic context for the follow-up choices.
f. C.Q. **F** was to understand which kind of self-interests should be involved in decision-making about orthopaedic patient follow-up

Precisely, orthopaedics participated in video-conference semi-structured interviews conducted by the principal investigator between April and June 2020. Each interview lasted between 60 and 80 min and was digitally recorded. The analytic process was guided by the principles of conventional content analysis (Hsieh and Shannon 2005), the interviews after the recording were transcribed verbatim, identifying information was removed, and data were stored in a password-protected computer. Verbatim transcription was investigated through the thematic analysis approach (Braun and Clarke 2006), following the methodological fit drawn from (Edmondson and

Mcmanus 2007). The results of the ongoing analysis were reviewed by the authors together with interviewees directly during the regular meetings; disagreements were resolved by discussion and consensus.

Proceeding further, Figure 1 shows the phases carried out in the methodology. Specifically, it includes the chronological order of all steps followed and the inclusion/exclusion criteria considered for interviewees choice.
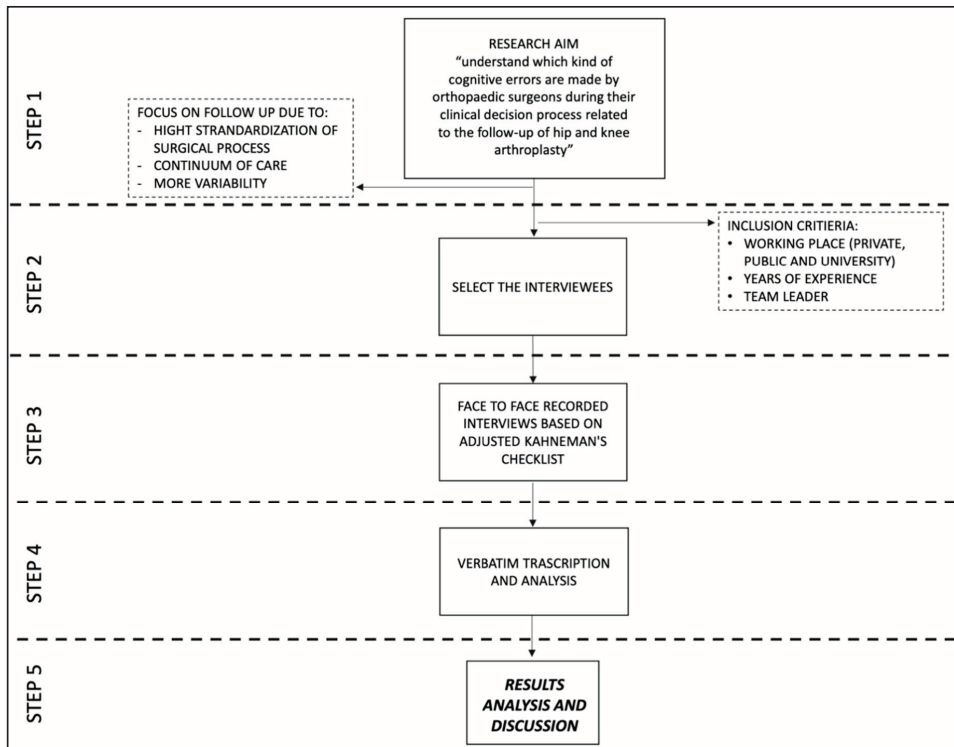
Figure 1. Step of analysis. Source: Author's elaboration.

4. Results

This section reports the findings obtained from the use of the checklist (Kahneman et al. 2011), already mentioned in the method section.

Looking at the biases, no evidence was found about the possibility that self-interest, sunk cost, disaster neglect, and loss aversion can lead the decision-making process of orthopaedics regarding patient follow-up. All three interviewees attested the presence of four biases in the decision-making process: Affect Heuristic (i.e., SH: "we do what literature tell us, avoiding customised follow-up"); Saliency, (i.e., SP: "a similar success in the past influences decisions above all"), Anchoring and Halo Effect (i.e., SD: "we make decisions based on the score that we apply; for sure decisions are influenced by decisions made by other departments or other clinical contexts").

Regarding the other biases analysed, their presence or absence depends on the interviewee characteristics. Groupthink and Availability came out from the SH and SD interviews but not from the one of SP. On the contrary, the Overconfidence affects the decision process of SP and SD but not the one of SH. Moreover, Confirmation bias emerged only from SH.

The results are summarised in the following table (Table 2).

Table 2. Results derived from the application of Kahnemen's checklist.

Questions	Bias/Code	Content Example	Respondent(s)	Bias Presence
In your choice of the patient's follow-up path, do you think there is any reason to think that the personal motivations of the clinical operator (orthopaedic doctor) influenced the prescription (number and frequency of checks)?	Self-interest	*"Most likely yes"*	SD	**NO**
		"Systematically not, however, there is a percentage of variability linked to the patient"	SP	**NO**
		"No, because the prosthetic follow-up is completely standardised"	SH	**NO**
Is it possible that the choice of a specific follow-up path has been made on the basis of consolidated practice, rather than on the specific analysis from the context in reference to the specific contingencies of the patient?	Affect heuristic	*"Probably yes"*	SD	**YES**
		"Yes, it is possible"	SP	**YES**
		"Customisable follow-ups are rare. We do what the scientific literature reported"	SH	**YES**
Are decisions regarding follow-up made at the operating team/ward level or at the individual doctor's (orthopaedic patient's) level?	Groupthink	*"Decisions are made by the operating team"*	SD	**YES**
		"In my working reality, the individual doctor decides because often the surgeons make follow-up in their private clinics"	SP	**NO**
		"Decisions are made due to standardisation of wards"	SH	**YES**
a. If conflicting opinions emerge, are they sufficiently examined? How are any "conflicts" resolved?		*"Conflicts are resolved by the team leader and/or the oldest one"*	SD	/
		Not available	SP	/
		"Yes. Conflicts are resolved by ward director"	SH	/
In your opinion, how much the choice of a specific follow-up path is influenced by the experience of the clinical operator regarding similar past situations?	Saliency	*"A little, because it is probably connected also with what you want to evaluate and with what literature reported"*	SD	**YES**
		"Above all. The choice is influenced almost exclusively by similar past situations"	SP	**YES**
		"It influences because, in addition to scientific bases, orthopaedic surgery also relies heavily on personal experience"	SH	**YES**
When choosing a follow-up path, are different credible and reliable alternatives considered?	Confirmation	*"Yes, they are"*	SD	**NO**
		"Not much. Alternatives exist but we don't consider them enough"	SP	**NO**
		"There are not many alternatives to standard follow-up"	SH	**YES**
What clinical information is used to make decisions about the patient follow-up process? If you could have other information (non-clinical) which would you need?	Availability	*"The ones reported by the literature"*	SD	**YES**
		"Patient's pain, functional skills, lifestyle habits, and job"	SP	**NO**
		"Mainly comorbidities and type of surgery are used to make a decision about follow-up. If I could have other information, I would like to know the patient's lifestyle habits and where he/she lives"	SH	**YES**
Which source provides you with the data referred to in the previous question?	Anchoring	*"Yes. Scientific literature gives us many things"*	SH	**YES**
		"The several international scores that you want to apply"	SD	**YES**
		"Medical examination and patient itself"	SP	**YES**

Table 2. *Cont.*

Questions	Bias/Code	Content Example	Respondent(s)	Bias Presence
When choosing a follow-up path, is it possible that the decision was made (or influenced) on the basis of similar decisions made by other departments or other clinical contexts?	**Halo effect**	*"Certainly yes"*	SD	**YES**
		"Yes. Opinion leaders and their modus operandi matter a lot"	SP	**YES**
		"A deeply patient's anamnesis"	SH	**YES**
When choosing a follow-up path, how does the patient's medical history influence your decision?	**Sunk-cost fallacy**	*"As far as the case of the clinical sphere is concerned, probably the embedding parameters make the difference"*	SD	**NO**
		"It could make follow-up more frequent"	SP	**NO**
		"It conditions a lot, for example in an epileptic or Parkinsonian patient it is known that a more frequent follow-up is necessary"	SH	**NO**
When choosing a follow-up path, do you usually consider extremely positive implication scenarios regarding the patient's specific contingencies?	**Overconfidence optimistic**	*"I determine the extent of the follow-up both for what I have read in literature and because I think that is the right period to detect the progress of that situation"*	SD	**YES**
		"I define the period according to the time for a patient to slowly start to have a normal life, without aids, without particular foreclosures"	SP	**YES**
		"When choosing a follow-up path, I usually consider always positive scenarios"	SH	**NO**
When choosing a follow-up path, always consider a realistic scenario regarding the patient's specific contingencies?	**Disaster neglect**	*"Actually, the period is defined because at that point I should have data that tells me if that path is a positive or negative path."*	SD	**NO**
		"That period has logic behind it. It is the healing time of the tissues from the intervention. I can imagine them repaired in a month and for this, I set that date for the medical examination"	SP	**NO**
		"The choice is always ideal as it should be"	SH	**NO**
When choosing a follow-up path, do you usually consider extremely negative implication scenarios regarding the patient's specific contingencies?	**Loss aversion**	*"Actually, the period is defined because at that point I should have data that tells me if that path is a positive or negative path."*	SD	**NO**
		"The guideline is the same logic that I said before"	SP	**NO**
		"When choosing a follow-up path, I usually consider always positive scenarios because complications are infrequent in this kind of surgery"	SH	**NO**

Source: Authors' elaboration inspired by Cristofaro (2017a).

5. Discussion

Thanks to face-to-face interviews, based on the Kahneman et al. (2011) checklist adjusted for orthopaedics, we derived some qualitative issues highlighting potential weaknesses of the cognitive path which steers orthopaedists in decisions. In particular, we preliminary understood that the follow-up choice (C.Q. **A**) can be considered as the only stage of the orthopaedic surgical process where physicians could potentially take decisions depending solely on the patient's real needs and conditions, without interferences from guidelines.

Nevertheless, the analysis of all the interviews discloses a high impact of consolidated practice also on clinical decision-making about follow-up. This might be due to two reasons: firstly, orthopaedics is a traditional specialisation, based on "standardisation of process" for this kind of healthcare pathway (Healy et al. 1998; Scranton 1999). The other reason is due to a "cultural issue" related to the physician's training, which makes practitioners feel more confident in doing what they have always done (as reported by SP during his interview); such behaviour can bring decision-makers to minimise risks of their practice and exacerbate its benefits (Kahneman et al. 2011) conducting to the **Affect Heuristic**.

Moreover, all respondents agree that a variable that certainly influences the decision-making is the coherence with decisions undertaken by other similar departments. According to Grove et al. (2015), orthopaedic surgeon decision-making is strongly influenced by the key-opinion leaders' guidelines and suggestions. This often brings the surgeon to take a decision in his/her operating context as an emulation of someone else's choice or endpoints; this kind of bias, however, could jeopardise the correct clinical decision.

This result is related to the scientific nature of medical science (which is based on scientific literature) as emerging:

- from the evidence-based medicine (based on best practice) (Timmermans and Angell 2001),
- from the impact of an "opinion leader" in healthcare disciplines (Locock et al. 2001).

In particular, evidence-based medicine (EBM) involves the use of the current best practices to make decisions regarding the patient's care (Sackett et al. 1996); in this way, decisions are steered together with the kind of data that a physician collects (Twells 2015). This approach, strongly related to the **Anchoring** bias, might speed up the doctors' decision-making with certain data and information (based on scholars' endpoints) without looking for (potentially useful) others.

Otherwise, the impact of other departments' evidence or key-opinion leader insights is a very meaningful aspect of understanding the decision process of surgeons; this concerns the **Halo Effect**. Accordingly, as reported by Cook et al. (2009), discussion with colleagues is more influential in clinical practice than empirical support; in this regard, SD is convinced that decisions are surely influenced also by the other departments' experience; and, as reported by SP, "for me, it is easier changing the surgical practice, if an opinion leader in the sector suggests me to change it". Moreover, according to all respondents' opinions, surgeons are more willing to change their practice on the basis of the experience of practitioners deemed most competent in the field.

Regarding the influence of past results (**Saliency**), according to Stewart and Stewart and Chambless (2007), all interviewed clinicians recognise that the past experience is more important in clinical treatment decisions than empirical research knowledge.

Nonetheless, there are some biases that are absent for some interviewees' opinions; to analyse more in detail these errors, it is important to notice that the respondents have some characteristics in common. In particular:

- SD and SP are more expert surgeons, they have more than fifteen years of experience, while SH has less than five years of experience;
- SD and SP are both directors of their department/surgery team;
- SD and SH share the same status of public employees, they both work in a public hospital;
- SP works in a private organisation, where he supervises only the operating theatre teams (whose he is the head) for elective surgeries.

Therefore, the errors of **Groupthink** and **Availability** (recognised by SD and SH) are probably most concerning to the context of the public ownership of the hospital. Indeed, as reported by SP, the simultaneous absence of Groupthink and Availability in his practice "is related to the characteristic of my working place: I have my private patients whose information is owned mostly by me. In the private hospital, we are several physicians with our own patients; I just made decisions for mine".

This result is in line with Smith et al. (2007) and Eisenberg (1979) that the identified external factors, features of clinicians, clinician's interaction (Robinson et al. 2017) with his/her profession, and the health care system as the factors that can modify the decision process. The context in which decisions are made can be very significant, but it has not been rigorously explored in prior studies (Durning et al. 2011).

Concerning the **Overconfidence** (the errors that SD and SP have in common), it may be caused by the lengthy experience of the surgeon. On the contrary, the lack of experience can be the explanation for the **Confirmation** bias as an error came out only from SH's interview. He is, indeed, the one with less than five years of experience.

Summarising, according to Kahneman's checklist, the analysis of the interviews showed the possibility that 8 biases out of 12 affect the decision-making process of the orthopaedic surgeons regarding the follow-up of patients undergoing hip and knee arthroplasty. Below, Table 3 reports the errors that emerged, their explanation, and medical scientific literature regarding them. The last column of Table 3 also reports which of the interviewees recognised the specific errors.

Table 3. literature on medical field our study's finding confirmed by literature.

Biases	Description *	Medical Literature	Errors Recognized By
Affect heuristic	The decision-maker tends to minimise the risks and costs and/or exaggerate the benefits of something he/she likes	(Makhinson 2012)	*SD, SP, SH*
Anchoring	The decision-maker makes the decision taking into consideration some initial reference data without adjusting its estimates according to the new information gained	(Nagaraj et al. 2018; Augestad et al. 2016)	*SD, SP, SH*
Halo effect	The decision-maker sees a story as more emotionally consistent than it really is	(Austin and Halvorson 2019; Vuong et al. 2017; Utter et al. 2006)	*SD, SP, SH*
Saliency	The decision-maker tends to approve a proposal that is similar to a successful one in the past	(Makhinson 2012; Vickrey et al. 2010) **	*SD, SP, SH*
Groupthink	The inclination of groups to converge on a decision because it reduces the conflict and can gain large support	(Kaba et al. 2016; Mailoo 2015)	*SD, SH*
Availability	The decision-maker makes the decision with the available data without making an effort to find other useful information that is uncovered	(Mamede et al. 2020; Waddington and Morley 2000)	*SD, SH*
Overconfidence	The decision-maker with positive track records is prone to excessive optimism in forecasts	(Cohen and Burgin 2016; Vickrey et al. 2010)	*SD, SP*
Confirmation	The decision-maker tends to elaborate only one alternative for which he/she tries to find confirming data	(Balsamo et al. 2018; Elston 2020)	*SH*

Source: Authors' elaboration inspired by Cristofaro (2017a); * All descriptions are taken from Cristofaro (2017a); ** Authors refer to Saliency as "Representativeness".

6. Conclusions and Implications

This paper addresses the theme of the clinical reasoning process in healthcare. Precisely, the work aims at understanding if and how the decision-making process of orthopaedic surgeons can be affected by cognitive biases. Particularly, within the decision process sphere, the choice regarding the patient's follow-up after knee and hip arthroplasty has been analysed. To achieve the goal of this study, Kahneman's checklist was employed in order to recognise which kind of errors can mostly lead surgeons' decision-making process; accordingly, we conducted three semi-structured interviews with key-decisional orthopaedic surgeons working in different organisations. The results show several biases that can affect the clinical decision process regarding follow-up after knee and hip arthroplasty.

In particular, some are in common for all the interviews (Affect heuristic, Anchoring, Halo effect, Saliency); the others (Groupthink, Availability, Overconfidence, Confirmation) are related to the following two personal variables of surgeon: (i) working experience; (ii) working context.

Concerning the biases which differ among interviewees, the following Figure 2 summarises the main contribution of the work.
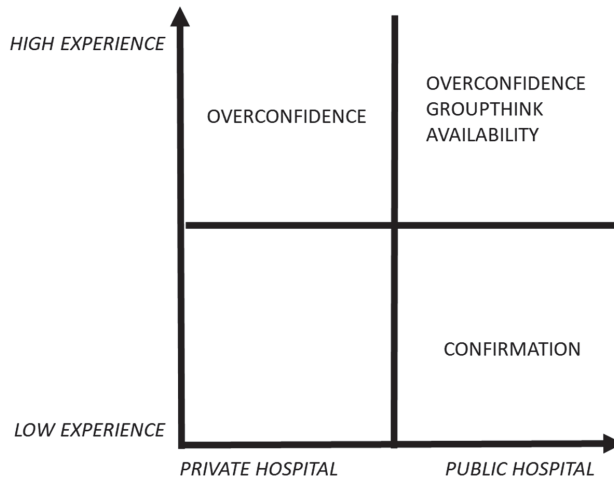

Figure 2. Matrix connection between physician's working experience and context with the cognitive biases in orthopaedics. Source: Author's elaboration.

Reading the figure as a matrix, it highlights the connection between working experience and working context with specific biases of the decision-making process in the orthopaedic field, in coherence with the main literature listed in Table 3.

Figure 2 shows that the less experienced a surgeon is, the more likely is he/she to look for **Confirmation** (Smith et al. 2010); this might be because he or she is very tied to theory and tends to look for what he knows. Ierano et al. (2019) confirmed that less experienced surgeons/junior health professionals always look for confirmation through guidelines. On the contrary, **Overconfidence** incurs due to high experience. Besides the working context, high experience leads the surgeons to think mostly on positive scenarios (Kahneman et al. 2011) regarding their work/task as they are more confident in their skills.

Groupthink and **Availability**, however, are both mostly related to the public context characteristics; the first one is typical of hospital ward teamwork, that is out of the SP's working sphere. The second one, instead, may be related to the data present as support to the decision-making path, whose availability (per timing, quality, and quantity) are mandatory only in public hospitals, according to public performance measurement roles (Bouckaert and Halligan 2007; Pinnarelli et al. 2015).

Hence, based on the level of experience (low/high) of surgeons and the ownership of the healthcare institution (public/private) in which they work, the matrix points out the most probable biases in the orthopaedic field according to the specific features of decision-makers. This could be very useful for the management of the healthcare institution in terms of prompt reaction to the expected cognitive errors.

Furthermore, for sure our results confirm that a qualitative cognitive tool, as the Kahneman et al. (2011) checklists, could potentially help physicians avoid these errors, but it needs to be integrated in daily practice, also as a more usable electronic version (Raymond et al. 2017; Otokiti 2019). For sure this manuscript presents some limitations; most of them are those related to the use of the qualitative method which implies the interpretive role of researchers and limited extension of data. The first limitation of this qualitative inquiry regards the lack of distinction between "heuristics" and "traps",

which both fall under the bias umbrella term. Although heuristics could generally have also a positive impact on decisions (thus, in particular circumstances, they should not be reduced), however, this is not proved in the medical field according to Ryan et al. (2018). In addition, only three physicians are interviewed. Nevertheless, as explained in the methodology section, the differences in terms of working experience and context of our interviewees would reduce such a limitation by giving a good representation of the Italian orthopaedic environment. Moreover, given that this research is moving its first steps and it is at an original level of investigation in a still understudied field, according to literature Cristofaro (2017a) and Jette et al. (2003), three interviewees can be considered enough if they represent the apical position for the decision-making context of their organisational environment. For sure to overcome these limitations, a higher number of interviews should be made in future research. Further studies could focus on theoretical exploration (e.g., systematic literature reviews, bibliometric literature reviews, etc.) of clinical decision-making in the surgical field, which would arise the difference between specialisation sub-fields. Moreover, given the fact that the magnitude of heuristic effects on complex clinical decisions is still unexplored, this specific aspect would also deserve to be investigated in future streams of research. In addition, the study leaves some areas of investigation uncovered; particularly surprising is the lack of connection with the Kahneman's bias of Self Interest. No direct evidence of this arose from the interviews; only insights regarding the decisions about the frequency of follow-ups came out. According to all respondents, the schedule of follow-up is established in line with literature, practice, and in some rare cases according to the patient's peculiarity (this would confirm all other results). Nevertheless, as highlighted by the control question E, a potential reason that could modify the follow-up frequency and schedule would be the specific interest of physicians in collecting information (both clinical and epidemiologic) according to healthcare management and scientific production based on big-data (Roski et al. 2014; Yan et al. 2017). Also, these aspects deserve to be further investigated.

In conclusion, this study has highlighted the linkage between the clinical decision-making process and management tools to improve decisions, by fostering debate in these fields. For practitioners, this study shows the experience of quality decision-making process tool (To et al. 2018) employment that brings out some cognitive shortcuts that can lead the clinical decision process. From an academic point of view, this article represents a preliminary contribution to the influence of cognitive biases in limiting the rational thinking of decision-makers in the specificity of the orthopaedic field.

With this regard, the study can surely contribute to the debate by both scholars and practitioners about the application of tools in improving the quality of the clinical decision process. According to Antonacci et al. (2020), indeed, the improvement of decision-making is one of the main leverages for enhancing better healthcare outcomes, which, in turn, can be translated into better performance (Skaržauskiene 2010; Safi and Burrell 2007; Oyewobi et al. 2016) for the healthcare organisation.

References

Abatecola, Gianpaolo. 2014. Untangling self-reinforcing processes in managerial decision making. Co-evolving heuristics? *Management Decision* 52: 934–49. [CrossRef]

Antonacci, Anthony C., Samuel P. Dechario, Caroline Antonacci, Gregg Husk, Vihas Patel, Jeffrey Nicastro, Gene Coppa, and Mark Jarrett. 2020. Cognitive Bias Impact on Management of Postoperative Complications, Medical Error, and Standard of Care. *Journal of Surgical Research* 258: 47–53. [CrossRef] [PubMed]

Ashoorion, Vahid, Mohammad Javad Liaghatdar, and Peyman Adibi. 2012. What variables can influence clinical reasoning? *Journal of Research in Medical Sciences* 17: 1170. [PubMed]

Atoum, Ibrahim A., and Nasser A. Al-Jarallah. 2019. Big data analytics for value-based care: Challenges and opportunities. *International Journal of Advanced Trends in Computer Science and Engineering* 8: 3012–16. [CrossRef]

Augestad, Liv Ariane, Knut Stavem, Ivar Sønbø Kristiansen, Carl Haakon Samuelsen, and Kim Rand-Hendriksen. 2016. Influenced from the Start: Anchoring Bias in Time Trade-off Valuations. *Quality of Life Research* 25: 2179–91. [CrossRef] [PubMed]

Austin, Jared P., and Stephanie A. C. Halvorson. 2019. Reducing the Expert Halo Effect on Pharmacy and Therapeutics Committees. *JAMA* 321: 453. [CrossRef]

Balsamo, Brittany, Mark D. Geil, Rebecca Ellis, and Jianhua Wu. 2018. Confirmation Bias Affects User Perception of Knee Braces. *Journal of Biomechanics* 75: 164–70. [CrossRef]

Baron, Robert A. 1998. Cognitive mechanisms in entrepreneurship: Why and when enterpreneurs think differently than other people. *Journal of Business Venturing* 13: 275–94. [CrossRef]

Bouckaert, Geert, and John Halligan. 2007. *Managing Performance: International Comparisons*. Abingdon: Routledge.

Braun, Virginia, and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology* 3: 77–101. [CrossRef]

Christensen, Nicole, Lisa Black, Jennifer Furze, Karen Huhn, Ann Vendrely, and Susan Wainwright. 2017. Clinical Reasoning: Survey of Teaching Methods, Integration, and Assessment in Entry-Level Physical Therapist Academic Education. *Physical Therapy* 97: 175–86. [CrossRef]

Cohen, Jeffrey M., and Susan Burgin. 2016. Cognitive biases in clinical decision making: A primer for the practicing dermatologist. *Jama Dermatology* 152: 253–54. [CrossRef] [PubMed]

Collin, Peter Hodgson. 2009. *Dictionary of Medical Terms*. London: A&C Black.

Cook, Joan M., Paula P. Schnurr, Tatyana Biyanova, and James C. Coyne. 2009. Apples don't fall far from the tree: Influences on psychotherapists' adoption and sustained use of new therapies. *Psychiatric Services* 60: 671–76. [CrossRef] [PubMed]

Cooper, Nicola, and John Frain. 2016. *ABC of Clinical Reasoning*. Hoboken: John Wiley & Sons.

Cristofaro, Matteo. 2017a. Reducing Biases of Decision-Making Processes in Complex Organizations. *Management Research Review* 40: 270–91. [CrossRef]

Cristofaro, Matteo. 2017b. Herbert Simon's Bounded Rationality: Its Historical Evolution in Management and Cross-Fertilizing Contribution. *Journal of Management History* 23: 170–90. [CrossRef]

Croskerry, Pat. 2003. The Importance of Cognitive Errors in Diagnosis and Strategies to Minimize Them. *Academic Medicine* 78: 775–80. [CrossRef]

Del Mar, C., J. Doust, and P. Glasziou. 2006. *Clinical Thinking; Evidence, Communication and Decision-Making*. Oxford: Blackwell Publishing Ltd. BMJ Books.

Dunbar, Miles, Stephen E. Helms, and Robert T. Brodell. 2013. Reducing Cognitive Errors in Dermatology: Can Anything Be Done? *Journal of the American Academy of Dermatology* 69: 810–13. [CrossRef]

Durning, Steven, Anthony R. Artino, Louis Pangaro, Cees P. M. van der Vleuten, and Lambert Schuwirth. 2011. Context and Clinical Reasoning: Understanding the Perspective of the Expert's Voice: Understanding the Perspective of the Expert's Voice. *Medical Education* 45: 927–38. [CrossRef]

Durning, Steven J., Anthony R. Artino, Lambert Schuwirth, and Cees van der Vleuten. 2013. Clarifying Assumptions to Enhance Our Understanding and Assessment of Clinical Reasoning. *Academic Medicine* 88: 442–48. [CrossRef]

Edmondson, Amy C., and Stacy E. Mcmanus. 2007. Methodological Fit in Management Field Research. *Academy of Management Review* 32: 1246–64. [CrossRef]

Eisenberg, John M. 1979. Sociologic Influences on Decision-Making by Clinicians. *Annals of Internal Medicine* 90: 957. [CrossRef]

El Said, Ghada Refaat. 2017. Understanding how learners use massive open online courses and why they drop out: Thematic analysis of an interview study in a developing country. *Journal of Educational Computing Research* 55: 724–52. [CrossRef]

Elston, Dirk M. 2020. Confirmation Bias in Medical Decision-Making. *Journal of the American Academy of Dermatology* 82: 572. [CrossRef]

Elvén, Maria, Jacek Hochwälder, Elizabeth Dean, and Anne Söderlund. 2019. Predictors of Clinical Reasoning Using the Reasoning 4 Change Instrument with Physical Therapist Students. *Physical Therapy* 99: 964–76. [CrossRef] [PubMed]

Fargen, Kyle M., and William A. Friedman. 2014. The science of medical decision making: Neurosurgery, errors, and personal cognitive strategies for improving quality of care. *World Neurosurgery* 82: e21–e29. [CrossRef] [PubMed]

Flynn, Darren, Meghan A. Knoedler, Erik P. Hess, M. Hassan Murad, Patricia J. Erwin, Victor M. Montori, and Richard G. Thomson. 2012. Engaging patients in health care decisions in the emergency department through shared decision-making: A systematic review. *Academic Emergency Medicine* 19: 959–67. [CrossRef] [PubMed]

Ghoneim, Abdulrahman, Bonnie Yu, Herenia Lawrence, Michael Glogauer, Ketan Shankardass, and Carlos Quiñonez. 2020. What Influences the Clinical Decision-Making of Dentists? A Cross-Sectional Study. A cura di Gururaj Arakeri. *PLoS ONE* 15: e0233652. [CrossRef] [PubMed]

Goldsby, Elizabeth, Michael Goldsby, Christopher B. Neck, and Christopher P. Neck. 2020. Under Pressure: Time Management, Self-Leadership, and the Nurse Manager. *Administrative Sciences* 10: 38. [CrossRef]

Grove, Amy, Aileen Clarke, and Graeme Currie. 2015. The barriers and facilitators to the implementation of clinical guidance in elective orthopaedic surgery: A qualitative study protocol. *Implementation Science* 10: 81. [CrossRef]

Haley, Usha C. V., and Stephen A. Stumpf. 1989. Cognitive Trails in Strategic Decision-Making: Linking Theories of Personalities and Cognitions. *Journal of Management Studies* 26: 477–97. [CrossRef]

Hausmann, Daniel, Cristina Zulian, Edouard Battegay, and Lukas Zimmerli. 2016. Tracing the Decision-Making Process of Physicians with a Decision Process Matrix. *BMC Medical Informatics and Decision Making* 16: 133. [CrossRef]

Healy, William L., Michael E. Ayers, Richard Iorio, Douglas A. Patch, David Appleby, and Bernard A. Pfeifer. 1998. Impact of a clinical pathway and implant standardization on total hip arthroplasty: A clinical and economic study of short-term patient outcome. *The Journal of Arthroplasty* 13: 266–76. [CrossRef]

Hendrick, Hal W. 1999. Handbook of human factors and ergonomics, edited by Gavriel Salvendy, 1997, New York: John Wiley & Sons, Inc., p. 2137, ISBN 0-471-11690-4. *Human Factors and Ergonomics in Manufacturing & Service Industries* 9: 321–22.

Hess, Erik P., Corita R. Grudzen, Richard Thomson, Ali S. Raja, and Christopher R. Carpenter. 2015. Shared decision-making in the emergency department: Respecting patient autonomy when seconds count. *Academic Emergency Medicine* 22: 856–64. [CrossRef] [PubMed]

Higgs, Joy, Gail M Jensen, Stephen Loftus, and Nicole Christensen. 2019. *Clinical Reasoning in the Health Professions*. Oxford: Elsevier Health Sciences.

Hsieh, Hsiu-Fang, and Sarah E. Shannon. 2005. Three approaches to qualitative content analysis. *Qualitative Health Research* 15: 1277–88. [CrossRef]

Ierano, Courtney, Karin Thursky, Trisha Peel, Arjun Rajkhowa, Caroline Marshall, and Darshini Ayton. 2019. Influences on surgical antimicrobial prophylaxis decision making by surgical craft groups, anaesthetists, pharmacists and nurses in public and private hospitals. *PLoS ONE* 14: e0225011. [CrossRef]

Itri, Jason N., and Sohil H. Patel. 2018. Heuristics and cognitive error in medical imaging. *American Journal of Roentgenology* 210: 1097–105. [CrossRef]

Jette, Diane U., Lisa Grover, and Carol P. Keck. 2003. A qualitative study of clinical decision making in recommending discharge placement from the acute care setting. *Physical Therapy* 83: 224–36. [CrossRef]

Kaba, Alyshah, Ian Wishart, Kristin Fraser, Sylvain Coderre, and Kevin McLaughlin. 2016. Are We at Risk of Groupthink in Our Approach to Teamwork Interventions in Health Care? *Medical Education* 50: 400–8. [CrossRef]

Kahneman, Daniel. 2011. *Thinking, Fast and Slow*. New York: Macmillan.

Kahneman, Daniel, Dan Lovallo, and Olivier Sibony. 2011. Before you make that big decision. *Harvard Business Review* 89: 50–60.

Kobus, David A., Sherry Proctor, and Steven Holste. 2001. Effects of experience and uncertainty during dynamic decision making. *International Journal of Industrial Ergonomics* 28: 275–90. [CrossRef]

Lippa, Katherine D., Markus A. Feufel, F. Eric Robinson, and Valerie L. Shalin. 2017. Navigating the Decision Space: Shared Medical Decision Making as Distributed Cognition. *Qualitative Health Research* 27: 1035–48. [CrossRef] [PubMed]

Lo, Bernard, and Mitchell H. Katz. 2005. Clinical decision making during public health emergencies: Ethical considerations. *Annals of Internal Medicine* 143: 493–98. [CrossRef] [PubMed]

Locock, Louise, Sue Dopson, David Chambers, and John Gabbay. 2001. Understanding the role of opinion leaders in improving clinical effectiveness. *Social Science & Medicine* 53: 745–57.

Mailoo, Venthan. 2015. Common Sense or Cognitive Bias and Groupthink: Does It Belong in Our Clinical Reasoning? *The British Journal of General Practice* 65: 27. [CrossRef]

Makhinson, Michael. 2012. Biases in the Evaluation of Psychiatric Clinical Evidence. *The Journal of Nervous and Mental Disease* 200: 76–82. [CrossRef]

Mamede, Sílvia, Marco Antonio de Carvalho-Filho, Rosa Malena Delbone de Faria, Daniel Franci, Maria do Patrocinio Tenorio Nunes, Ligia Maria Cayres Ribeiro, Julia Biegelmeyer, Laura Zwaan, and Henk G. Schmidt. 2020. "Immunising" Physicians against Availability Bias in Diagnostic Reasoning: A Randomised Controlled Experiment. *BMJ Quality & Safety* 29: 550–59. [CrossRef]

McBee, Elexis, Temple Ratcliffe, Katherine Picho, Anthony R. Artino, Lambert Schuwirth, William Kelly, Jennifer Masel, Cees van der Vleuten, and Steven J. Durning. 2015. Consequences of Contextual Factors on Clinical Reasoning in Resident Physicians. *Advances in Health Sciences Education* 20: 1225–36. [CrossRef]

Ministero della Salute. 2016. Tavole Rapporto SDO. Available online: http://www.salute.gov.it/portale/documentazione/p6_2_8_3_1.jsp?lingua=italiano&id=28 (accessed on 20 October 2020).

Nagaraj, Guruprasad, Carolyn Hullick, Glenn Arendts, Ellen Burkett, Keith D. Hill, and Christopher R. Carpenter. 2018. Avoiding Anchoring Bias by Moving beyond "mechanical Falls" in Geriatric Emergency Medicine. *Emergency Medicine Australasia* 30: 843–50. [CrossRef]

Neergaard, Mette Asbjoern, Frede Olesen, Rikke Sand Andersen, and Jens Sondergaard. 2009. Qualitative description–the poor cousin of health research? *BMC Medical Research Methodology* 9: 52. [CrossRef]

Norman, Geoffrey. 2005. Research in Clinical Reasoning: Past History and Current Trends. *Medical Education* 39: 418–27. [CrossRef]

Olszak, Celina M., and Kornelia Batko. 2012. Business intelligence systems. New chances and possibilities for healthcare organizations. *Informatyka Ekonomiczna* 5: 123–38.

Otokiti, Ahm. 2019. Using informatics to improve healthcare quality. *International Journal of Health Care Quality Assurance* 32: 425–430. [CrossRef] [PubMed]

Oxford Dictionary. 2012. Oxford Dictionary. Available online: https://www.oed.com/ (accessed on 20 November 2020).

Oyewobi, Luqman Oyekunle, Abimbola Windapo, and James Olabode Bamidele Rotimi. 2016. Relationship between decision-making style, competitive strategies and organisational performance among construction organisations. *Journal of Engineering, Design and Technology* 14: 713–38. [CrossRef]

Patton, Michael Quinn. 2002. Two decades of developments in qualitative inquiry: A personal, experiential perspective. *Qualitative Social Work* 1: 261–83. [CrossRef]

Pinnarelli, Luigi, Alice Basiglini, Danilo Fusco, and Marina Davoli. 2015. *Piano Nazionale Esiti.* Available online: https://www.agenas.gov.it/tassi-di-assenza-giugno-2015/monitor-n-30 (accessed on 20 October 2020).

Porter, Michael E. 2009. A Strategy for Health Care Reform—Toward a Value-Based System. *New England Journal of Medicine* 361: 109–12. [CrossRef] [PubMed]

Rashid, Ahmad, and Halim Boussabiane. 2019. Conceptualizing the influence of personality and cognitive traits on project managers' risk-taking behaviour. *International Journal of Managing Projects in Business.* [CrossRef]

Raymond, Louis, Guy Paré, and Éric Maillet. 2017. IT-based clinical knowledge management in primary health care: A conceptual framework. *Knowledge and Process Management* 24: 247–56. [CrossRef]

Robinson, James C., Alexis Pozen, Samuel Tseng, and Kevin J. Bozic. 2012. Variability in costs associated with total hip and knee replacement implants. *JBJS* 94: 1693–98. [CrossRef] [PubMed]

Robinson, Jennifer, Marta Sinclair, Jutta Tobias, and Ellen Choi. 2017. More dynamic than you think: Hidden aspects of decision-making. *Administrative Sciences* 7: 23. [CrossRef]

Robinson, Frank Eric, Markus A. Feufel, Valerie L. Shalin, Debra Steele-Johnson, and Brian Springer. 2020. Rational Adaptation: Contextual Effects in Medical Decision Making. *Journal of Cognitive Engineering and Decision Making* 14: 112–31. [CrossRef]

Roski, Joachim, George W. Bo-Linn, and Timothy A. Andrews. 2014. Creating value in health care through big data: Opportunities and policy implications. *Health Affairs* 33: 1115–22. [CrossRef]

Rubio-Navarro, Alfonso, Diego José García-Capilla, Maria José Torralba-Madrid, and Jane Rutty. 2020. Decision-Making in an Emergency Department: A Nursing Accountability Model. *Nursing Ethics* 27: 567–86. [CrossRef] [PubMed]

Ryan, Aedin, Sophie Duignan, Damien Kenny, and Colin J. McMahon. 2018. Decision making in paediatric cardiology. Are we prone to heuristics, biases and traps? *Pediatric Cardiology* 39: 160–67. [CrossRef]

Sackett, David L., William MC Rosenberg, JA Muir Gray, R. Brian Haynes, and W. Scott Richardson. 1996. Evidence Based Medicine: What It Is and What It Isn't. *BMJ* 312: 71–72. [CrossRef] [PubMed]

Safi, Asila, and Darrell Norman Burrell. 2007. Developing Advanced Decision-Making Skills in International Leaders and Managers. *Vikalpa* 32: 1–8. [CrossRef]

Scapens, Robert W. 1990. Researching Management Accounting Practice: The Role of Case Study Methods. *The British Accounting Review* 22: 259–81. [CrossRef]

Scranton, Pierce E., Jr. 1999. The cost effectiveness of streamlined care pathways and product standardization in total knee arthroplasty. *The Journal of Arthroplasty* 14: 182–86. [CrossRef]

Simon, H. 1947. *Administrative Behaviour*. New York: The Free Press.

Sizer, Phillip S., Manuel Vicente Mauri, Kenneth Learman, Clare Jones, Norman 'Skip' Gill, Chris R. Showalter, and Jean-Michel Brismée. 2016. Should Evidence or Sound Clinical Reasoning Dictate Patient Care? *Journal of Manual & Manipulative Therapy* 24: 117–19. [CrossRef]

Skaržauskiene, A. 2010. Managing complexity: Systems thinking as a catalyst of the organization performance. *Measuring Business Excellence* 14: 49–64. [CrossRef]

Smith, Megan, Joy Higgs, and Elizabeth Ellis. 2007. Physiotherapy decision making in acute cardiorespiratory care is influenced by factors related to the physiotherapist and the nature and context of the decision: A qualitative study. *Australian Journal of Physiotherapy* 53: 261–67. [CrossRef]

Smith, Megan, Higgs Joy, and Elizabeth Ellis. 2010. Effect of experience on clinical decision making by cardiorespiratory physiotherapists in acute care settings. *Physiotherapy Theory and Practice* 26: 89–99. [CrossRef]

Sousa, Maria José, António Miguel Pesqueira, Carlos Lemos, Miguel Sousa, and Álvaro Rocha. 2019. Decision-Making Based on Big Data Analytics for People Management in Healthcare Organizations. *Journal of Medical Systems* 43: 290. [CrossRef] [PubMed]

Spano, Alessandro, and Anna Aroni. 2018. Organizational Performance in the Italian Health care Sector. In *Outcome-Based Performance Management in the Public Sector*. Cham: Springer, pp. 25–43.

Stewart, Rebecca E., and Dianne L. Chambless. 2007. Does psychotherapy research inform treatment decisions in private practice? *Journal of Clinical Psychology* 63: 267–81. [CrossRef]

Stiegler, M. P., Jacques P. Neelankavil, Cecilia Canales, and A. Dhillon. 2012. Cognitive errors detected in anaesthesiology: A literature review and pilot study. *British Journal of Anaesthesia* 108: 229–35. [CrossRef] [PubMed]

Stylianou, Stelios. 2008. Interview control questions. *International Journal of Social Research Methodology* 11: 239–56. [CrossRef]

Sun, Alexander Y., and Bridget R. Scanlon. 2019. How can Big Data and machine learning benefit environment and water management: A survey of methods, applications, and future directions. *Environmental Research Letters* 14: 073001. [CrossRef]

Timmermans, Stefan, and Alison Angell. 2001. Evidence-based medicine, clinical uncertainty, and learning to doctor. *Journal of Health and Social Behavior* 42: 342–59. [CrossRef]

To, Wai Ming, Billy T. W. Yu, and Peter K. C. Lee. 2018. How quality management system components lead to improvement in service organizations: A system practitioner perspective. *Administrative Sciences* 8: 73. [CrossRef]

Torre, M., E. Carrani, and I. Luzi. 2017. *Progetto Registro Italiano Artroprotesi. Potenziare la Qualità dei dati per Migliorare la Sicurezza dei Pazienti.* Quarto Report. Rome: Il Pensiero Scientifico Editore.

Twells, Laurie K. 2015. Evidence-Based Decision-Making 1: Critical Appraisal. In *Clinical Epidemiology*. Edited by a cura di Patrick S. Parfrey and Brendan J. Barrett. New York: Springer, vol. 1281, pp. 385–96. [CrossRef]

Utter, Garth H., Ronald V. Maier, Frederick P. Rivara, and Avery B. Nathens. 2006. Outcomes after Ruptured Abdominal Aortic Aneurysms: The "Halo Effect" of Trauma Center Designation. *Journal of the American College of Surgeons* 203: 498–505. [CrossRef]

Vickrey, Barbara G., Martin A. Samuels, and Allan H. Ropper. 2010. How neurologists think: A cognitive psychology perspective on missed diagnoses. *Annals of Neurology* 67: 425–33. [CrossRef]

Vogel, P., and D. H. V. Vogel. 2019. Cognition errors in the treatment course of patients with anastomotic failure after colorectal resection. *Patient Safety in Surgery* 13: 4. [CrossRef]

Vuong, Phoenix, Jason Sample, Mary Ellen Zimmermann, and Pierre Saldinger. 2017. Trauma Team Activation: Not Just for Trauma Patients. *Journal of Emergencies, Trauma, and Shock* 10: 151–53. [CrossRef] [PubMed]

Waddington, L., and S. Morley. 2000. Availability Bias in Clinical Formulation: The First Idea That Comes to Mind. *The British Journal of Medical Psychology* 73 Pt 1: 117–27. [CrossRef] [PubMed]

Wainwright, Susan Flannery, Katherine F. Shepard, Laurinda B. Harman, and James Stephens. 2011. Factors that influence the clinical decision making of novice and experienced physical therapists. *Physical Therapy* 91: 87–101. [CrossRef] [PubMed]

Wu, Tungju, Yenchun Jim Wu, Hsientang Tsai, and Yibin Li. 2017. Top management teams' characteristics and strategic decision-making: A mediation of risk perceptions and mental models. *Sustainability* 9: 2265. [CrossRef]

Yan, X., C. Dong, and C. Yao. 2017. The evolvement of evidence-based medicine research in the big data era. *Chinese Journal of Evidence-Based Medicine* 17: 249–54. [CrossRef]

Yin, R. K. 2004. Case study methods. In *Handbook of Complementary Methods in Education Research, American Educational Research Association*. Edited by Judith. L. Green, Gregory Camilli and Patricia. B. Elmore. Washington, DC: Taylor & Francis Group, pp. 111–22.

Yin, Robert K. 2017. *Case Study Research and Applications: Design and Methods*. Thousand Oaks: Sage Publications.

Zavala, Alicia M., Gary E. Day, David Plummer, and Anita Bamford-Wade. 2018. Decision-making under pressure: Medical errors in uncertain and dynamic environments. *Australian Health Review* 42: 395–402. [CrossRef]

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Article

Under Pressure: Time Management, Self-Leadership, and the Nurse Manager

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Abstract: Decision making by nurses is complicated by the stress, chaos, and challenging demands of the work. One of the major stressors confronting nurses is perceived time pressure. Given the potential negative outcomes on nurses due to perceived time pressures, it seems logical that a nurse manager's ability to lead nurses in moderating this time pressure and in turn to make better decisions could enhance nurse well-being and performance. Paralleling research in the nursing literature suggests that, in order to improve patients' judgement of the care they received, nurse managers should embrace ways to lower nurses' perceived time pressure. In this conceptual paper, we propose a model to help mitigate time pressure on nurse managers and their frontline nurses based on the research regarding time pressure, psychosocial care, time management, and self-leadership. Three metaconjectures and suggested future studies are given for further consideration by organizational and psychological researchers.

Keywords: nurse manager; time pressure; self-leadership; stress

1. Introduction

People who agree to assume important management roles in organizations often bear many responsibilities to a varied set of stakeholders in their daily work. Given the impact managers have on their organizations, research has examined many facets of the challenging nature of this work. The better scholars can shed insight into managing and mitigating the stressors management positions hold, the better the manager will perform as both a professional and person. In turn, the better the manager performs, the better the organization will do as well (Bakker and Demerouti 2007). The job demands research tradition is one management area that holds particular significance for studying issues managers face in their daily work (Demerouti et al. 2001). Specifically, job demands have been defined as "the degree to which a given executive experiences his or her job as difficult or challenging" (Hambrick et al. 2005, p. 473). Job demands are not inherently a negative phenomenon in the workplace. If job demands are reasonably manageable, many managers may find the challenges interesting and satisfying, as the work offers them opportunity to apply and develop their expertise and experience (Gardner 1986; Garner and Cummings 1988; Janssen 2001; Scott 1996). After all, people in leadership positions usually reach their status from seeking and succeeding in situations others may avoid. However, researchers have also discovered that overly taxing job demands can entail great mental strain and stress (Karasek 1979; Van Yperen and Snijders 2000; Wall et al. 1996; Xie and Johns 1995) and incur physical health problems (Fox et al. 1993; Theorell and Karasek 1996; Warr 1990). The nature of whether a job demand is stimulating or taxing is dependent on three factors: task challenges,

performance challenges, and personal performance aspirations (Hambrick et al. 2005). The degree of stress a manager finds in addressing their tasks, organizational expectations, and personal aspirations can also impact the quality of their decision-making (Ganster 2005). Therefore, overly demanding jobs can lead to poor decisions by managers. This negative consequence is multiplied when made by leaders who supervise outcomes with great impact on their organization and/or society. Few professionals in society make more important decisions than nurse managers. They routinely are faced with "life or death" situations requiring decisions of how their frontline nurses are to proceed. Better practices for assisting nurse managers with the demands they face in their work will improve their decision making and, ultimately, will better serve their patients with quality care as well as address patient safety.

The job of the nurse is filled with much stress and chaos given the challenging demands within today's medical environment (Goldsby et al. 2020; Greggs-McQuilkin 2004). One of the major stressors confronting nurses is perceived time pressure (Teng et al. 2010). Time pressure impairs the decision making of nurses (Hahn et al. 1992), reduces their emotional well-being (Gärling et al. 2016), and leads to nurse exhaustion Gelsema et al. (2006). Furthermore, recent research in the psychological sciences suggests that increased time pressure can lead to more dishonesty (Protzko et al. 2019). Given such potential negative outcomes on nurses due to perceived time pressures, it seems logical that a nurse manager's ability to help nurses manage this time pressure and become better decision makers (that is, become better time managers) could enhance nurse well-being and performance. Research in the organizational time management literature shows a positive relationship between time management and job satisfaction, health, and performance outcomes (Claessens et al. 2007). Paralleling research in the nursing literature suggests that in order to improve the perception patients have of the quality of care they receive, nurse managers should embrace ways to lower perceived time pressure (Teng et al. 2010). However, while time pressure on nurse managers has been studied as a common problem in hospitals, a theory-based framework for better performance within those constraints has not been provided in the literature. We seek to address that literature gap by answering the following research question in the upcoming sections: How can nurse managers and nurses provide quality patient care by making better decisions under time pressure? This conceptual paper provides a step in that direction; that is, to help nurse managers reduce perceived time pressure by nurses and improve the decision making of nurse managers and nurses. In this article, we suggest how evidence-based time management practices (Garbugly 2013; Saunders 2014) and self-leadership theory (e.g., Neck et al. 2019) can help nurse managers to reduce perceived time pressure by the nurses that they manage. We capture these insights in a framework we call *The Time Pressure Mitigation Model for Nurse Managers* (see Figure 1). We propose that guidelines inherent in this model will also serve other managers who find themselves making decisions under time pressure constraints.
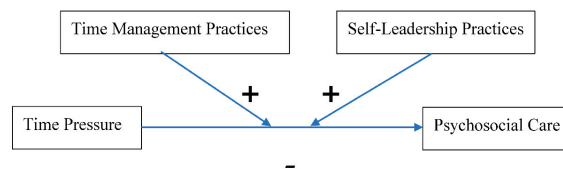
Figure 1. The time pressure mitigation model for nurse managers.

Our proposed model mitigates the time pressure nurse managers face based on three areas of research: psychosocial care, time management, and self-leadership. Based on the conceptual methodology of metatriangulation (Lewis and Grimes 1999; Saunders et al. 2003; Cristofaro, Matteo 2020. Unfolding Irrationality: How do Meaningful Coincidences Influence Management Decisions? forthcoming), we provide three metaconjectures for further consideration by organizational and psychological researchers. Metaconjectures are "propositions that can be interpreted from multiple paradigms" (Saunders et al. 2003, p. 251). Saunders et al. (2003), for example, applied the approach to examining power and information technology. The context of nurse managers is included in the title of

the framework because the professional outcome pertinent to their roles is psychosocial care. Based on the research on nurse management studies, we conjecture that time pressure will impede good decision making and detract from providing quality psychosocial care. However, the research in time management and self-leadership warrant us to also conjecture that when practices from these two areas are successfully implemented, the negative effect of time pressure on decisions related to psychosocial care can be lessened. In other words, proper application of time management and self-leadership practices moderates the relationship between time pressure and psychosocial care by nurse managers.

In this conceptual paper, we first describe the context nurse managers face that affects their decision making. We then provide the model and its constituent parts. An example is then given that demonstrates how the model may work in a healthcare setting. We conclude with considerations for future development of the model.

2. The Context of Healthcare Settings

Time is a major issue in healthcare today. The emphasis on quality of care, safety, standardization, and efficiency has to be managed within the constraints of an increase in the amount of patients being treated and a condensed length of stay (Bundgaard et al. 2016). Nurses are often in a continuous struggle to perform an increasing number of complex tasks under time-crunched conditions (Chan et al. 2013). Further complicating the nurse's job are the many decisions that must be made within that limited time (Saintsing et al. 2011). In a study of a medical admissions unit, it was found that a nurse confronts up to 50 important clinical decisions in a single 8-hour shift (Thompson et al. 2004). Other researchers have discovered similar patterns of clinical judgements and choices in controlled time frames. Thompson et al. (2008), for example, discovered that nurses in intensive therapy units encountered a clinical judgment or decision every 30 seconds. Along with that, in a study by Saintsing et al. (2011), nurses reported time constraints that limited their patient assessments with approximately 80% of the novice nurses acknowledging making mistakes due to time pressure. In this study, it was reported that each nurse made better decisions when there was no time pressure confronting their interactions. Additionally, Gonzalez (2004) demonstrated that people making decisions under limited time conditions performed worse than others faced with the same situations but with more time.

Accelerated information processing (Maule and Edland 1997) has been recognized as a natural response to time pressure when implementing a desired strategy (Payne et al. 1993). Furthermore, novice nurses described that peer-pressure is an indirect basis of time constraint (Ebright et al. 2004). Specifically, they feel pressure to leave no unfinished tasks for the incoming nurses that start the next shift, pressured to complete their allotted tasks so that incoming nurses start their shifts without leftover work. This self-inflicted time constraint is pervasive in healthcare, especially for new nurses who want to avoid being seen as incapable of thoroughly completing their responsibilities. The "must-do work" supersedes the "should-do work" (Bowers et al. 2001), thereby causing nurses to perform in a reactive fashion rather than being proactive with decision making (Hoffman et al. 2009). Nurses report that pressure to perform, workload, technology, and system issues produce barriers that prevent them from providing compassionate care. The often-chaotic environment weakens their capacity to care for others as well as themselves. This can result in dissatisfaction, burnout, and compassion fatigue (Roussel et al. 2020). Moreover, time pressure bears a high price of energy expenditure as nurses rely on coping mechanisms to bear the increased anxiety that comes with time pressure. In other words, nurses are not able to fully focus on their job, but must engage in self-coping to stand up to the pressure. This unfortunate predicament can drain energy over a work shift (Maule et al. 2000). Given this context of time pressure within a healthcare setting, we next explain the Time Pressure Mitigation Model for Nurse Managers and offer related metaconjectures for future study.

3. The Time Pressure Mitigation Model for Nurse Managers

Time pressure is the perception that scarcity of time exists to finish obligatory tasks (Teng and Huang 2007). Nursing responsibilities have been rising along a range of complexity.

This amplified workload can complicate nursing (Gurses et al. 2009). Too much to do without enough help was found to be the top source of stress in a study of Iranian nurses (Mosadeghrad 2013). In the study, occupational stress was found to lessen the quality of care due to having less time to demonstrate compassion for the patients in their care. Additionally, mistakes and practice errors occurred more often when occupational stress increased. Stress is related to time pressure in that it is recognized as inadequate time for accomplishing required tasks that compromises one's ability to cope. Under intense time pressure, it was found that individuals tend to escalate information processing, hinder decision-making quality, and experience information overload (Ben-Zur and Breznitz 1981; Hahn et al. 1992). Concurrently, the stress of time pressure has physical complications, such as increased blood pressure and a rise in human cortisone levels (Wellens and Smith 2006; Greiner et al. 2004). Thompson et al. (2008) found that time pressure reduced the nurses' capacity to assess patient needs in acute care and affected nurses' risk assessment decisions. Time pressure also creates negative emotions, increases anxiety, and leads to nurse emotional exhaustion (Gelsema et al. 2006) or burnout (Ilhan et al. 2008). When in a state of high anxiety, one's working memory resources are constrained, significantly diminishing resources for completing tasks and ultimately diminishing individual effectiveness. Patients are aware of this limited cognition, which can diminish client satisfaction and confidence in the hospital. Teng et al. (2010) discovered that nursing-perceived time pressure is negatively related to patient perceptions of dependability, accountability, responsiveness and assurance of the nurse. Thus, to enhance patient perception of care quality, nursing managers must develop means to lessen nurse-perceived time pressure.

3.1. Time Pressure and Psychosocial Care

Psychosocial care, a holistic approach to nursing to meet the psychological and social needs of patients (Kenny and Allenby 2013), is an important healthcare outcome compromised by insufficient time and heavy workloads (Legg 2011). Barriers, including lack of time, stand in the way of appropriate psychosocial care (Legg 2011). Recent studies reveal that offering good psychosocial care may improve patient overall health outcomes (Chen and Raingruber 2014). Additionally, appropriate psychosocial care reduces patient anxiety and stress and alleviates pain, thereby improving quality of life as well as a reduction in hospitalization cost due to a decreased need for medical resources (Kenny and Allenby 2013; Legg 2011). Studies by Legg (2011) and Rodriguez et al. (2010) found that good psychosocial care decreased the duration of hospitalization.

Unfortunately, psychosocial care does not often become an area of focus in hectic acute care settings (Legg 2011; O'Gara and Pattison 2015). In a study by Chen and Raingruber (2014), all the participants stated that, although often limited, positive interactions with patients and their family members were vital for providing psychosocial care. Communication within a time-pressured environment is hard to come by. As one nurse in the study said, "I think in order to know the needs of the patient, you need to communicate with them, and then you will know what they need." (p. 229).

The literature supports that effective interactions between nurses and patients result in increased rapport, trust and medical care, thus making therapeutic relationships possible (Belcher and Jones 2009; Josefsson 2012; Mcmillan et al. 2016). Furthermore, although nurses support spiritual care, they commonly said it was not possible when under time constraints (Balboni et al. 2014). Most participants in Legg (2011) study responded that time constraints due to excessive workloads was the top obstacle to offering psychosocial care. Time constraints shortened conversations with patients that would better uncover individualized needs. Other studies support this conclusion that most nurses contend with time-related pressures (Legg 2011; Chen and Raingruber 2014; DeCola and Riggins 2010; Lawless et al. 2010). A likely cause for this occurrence are the high patient workloads in hospitals and the distribution of tasks that require a specific schedule that needs completed before the end of one's shift (Lim et al. 2010). An enormous preoccupation with documentation also limits time available for psychosocial needs (Legg 2011). Most nurses in this study expressed that a preoccupation with

timely documentation requirements limiting patient interaction was the cause of not attending to psychosocial needs.

Quality decisions within a healthcare context are also affected by time pressure. Good decisions are greatly dependent on the information considered by decision makers. However, new findings in the psychological sciences reveal that time pressure can cause nurses to misrepresent actual events and results, in order to appear more favorable to other people (Protzko et al. 2019). This was affected, though, by participants' beliefs on whether their true self was virtuous. Bear and Rand (2016) and Rand et al. (2014) proposed that one's automatic responses develop from internalizations of actions commonly agreed to as good to others in social exchanges. With this notion in mind, when time pressure is at hand, an individual might say what would appear to be the right response when indeed it might not be the truthful response. An example of this could be when a nurse reports to the nurse manager that she/he has followed protocol and checked all the necessary patient identifiers before giving medications during a busy shift, while in reality the nurse is telling the nurse manager what she/he thinks she/he wants to hear. This error in judgment could result in a medication error, which is one of the most common—and dangerous—mistakes in healthcare. When people are under time-crunched conditions, they often offer socially desirable answers or information as a default. A clash between a person's long-held self-conception and workplace role takes place. Thus, under time pressure, people often operate in opposition to their true self-concept, responding consistently with the internalized social norm of how the unit is supposed to operate from day-to-day (Everett et al. 2017). Positive self-presentation becomes a habitual tendency when time pressure is present (Protzko et al. 2019). When intentions and actual events are in misalignment, cognitive dissonance can place further stress on the nurse's psyche—sometimes lasting well beyond the date of the actual occurrence.

Given this discussion of the effect of time pressure on psychosocial care, we offer the following metaconjecture based on the literature:

> **Metaconjecture 1:** *In situations where nurse managers face increased time pressure, providing quality psychosocial care will be compromised; i.e., the more time pressure a nurse manager experiences, the less psychosocial care their patients receive.*

3.2. Time Management for Nurse Managers

Nurse managers must create a positive work environment even when they are confronted with ever-changing priorities. They must especially consider time pressure of their staff when designing their schedules. Workload should relate to a realistic assessment of individual nurses' capabilities and resources. Adequate staff can help in keeping nurses' assignments realistic to sufficiently manage workloads (Waterworth 2003). Nurse managers should initiate strategies to provide substantial support for the nurses to deal with the stresses that are at hand. Numerous studies have considered time pressure and work overload as major contributors to work stress among healthcare professionals. A burdensome workload intensifies job tension and reduces job satisfaction which, in turn, increases the probability of turnover. Although, Efron (2014) identifies poor leadership as the main reason for staff to leave and notes that staff quit the leader, not the organization. Roussel et al. (2020) report that the highest turnover takes place within one year of employment, with the cost of replacement at USD 75,000 due to recruitment, temporary staff, overtime, orientation and replacement. Moreover, the remaining staff are affected with heavier work assignments and overtime, which also leads to burnout. If the vacancy rate remains high, burnout may lead to more vacancies and, in turn, increase the potential for further burnout among the remaining staff leading to a downward spiral. It is as if a unit is unintentionally downsizing itself.

Inadequate staffing also impacts quality of care and patient outcomes (Aiken et al. 2002). Conscientious management of all these factors is key. Time management for nurse managers is an important issue (Mirzaei et al. 2012) because it directly affects people's health, availability of critical time, and can cause a decrease in efficiency (Soleymani et al. 2011). It was found in a study by

Ziapour et al. (2015) that training nurse managers according to time management practices delivers positive results in healthcare centers.

A main objective for the nurse is to make optimum usage of the time at hand. Nurses keep part of their focus on maintaining the expectations of the greater healthcare system while also providing individualized care in the most efficient way they can. Thus, instead of developing a relationship with a patient, much of the allotted time is spent on the technical and instrumental responsibilities in nursing. As a result, compassionate nursing becomes harder to provide (Bundgaard et al. 2016). Therefore, productivity, and not compassion, becomes the key objective of the job. Numerous researchers cited Lakein (1973) when studying time management, emphasizing the practices of needs assessment, setting goals to meet these needs, prioritizing, and task planning necessary to meet the set goals. Practices proposed to extend intellectual efficiency were suggested by Britton and Tesser (1991). Kaufman-Scarborough and Lindquist (1999) provided methods for strategizing activities by prioritizing them by their relative importance to the healthcare mission.

Collections of behaviors that are considered to aid efficiency and lessen stress were suggested by Lay and Schouwenburg (1993). Based on a review of the time management literature, Claessens et al. (2007) suggest the following definition: "behaviors that aim at achieving an effective use of time while performing certain goal-directed activities" p. 262. Since the focus is on goal-directed activities that are accomplished in a manner that implies successful use of time, the following behaviors are included in their definition: (1) Time Assessment Behaviors—focusing on mindfulness of the past, present and future with self-awareness of time usage within the boundaries of one's abilities (Kaufman et al. 1991) and self-awareness of time handling by deciding which tasks suitably fit into one's abilities; (2) Planning Behaviors—with the goal of effective use of time, that includes goal setting, development, prioritizing, formulating a to-do list, and arranging tasks (Britton and Tesser 1991; Macan 1996); and (3) Monitoring Behaviors—with the objective of attending to how time is allotted, engagement of planned undertakings, and limiting the impact of disturbances by others in the completion of tasks and goals (Fox and Dwyer 1996; Zijlstra et al. 1999).

Nurses face time management problems due to the unpredictability and complexity of their assignments. Accomplishing tasks effectively and minimizing interruptions are essential to the nurse. The importance of routines and prioritization is key to time management in a healthcare setting (Waterworth 2003). Furthermore, in complex environments, routines allow for a way of maintaining order since actions have already been planned out and can decrease thinking time needed to make decisions. Routines bring about a sense of predictability, awareness of time control, and familiarity of experience that is pertinent to time management (Waterworth 2003). Furthermore, prioritization is a prerequisite for effective work performance for nurses. Sequencing work and its duration is necessary as well. It is imperative for timing and speed that there is synchronicity with others in the nursing environment. Determining what is urgent and important is a critical step to attaining high returns on time investments. Simply put, more hours worked does not mean more hours of productivity. Therefore, productivity experts offer many suggestions for being more deliberate and conscious of where time on activities is allocated. Some of the latest advice for nurses on time management includes (Garbugly 2013; Saunders 2014):

1. Never relying solely on your memory and instead referring to reminders and lists.
2. Accomplishing the most important task as early in the day as possible.
3. Paying attention to the time of day that you are most productive and utilizing that time for your most important tasks.
4. Keep multitasking to a minimum. Many psychologists believe that multitasking does not actually exist, meaning you can only put your attention on one thing at a time. When people think they are multitasking, they are actually only shifting their attention inefficiently from one matter to another in quick bursts. Each time a person moves their attention back to a previous matter, a transition in cognition must take place. Any momentum the person had in their thought process is interrupted, and the brain must reorient to the new focus. These reorientations may be

minute, but over the course of hours, days, and weeks, significant time can be lost in perceived "multitasking." Thus, it is more efficient and productive to complete tasks with full attention and then move onto the next one needing accomplished.

5. Attending to emails only at set times each day, and, when possible, for a determined amount of time.
6. Keeping your work area neat and organized. It can help minimize search time for needed resources. Additionally, many productivity experts believe that removing clutter in a physical space helps the mind to focus attention more fully on that matter at hand.
7. If able, finishing small tasks before handling larger ones.
8. Defining what work needs to be done the next day and writing it down before the end of the shift.
9. Taking breaks and doing something enjoyable after you have accomplished a task. Recharge a bit, if possible, before moving onto the next task that needs attention. Improved productivity is a long-term game, not a short burst of frantic task hopping.
10. Enjoying the dopamine that the brain secretes when tasks and goals are accomplished. Completing activities feels good and serves to encourage further accomplishment. Therefore, consciously managing activities and the time required for their accomplishment boosts mental and physical health by releasing positive neurochemicals into the bloodstream, as opposed to excessive cortisol that is released over time in unorganized and pressure-packed environments (Lee et al. 2015).

Given this extensive review of research on time management theory and practices for better performance, we offer the following metaconjecture:

Metaconjecture 2: *In situations where nurse managers face increased time pressure, proper application of research-based time management practices can improve psychosocial care; i.e., time management practices positively moderate the negative relationship between time pressure and psychosocial care.*

3.3. Self-Leadership for Nurse Managers

The research in self-leadership suggests that it can be an appropriate training tool for nurse managers in better performing their roles. Based in social cognitive theory, self-leadership can help nurse managers better manage their thoughts, behaviors, and environment to create a better workplace for improved results. Self-leadership (Manz 1986; Manz and Neck 2004) is a process in which people can regulate what they do, how they interact with others, and how they decide to lead themselves and others by using certain behavioral and cognitive strategies. Self-leadership strategies fall into three groups focused on behavior, natural rewards, and positive thought patterns (Manz and Neck 2004; Prussia et al. 1998; Neck and Houghton 2006). Strategies revolving around behavior improve the awareness a person has on what they are trying to accomplish, especially regarding tasks with which one might want to procrastinate (Manz and Neck 2004; Neck and Houghton 2006). Behavior-focused strategies are:

1. Self-observation—Developing the self-knowledge of when and why a person participates in the actions she/he does. In the context of nurse managers, this suggests that the self-awareness of the antecedents and consequences of perceived time pressure is critical. Self-awareness is a crucial aspect of altering or eradicating self-destructive or limiting behaviors; (Manz and Sims 1980; Manz and Neck 2004; Neck and Houghton 2006).
2. Self-goal setting—Having awareness of present actions and results can help a person set meaningful goals for themselves (Manz 1986; Manz and Neck 2004; Manz and Sims 1980; Neck and Houghton 2006). Research supports the effectiveness of establishing challenging and precise goals to improve a person's performance (Locke and Latham 1990; Neck and Houghton 2006).
3. Self-reward—Personal goals that are met with rewards one finds pleasing and desirable can encourage a person to take the initiative to overcome procrastination and/or poor prioritization (Manz and Sims 1980; Manz and Neck 2004).

4. Self-punishment (also known as "self-correcting feedback")—Entails positive honesty, reframing failures and unproductive actions in a way that can help a person remodel future actions. This strategy comes with a caveat, though: self-punishment centered on self-criticism should be used sparingly, lest a person incur excessive guilt that damages self-esteem, self-efficacy, and self-confidence that hinders future performance (Manz and Sims 1991; Neck and Houghton 2006).

5. Self-cueing—Designing your work environment with reminders to maintain positive self-leadership behaviors and thoughts. Concrete environmental cues such as notes, lists, and inspiring quotes can help a person return their attention to making progress toward their goals. For example, nurse managers could place pictures in the rooms in which they work reminding them to take deep breaths and focus on the patients on the unit at that particular point in time.

Natural reward strategies are designed to establish conditions that spur correct actions through focusing on the gratifying aspects of a task (Manz and Neck 2004; Neck and Houghton 2006). These strategies encourage a sense of competence and self-determination in the person practicing them, two key drivers of intrinsic motivation (Deci and Ryan 1985). The necessity for competence comprises the need to practice and increase a person's proficiencies, and self-determination implicates one's desire to be independent from pressures such as conditional rewards. When individuals feel negatively controlled by their environment and they associate their expected actions to external pressures, they are likely to be less motivated by the work itself. To avoid this negative perspective of work, two natural rewards strategies that can be practiced are:

1. Building positive features into an activity, so that doing it becomes a reward in itself (Manz and Neck 2004; Manz and Sims 1991). For example, if a nurse manager likes music, she/he could relate what she/he wants to accomplish on the unit at the moment with a song. Perhaps she/he could sing to himself, "Everybody's workin' for the weekend!" as she/he looks at timesheets.

2. Deliberately turning attention from the ungratifying features of a task and placing it on the more inherently rewarding characteristics of the required action (Manz and Neck 2004; Manz and Sims 1991; Neck and Houghton 2006). An example for the nurse manager could be a daily mental reminder to themselves and their staff as to why they entered the profession in the first place—that is, a reminder to help and care for people. This reminder could help the nurse manager focus on the naturally rewarding aspect of the job instead of focusing on the perceived time pressure.

Effective thought pattern strategies are devised to enable a positive stream of recurring thoughts and constructive thinking habits that can enhance a person's performance (Manz and Neck 2004; Neck and Manz 1992). Positive thought pattern strategies include:

1. Acknowledging and replacing dysfunctional beliefs and assumptions—A person should scrutinize thoughts that are not helpful to achieving goals and exchange them for more rational and productive thoughts and beliefs (Ellis 1977; Manz and Neck 2004; Neck and Manz 1992).

2. Practicing positive self-talk—What we quietly say to ourselves should be positive (Neck and Manz 1992, 1996), including our self-evaluations and reactions to events (Ellis 1977; Neck and Manz 1992). Negative and unhelpful self-talk should be acknowledged and exchanged with helpful internal monologues. Mindfully observing the patterns we use to talk to ourselves helps us to replace unconstructive self-talk when it arises. The mind can only focus on one matter at a time, so it is better to place its attention on self-dialogues that are optimistic and hopeful (Seligman 1991).

3. Practicing mental imagery or visualization—Develop the skill of intentionally imagining a future event or task in advance of its actual occurrence (Finke 1989; Neck and Manz 1992, 1996). Those who can picture successful completion of a future event or task before it is actually performed are more likely to attain that result (Manz and Neck 2004). Moreover Driskell et al. (1994)

conducted a meta-analysis of 35 empirical studies and discovered that mental imagery has a significant positive effect on individual performance (Manz and Neck 2004; Manz and Sims 1980, 2001). Mental imagery can be useful when a problem stems from time pressure. In that case, the nurse manager would picture herself in a calm manner listening to the nurses' concerns over the challenges at hand, offering timely encouragement, and providing useful, deliberate direction. Solutions can be created that can ultimately save time in the future.

When time pressure is at hand, having a deliberate strategy with self-leadership skills is key. While many factors in the surrounding environment can cause stress on a nurse manager, her/his state of mind is within her/his power. Dysfunctional thinking, however, often hinders the nurse manager in advancing a unit toward its preferred benchmarks (Goldsby et al. 2020). Fortunately, dysfunctional or self-limiting thinking can be changed to be more constructive with evidence-based self-leadership strategies.

A significant research finding in the past 30 years is that people can decide on the way they wish to think (Seligman 1991). In the book, Talking to Yourself, Dr. Pamela Butler proposes that people participate in "an ever-constant dialogue" with themselves so that they can pilot their behaviors, feelings, and even stress level (Butler 1983). Much of this self-dialogue is centered on where a person places their attention. Nurses often struggle over difficulties that are not within their power to change, such as situations resulting from time pressure. Many are burdened about consequences that they cannot anticipate. Then, when time pressure is at hand with the potential stress that comes with it, self-defeating thinking can be the cause of extra burden. Significant challenges stem from dysfunctional thinking patterns. The most common dysfunctional thinking patterns are (Manz 1992):

1. All-or-nothing thinking—one perceives issues as "black-and-white" instead of as complex situations with a lot of variables and possible perspectives (for example, if events do not play out as hoped, one distinguishes only all-embracing failure).
2. Overgeneralization—one oversimplifies a specific failure as having a perpetual nature to it (for example, a person may say to themselves, "I always screw up!").
3. Mental Filtering—one perseverates on one dissatisfying feature of something, thus misrepresenting all other aspects of reality (for example, a nurse manager may have one nurse in the unit who is particularly challenging to her/him, and she/he may think, "My employees all hate me!").
4. Disqualifying the positive—one disregards valuable occurrences (for example, "Well, I got lucky there. That will never happen again.").
5. Jumping to conclusions—one assumes certain conditions of a situation are negative before there is enough evidence to do so (for example, "The top administrators of the hospital are coming today to inspect the unit. They're bound to find something they're not happy with.").
6. Magnifying and minimizing—one heightens the significance of negative elements and lessens the presence of positive ones (for example, "Yes, the new nurses on the unit are doing great work, but you know they'll move onto higher paying hospitals. The good ones always do.").
7. Emotional reasoning—one is steered by negative emotions (for example, on entering the hospital, the nurse manager says to herself, "Well, I wonder what disaster will happen today on the unit.").
8. Labeling and mislabeling—one spontaneously applies undesirable labels to describe oneself, others, or an event (for example, during a break, the nurse manager sarcastically thinks to himself, "How did I end up being the king on this 'island of misfits'?").
9. Personalization—one accuses oneself for undesirable situations or conclusions that have other origins (for example, "I just know these new directives from the director are because of something I did wrong!").

Psychologists point to cognitive distortions as sources of these mental states that can undercut personal effectiveness (Neck and Barnard 1996). Even forms of depression can be the result of these mindsets. When nurse managers can recognize their self-defeating self-talk when it is taking

place, they have the opportunity to alter and re-verbalize these personal dialogues. There is always potential for creating a more positive outlook that will enhance their performance and satisfaction (Goldsby et al. 2020).

Once the self-leadership practices of the nurse manager and nurses are improved, the interactions between the two parties can be honed as well. Social cognitive theory (SCT) (Bandura 1986)—the underlying theoretical foundation of self-leadership—explains that performance is the outcome of a three-way relationship between a person's thoughts, actions, and surroundings in which they find themselves. Self-efficacy, which is a self-assessment of a person's ability to achieve specific undertakings, is in particular an important concept of social cognitive theory. Thus, self-efficacy is also significant within the practice of self-leadership (Neck and Houghton 2006). Furthermore, a chief aspiration of self-leadership practices, including thought pattern strategies, is the development of high self-efficacy prior to performing an activity (e.g., Manz 1986; Manz and Neck 2004; Neck and Manz 1992, 1996). Thus, increased task-specific self-efficacy promotes superior performance expectations (Bandura 1991). Backed by empirical research, self-leadership has been found to be a very helpful process for achieving perceptions of high self-efficacy and task performance (Neck and Houghton 2006). According to self-leadership theory—to the degree that an activity or task is selected—a strong belief in self-determination coupled with the application of practiced skills in increasing a sense of proficiency can enhance a person's performance on a task (Neck and Houghton 2006). In other words, once a person truly believes something is within their hands to do and that they have the ability to do it, they have a much better chance of doing so. The aforementioned self-leadership strategies intentionally practiced over time increases that desired self-efficacy.

It should be noted though that self-leadership is not an isolated process. Improving not only the personal habits of thoughts and behavior but the interactions between all parties in the environment is crucial as well. After all, much of time pressure can be due to systematic factors within a unit. Systems improvements require the involvement of the whole team. Once the nurse manager has improved her/his practices of self-leadership, it is time to improve the environment he or she co-exists in with others in the unit. Turning a manager's employees into better self-leaders themselves is a process known as SuperLeadership. The best managers set the example of what a good self-leader does and empowers and coaches the rest of the team to reach that same level of self-performance. When achieved, a team can outperform others who must wait for a manager to inform them how to handle complex situations. In a sense, the SuperLeader has inculcated the values and goals into each team member to exceed what she/he can do alone (Manz and Sims 1989, 1991; Manz 1990, 1991, 1992; Neck and Houghton 2006). The best SuperLeaders of self-managing teams encourage and support their employees to learn and practice the self-leadership process (Neck and Houghton 2006). The nurse manager, after all, cannot find or fix all the factors and issues causing time pressure on the unit.

Given this extensive review of research on self-leadership theory and practices for better performance, we offer the following metaconjecture:

> **Metaconjecture 3:** *In situations where nurse managers face increased time pressure, proper application of self-leadership practices can improve psychosocial care; i.e., self-leadership practices positively moderate the negative relationship between time pressure and psychosocial care.*

4. Discussion

Thus far, this paper has provided a phenomenon of concern to nurse managers. Specifically, we discuss the negative impact of time pressure on psychosocial care, which is a key performance outcome for healthcare, and offer two evidence-based approaches to positively moderate that negative relationship. We have also provided metaconjectures to better demonstrate how practitioners can deliberately manage their time pressure situations. Yet, research tradition alone may not fully demonstrate the impact the application of theory to practice can have in a nurse manager's work environment. In this section, we go a step further to demonstrate how the quality of interactions between nurse manager and staff can be improved, and thus lead to a better climate for patient care.

Therefore, we now provide a scenario to better understand how the Time Pressure Mitigation Model for Nurse Managers might apply to decision making in a healthcare environment:

Tina was a young nurse who found herself in a challenging situation on a medical/surgical unit. Currently, she was responsible for an elderly patient who was upset because his pain medication was not sufficiently relieving his discomfort. Visiting family members were also giving Tina a challenging time with regular interruptions, unhappy that their father had pushed the call light repeatedly and felt he was not receiving the attention he deserved from his nurse. It seemed the whole day had gone like this for Tina. Tina started her day with documentation being behind from the previous shift, and she had two new admissions waiting for her in the Emergency Department. Additionally, the phone was ringing intermittently due to the nursing secretary calling in sick with no replacement at hand at that time. This was a stressor that she felt needed attention by someone other than herself. Her patient load was filled with several patients with high acuity who needed a variety of treatments this day. She felt that she was trying her best with the time that she had with this patient who was in pain, but she felt overwhelmed. Unfortunately, the next time Tina went by the room of the patient that was in pain, she blew up and shouted into the room, "Look. I don't have time for this! Your dad will get his needs met, but I've got two other rooms I have to deal with right now that have patients in a lot worse condition who need my attention!"

Suzanne, the nurse manager on the unit, hearing the commotion, entered the room to find the patient crying, an upset family pacing, and Tina dashing down the hallway. Suzanne reassured the family that she would help address the issue immediately, which she does with the rounding doctor at hand. Suzanne was not happy with Tina's interaction with the family, but unfortunately scenarios of this nature were far from uncommon on her unit. Time-pressure seemed to be a constant adversary for both her and her nursing team. She felt the whole team needed self-leadership training and at this point she needed to step up and practice some of her own self-leadership skills. Suzanne decides to use constructive self-talk to improve her interaction with the distraught patient and the family members, as well as Tina, who seemed to be in crisis mode. She says to herself, "I've dealt with similar problems in the past, and the stress on my unit has been lessened." "I picture myself in a calm manner listening to the patient and family and providing individualized care." She also addressed Tina's concerns over her challenges and offers her timely help, encouragement, and useful, deliberate direction. She also visualizes a later meeting with Tina going well and leaving with a feeling like she can tackle her next shift in a positive manner. She tells herself she is in this role because of how she's handled similar situations. Suzanne reminds herself that, though her unit is on the verge of being understaffed, she has just hired a new nurse. That hire will surely help spread some of the duties among the staff. Then Suzanne returns to the patient that was in pain to check on his status.

In the above situation, we observe a nurse manager addressing a poor decision made by a frontline nurse under time pressure. In the hypothetical scenario, self-leadership practices help her envision a way to provide better psychosocial care in her unit. Time pressure situations like this could also be moderated with better time management practices as well. For Suzanne to provide improved psychosocial care to her patients in her unit, the Time Pressure Mitigation Model for Nurse Managers suggests that she become an expert implementer and coach of time management and self-leadership practices.

5. Conclusions

This conceptual paper examined the research question: How can nurse managers and nurses provide quality patient care by making better decisions under time pressure? Many factors contribute to nurse managers experiencing time pressure, such as: (1) patient safety; (2) patient satisfaction; (3) hiring; (4) staffing; (5) up-to-date, required education of the nurses; (6) playing the role of a front line nurse when the unit is understaffed; (7) serving as the liaison go-between, communicating changes on new policies or procedures that come from the administration and keeping up with Joint Commission on Hospital Accreditation requirements; (8) serving as the liaison go-between of the front line nurses

and the hospital administration; (9) keeping doctors satisfied; (10) dealing with higher patient acuity; and (11) addressing the high stress among nurses, which includes burnout, suicide, and substance abuse (Davidson et al. 2018). Given this list of responsibilities, it is understandable why nurse managers are also described as nurse executives. In that, they have responsibilities in line with someone with a business degree requiring knowledge on financial management, sourcing and procurement, operations, and other business skills that must be learned on the job, all while meeting their patient and nurse responsibilities (Roussel et al. 2020). Therefore, readers of this paper who are not healthcare providers but who are in similarly time-pressured situations may find the model and suggested practices useful as well.

As with other professions that experience significant time pressure, handling an amalgam of such diverse concerns can cause emotional exhaustion and often lead to burnout for the nurse manager (Warshawsky and Havens 2014). However, we contend that the reason nurse managers incur such consequences is because they carry much of the load of their units in providing quality care and meeting administrative objectives. Operating as the center of the unit rather than as a facilitator of their team's growth and development can hinder deliberative improvement of their processes and practices. As a result, they may find themselves running from one crisis to another. The nurses on the unit also experience this time pressure, as nurse managers often do not model appropriate time management skills and operational efficiencies and improvements. However, it is our hope that by applying the practices of time management and self-leadership encompassed in the Time Pressure Mitigation Model for Nurse Managers, more interactions with a nurse manager's staff will be positive and productive.

Helping nurses to become better time managers should be a part of each nurse manager's day with their staff. Deliberate and persistent use of time management and self-leadership practices will also reduce the dissatisfiers that drain time and energy on the unit and open up more opportunities to find the little fixes that add marginal time savings as well. Workshops and on-the-job training implementing evidence-based approaches in time management (Waterworth 2003) and self-leadership (Neck et al. 2019) would provide structure in reaching these objectives. As Waterworth (2003, p. 433) observed, "Literature on time management in nursing is mainly anecdotal", without providing structure regarding what specific strategies to use and when. Additionally, with regard to self-leadership, practitioners may confuse this research tradition with popular books that fall into the commercial category McGee calls "Self-Help, Inc." (McGee 2005). However, self-leadership, like time management, has proponents in academia as well as popular culture, and it is the evidence-based practices that our model advises nurse managers to apply. Application of anecdotal work alone can lead to hit-and-miss results, which may lead practitioners to abandon a focus on better time management and self-leadership, and fall back into their past habits. The importance of a model like the one proposed in this article is that it is comprised of key variables related to a phenomenon of concern (time pressure and its effect on psychosocial care), evidenced-based practices grounded in extensive research traditions (time management and self-leadership), and explanation for how the variables create the potential for better performance (the negative relationship between time pressure and psychosocial care and the positive moderating effects time management and self-leadership practices have on that relationship). As Lewin stated (Lewin 1952, p. 169), "There is nothing more practical than a good theory." A good theory is based on many studies of a phenomenon of concern that over time leads to better practices for progress in a field. Thus, it is our hope that nurse managers who apply practices in a research-based model as the one proposed in this conceptual paper may find their pursuit of better psychosocial care in their units to be met with more efficiency and effectiveness. Before long, the unit will find it has more time to focus on the work they care about and be in a less stressed state of mind for handling the crises that do inevitably arise.

In a qualitative study of nursing, nurse managers summarized the complexity of their workplaces: "Keeping everyone happy—the docs, the administration, the patients, the nurses". "I'm a staff morale-booster, the problem solver, and counselor, and anything else I can think of to keep people relatively happy" (Tuckett et al. 2015). The breadth and scope of nurse manager roles can be tremendous.

However, because front-line nurse managers are "close to the action," they are in paramount positions to foster change in creating a positive work environment for nurses that parleys the emergent pressures that are commonplace. Many organizations place their managers in similar situations as nurse managers when they are confronted with many of the same challenges found in today's healthcare environments where time pressure is a common occurrence. Another common managerial issue is the promotion of high-performing front-line employees into management positions. What worked for the manager as an individual performer will not necessarily be effective for the frontline they now oversee. With regard to nurse managers, many are promoted from front-line nursing status without master's degrees or leadership certifications that could have prepared them for the complexities of the position (Mathena 2002). While the tasks and responsibilities of the position can be learned fairly quickly, leadership is a skill that takes time to hone. However, learning self-leadership skills can have incredible results if consistently applied with employees.

It is our hope that this conceptual paper sheds light on the dynamics of these situations, and provides helpful advice for improving decision making, reducing time pressure and its related stressors, and bettering the healthcare experience. Metatriangulation with thorough research traditions in time pressure, psychosocial care, time management, and self-leadership provide support that the Time Pressure Mitigation Model for Nurse Managers warrants application in hospital units. But support for the model would be enhanced by empirical research. A common practice in emergency departments that requires sound decision making in often stressful situations is triage. Triage places a registered nurse in a situation to assess the treatment acuity—that is, how long a patient should be allowed to wait for needed medical care—and decide which interventions are required for emergency care in the moment. Nurse managers hold significant responsibility for the outcomes of triage in their units. For future study to further support the Time Pressure Mitigation Model, researchers could test whether time management and self-leadership practices improve psychosocial care in units with similar time pressure as emergency departments face. Given the literature on triage practices and decision making though (Mackway-Jones et al. 1997; Gerdtz and Bucknall 1999, 2001; Cone and Murray 2002; Barberà-Mariné et al. 2019), triage decisions in an emergency department may be a good starting point for future empirical research. Yet, the model in this paper is not limited to nurse managers. As warranted by metatriangulation, models based on thorough research can be applied to different domains as well. In most cases, extensions of the model in this paper could be achieved by replacing psychosocial care with another outcome variable. For example, hospitality managers often face time pressure serving large numbers of guests during busy periods such as hosting conferences and conventions. In a hotel setting, guest satisfaction could be measured as the dependent variable pre- and post-test to time management and self-leadership training. Other fields could perform similar experiments by modifying the performance outcome. We contend that the model in this conceptual paper provides one route to improving decision making for a wide range of leaders in time pressured environments.

References

Aiken, Linda H., Sean P. Clark, Douglas M. Sloane, Julie Sochalski, and Jeffry H. Silber. 2002. Hospital Nurse Staffing and Patient Mortality, Nurse Burnout, and Job Dissatisfaction. *JAMA* 288: 1987–93. [CrossRef] [PubMed]

Bakker, Arnold B., and Evangelia Demerouti. 2007. The Job Demands-Resources model: State of the Art. *Journal of Managerial Psychology* 22: 309–28. [CrossRef]

Balboni, Michael J., Adam Sullivan, Andrea C. Enzinger, Zachary D. Epstein-Peterson, Yolanda D. Tseng, Christine Mitchell, Joshua Niska, Angelika Zollfrank, Tyler J. VanderWeele, and Tracy A. Balboni. 2014. Nurse and Physician Barriers to Spiritual Care Provision at the End of Life. *Journal of Pain and Symptom Management* 48: 400–10. [CrossRef] [PubMed]

Bandura, Albert. 1986. *Social Foundations of Thought and Action: A Social Cognitive Theory*. Englewood Cliffs: Prentice-Hall.

Bandura, Albert. 1991. Social Cognitive Theory of Self-regulation. *Organizational Behavior and Human Decision Processes* 50: 248–87. [CrossRef]

Barberà-Mariné, M. Gloria, Lorella Cannavacciuolo, Adelaide Ippolito, Cristina Ponsiglione, and Giuseppe Zollo. 2019. The Weight of Organizational Factors on Heuristics. *Management Decision* 57: 2890–910. [CrossRef]

Bear, Adam, and David G. Rand. 2016. Intuition, Deliberation, and Evolution of Cooperation. *Proceedings of the National Academy of Sciences USA* 113: 936–41. [CrossRef] [PubMed]

Belcher, Melanie, and Linda K. Jones. 2009. Graduate Nurses Experiences of Developing Trust in the Nurse-patient Relationship. *Contemporary Nurse* 31: 142–52. [CrossRef]

Ben-Zur, Hasida, and Shlomo J. Breznitz. 1981. The Effect of Time Pressure on Risky Choice Behavior. *Acta Psychologica* 47: 89–104. [CrossRef]

Bowers, Barbara J., Cathy Lauring, and Nora Jacobson. 2001. How Nurses Manage Time and Work in Long-term-care. *Journal of Advanced Nursing* 33: 484–91. [CrossRef] [PubMed]

Britton, Bruce K., and Abraham Tesser. 1991. Effects of Time-management Practices on College Grades. *Journal of Educational Psychology* 83: 405–10. [CrossRef]

Bundgaard, Karin, E. Erik Sorensen, and Charlotte Delmar. 2016. Time-making the Best of it! A Fieldwork Study Outlining Time in Endoscopy Facilities for Short-Term Stay. *Open Nursing Journal* 10: 15–25. [CrossRef]

Butler, Pete E. 1983. *Talking to Yourself—Learning the Language of Self-Support.* New York: Harper and Row.

Chan, Engle A., Aled Jones, and Kitty Wong. 2013. The Relationships between Communication, Care and Time are Intertwined: A Narrative Inquiry Exploring the Impact of Time on Registered Nurses' Work. *Journal of Advanced Nursing* 69: 2020–29. [CrossRef] [PubMed]

Chen, Cheng H., and Bonnie Raingruber. 2014. Educational Needs of Inpatient Oncology Nurses in Providing Psychosocial Care. *Clinical Journal of Oncology Nursing* 18: E1–E5. [CrossRef]

Claessens, Brigitte J. C., Wendelien Eerde, Christel G. Rutte, and Robert A. Roe. 2007. A Review of the Time Management Literature. *Personnel Review* 36: 255–76. [CrossRef]

Cone, Kelly J., and Ruth Murray. 2002. Characteristics, Insights, Decision Making, and Preparation of ED Triage Nurses. *Journal of Emergency Nursing* 28: 401–6. [CrossRef] [PubMed]

Cristofaro, Matteo 2020. Unfolding Irrationality: How do Meaningful Coincidences Influence Management Decisions? *International Journal of Organizational Analysis.* forthcoming.

Davidson, Judy, Janet Mendis, Amy R. Stuck, Gianni DeMichele, and Sidney Zisook. 2018. *Nurse Suicide: Breaking the Silence. NAM Perspectives*. Discussion Paper. Washington, DC: National Academy of Medicine. [CrossRef]

Deci, Edward, and Richard Ryan. 1985. The Support of Autonomy and Control of Behavior. *Journal of Personality and Social Psychology* 53: 1024–37. [CrossRef]

DeCola, Paula R., and Phil Riggins. 2010. Nurses in the Workplace: Expectations and Needs. *International Nursing Review* 57: 335–42. [CrossRef]

Demerouti, Evangelia, Arnold B. Bakker, Friedhelm Nachreiner, and Wilmar B. Schaufeli. 2001. The Job Demands-resources Model of Burnout. *Journal of Applied Psychology* 86: 499–512. [CrossRef] [PubMed]

Driskell, James E., Carolyn Cooper, and Aidan Moran. 1994. Does Mental Practice Enhance Performance? *Journal of Applied Psychology* 79: 481–92. [CrossRef]

Ebright, Patricia R., Linda Urden, Emily Patterson, and Barbara Chalko. 2004. Themes Surrounding Novice Nurse Near-miss and Adverse-event Situations. *Journal of Nursing Administration* 34: 531–38. [CrossRef] [PubMed]

Efron, Louis. 2014. Six Reasons your Best Employees Quit You. Available online: http://www.forbes.com/sites/louisfron/2013/06/24/six-reasons-your-best-employees-quit-you/ (accessed on 20 May 2020).

Ellis, Albert. 1977. *The Basic Clinical Theory of Rational-Emotive Therapy*. New York: Springer.

Everett, Jim A., Zach Ingbretsen, Fiery Cushman, and Mina Cikara. 2017. Deliberation Erodes Cooperative Behavior-Even Towards Competitive Out-groups, Even When Using a Control Situation, and Even When Eliminating Selection Bias. *Journal of Experimental Social Psychology* 73: 76–81. [CrossRef]

Finke, Ronald A. 1989. *Principles of Mental Imagery*. Cambridge: MIT Press.

Fox, Marilyn L., and Deborah J. Dwyer. 1996. Stressful Job Demands and Worker Health: An Investigation of the Effects of Self-monitoring. *Journal of Applied Social Psychology* 25: 1973–95. [CrossRef]

Fox, Marilyn L., Deborah J. Dwyer, and Daniel C. Ganster. 1993. Effects of Stressful Job Demands and Control of Physiological and Attitudinal Outcomes in a Hospital Setting. *Academy of Management Journal* 26: 289–423.

Ganster, Daniel C. 2005. Executive Job Demands: Suggestions from a Stress and Decision-making Perspective. *Academy of Management Review* 30: 492–502. [CrossRef]

Garbugly, Etienne. 2013. Time Management Hacks I Wish I had known. Available online: www.slideshare.net/egarbugli/26-time-management-hacks-i-wish-id-known-at20?utm_source= slideshowandutm_medium-ssemailandutm_campaign=weekly_digest (accessed on 20 May 2020).

Gardner, Donald G. 1986. Activation Theory and Task Design: An Empirical Test of Several New Predictions. *Journal of Applied Psychology* 71: 411–19. [CrossRef]

Gärling, Tommy, Amelie Gamble, Filip Fors, and Mikael Hjerm. 2016. Emotional Well-being Related to Time Pressure, Impediment to Goal Progress, and Stress-related Symptoms. *Journal of Happiness Studies* 17: 1789–99. [CrossRef]

Garner, Donald G., and Lindsey L. Cummings. 1988. Activation Theory and Job Design: Review and Reconceptualization. *Research in Organizational Behavior* 10: 81–122.

Gelsema, Tanya I., Margot van der Doef, Stan Maes, Marloes Janssen, Simone Akerboom, and Chris Verhoeven. 2006. A Longitudinal Study of Job Stress in the Nursing Profession: Causes and Consequences. *Journal of Nursing Management* 14: 289–99. [CrossRef]

Gerdtz, Marie F., and Tracey K. Bucknall. 1999. Why We do the Things We do: Applying Clinical Decision-making Frameworks to Triage Practice. *Accident and Emergency Nursing* 7: 50–57. [CrossRef]

Gerdtz, Marie F., and Tracey K. Bucknall. 2001. Australian Triage Nurses' Decision-making and Scope of Practice. *Australian Emergency Nursing Journal* 4: 19–26. [CrossRef]

Goldsby, Elizabeth, Michael Goldsby, Christopher P. Neck, and Christopher B. Neck. 2020. Self-leadership in a Hospital Setting: A Framework for Addressing the Demands of Nurse Managers. *Journal of Leadership and Management*. forthcoming.

Gonzalez, Cleotilde. 2004. Learning to Make Decisions in Dynamic Environments: Effects of Time Constraints and Cognitive Abilities. *Human Factors* 46: 449–60. [CrossRef] [PubMed]

Greggs-McQuilkin, Doris. 2004. The Stressful World of Nursing. *Medsurgical Nursing* 13: 141, 189.

Greiner, Birgit A., Niklas Krause, David Ragland, and June M. Fisher. 2004. Occupational Stress and Hypertension: A Multi-method Study Using Observer-based Job Analysis and Self-reports in Urban Transit Operators. *Social Science and Medicine* 59: 1081–94. [CrossRef] [PubMed]

Gurses, Ayse P., Pascale Carayon, and Melanie Wall. 2009. Impact of Performance Obstacles on Intensive Care Nurses' Workload, Perceived Quality, and Safety of Care, and Quality of Working Life. *Health Services Research* 44: 422–43. [CrossRef]

Hahn, Minhi, Robert Lawson, and Young G. Lee. 1992. The Effect of Time Pressure and Information Load on Decision Quality. *Psychology and Marketing* 9: 365–78. [CrossRef]

Hambrick, Donald C., Sydney Finkelstein, and Ann C. Mooney. 2005. Executive Job Demands: New Insights for Explaining Strategic Decisions and Leader Behaviors. *Academy of Management* 30: 473. [CrossRef]

Hoffman, Kerry A., Leann M. Aitken, and Christine Duffield. 2009. A Comparison of Novice and Expert Nurses' Cue Collection during Clinical Decision-making: Verbal Protocol Analysis. *International Journal of Nursing Studies* 46: 1335–44. [CrossRef] [PubMed]

Ilhan, Mustafa N., Elif Durukan, Ender Taner, Isil Maral, and Mehmet A. Bumin. 2008. Burnout and its Correlates among Nursing Staff: Questionnaire Study. *Journal of Advanced Nursing* 61: 100–6. [CrossRef] [PubMed]

Janssen, Onne. 2001. Fairness Perceptions as a Moderator in the Curvilinear Relationships between Job Demands, and Job Satisfaction and Job Performance. *Academy of Management Journal* 44: 1039–50.

Josefsson, Karin. 2012. Registered Nurses' Health in Community Elderly Care in Sweden. *International Nursing Review* 59: 409–15. [CrossRef] [PubMed]

Karasek, Robert A. 1979. Job Demands, Job Decision Latitude and Mental Strain: Implications for Job Redesign. *Administrative Science Quarterly* 24: 285–311. [CrossRef]

Kaufman, Carol J., Paul M. Lane, and Jay D. Lindquist. 1991. Time Congruity in the Organization: A Proposed Quality of Life Framework. *Journal of Business and Psychology* 6: 79–106. [CrossRef]

Kaufman-Scarborough, Carol, and Jay D. Lindquist. 1999. Time Management and Polychronicity: Comparisons, Contrasts, and Insights for the Workplace. *Journal of Managerial Psychology* 14: 288–312. [CrossRef]

Kenny, Amanda, and Ann Allenby. 2013. Barriers to Nurses Providing Psychosocial Care in the Australian Rural Context. *Nursing and Health Sciences* 15. [CrossRef]

Lakein, Alan. 1973. *How to Get Control of your Time and Life*. New York: Nal Penguin Inc.

Lawless, Jane, Lixin Wan, and Irene Zeng. 2010. Patient Care 'Rationed' as Nurses Struggle under Heavy Workloads—Survey. *Nursing New Zealand* 16: 16–18. [PubMed]

Lay, Clarry, and Henri C. Schouwenburg. 1993. Trait Procrastination, Time Management, and Academic Behavior. *Journal of Social Behavior and Personality* 8: 647–62.

Lee, Do Y., Eosu Kim, and Man H. Choi. 2015. Technical and Clinical Aspects of Cortisol as a Biochemical Marker of Chronic Stress. *BMB Reports* 48: 209–16. [CrossRef]

Legg, Melanie J. 2011. What is Psychosocial Care and How Can Nurses Better Provide it to Adult Oncology Patients. *Australian Journal of Advanced Nursing* 28: 61–7.

Lewin, Kurt. 1952. *Field Theory in Social Science: Selected Theoretical Papers by Kurt Lewin*. London: Tavistock.

Lewis, Marianne, and Andrew Grimes. 1999. Metatriangulation: Building Theory from Multiple Paradigms. *The Academy of Management Review* 24. [CrossRef]

Lim, Joanne, Fiona Bogossian, and Kathy Ahern. 2010. Stress and Coping in Singaporean Nurses: A Literature Review. *Nursing and Health Sciences* 12: 251–58. [CrossRef] [PubMed]

Locke, Edwin A., and Gary P. Latham. 1990. *A Theory of Goal Setting and Task Performance*. Englewood Cliffs: Prentice-Hall.

Macan, Therese H. 1996. Time-management Training: Effects on Time Behaviors, Attitudes, and Job Performance. *The Journal of Psychology* 130: 229–36. [CrossRef] [PubMed]

Mackway-Jones, Kevin, Janet Marsden, and Jill Windle. 1997. *Emergency Triage: Manchester Triage Group*. London: BMJ.

Manz, Charles C. 1986. Self-leadership: Toward an Expanded Theory of Self-influence Processes in Organizations. *The Academy of Management Review* 11: 585–600. [CrossRef]

Manz, Charles C. 1990. Beyond Self-managing Work Teams: Toward Self-leading Teams in the Workplace. In *Research in Organizational Change and Development*. Edited by Richard Woodman and William Pasmore. Greenwich: JAI Press, pp. 273–99.

Manz, Charles C. 1991. Developing Self-leaders through SuperLeadership. *Supervisory Management* 36: 3.

Manz, Charles C. 1992. *Mastering Self-Leadership: Empowering Yourself for Personal Excellence*. Englewood Cliffs: Prentice-Hall.

Manz, Charles C., and C. P. Neck. 2004. *Mastering Self-Leadership: Empowering Yourself for Personal Excellence*, 3rd ed. Upper Saddle River: Pearson Prentice-Hall.

Manz, Charles C., and H. P. Sims Jr. 1980. Self-management as a Substitute for Leadership: A Social Learning Perspective. *Academy of Management Review* 5: 361–67. [CrossRef]

Manz, Charles C., and H. P. Sims Jr. 1989. *Superleadership: Leading Others to Lead Themselves*. Englewood Cliffs: Prentice-Hall.

Manz, Charles C., and H. P. Sims Jr. 1991. Superleadership: Beyond the Myth of Heroic Leadership. *Organizational Dynamics* 19: 18–35. [CrossRef]

Manz, Charles C., and H. P. Sims Jr. 2001. *The New Superleadership: Leading Others to Lead Themselves*. Oakland: Berrett-Koehler Publishers.

Mathena, Katherine A. 2002. Nursing Manager Leadership Skills. *Journal of Nursing Administration* 32: 136–42. [CrossRef]

Maule, John A., and Anne C. Edland. 1997. *Decision Making: Cognitive Models and Explanations*. London: Routledge.

Maule, John A., Robert J. Hockey, and Larissa Bdzola. 2000. Effects of Time Pressure on Decision-making under Uncertainty: Changes in Affective State and Information Processing Strategy. *Acta Psychol* 104: 283–301. [CrossRef]

McGee, Micki. 2005. *Self-help, Inc.: Makeover Culture in American Life*. London: Oxford University Press.

Mcmillan, Kristy, Phyllis Butow, Jane Turner, Pasty Yates, Kate White, Sylvie Lambert, Moira Stephens, and Catalina Lawsin. 2016. Burnout and the Provision of Psychosocial Care amongst Australian Cancer Nurses. *European Journal of Oncology Nursing* 22: 37–45. [CrossRef]

Mirzaei, Tyebeh, Fatemeh Oskouie, and Forough Rafii. 2012. Nursing Students' Time Management, Reducing Stress and Gaining Satisfaction: A Grounded Theory Study. *Nursing and Health Sciences* 14: 46–51. [CrossRef] [PubMed]

Mosadeghrad, Ali M. 2013. Occupational Stress and Turnover Intention: Implications for Nursing Management. *International Journal of Health Policy and Management* 1: 169–76. [CrossRef] [PubMed]

Neck, Christopher P., and Annette H. Barnard. 1996. Managing your Mind: What are you Telling Yourself? *Educational Leadership* 53: 24–27.

Neck, Christopher P., and Jeffery D. Houghton. 2006. Two Decades of Self-leadership Theory and Research: Past Developments, Present Trends, and Future Possibilities. *Journal of Managerial Psychology* 21: 270–95. [CrossRef]

Neck, Christopher P., and Charles C. Manz. 1992. Thought Self-leadership: The Impact of Self-talk and Mental Imagery on Performance. *Journal of Organizational Behavior* 12: 681–99. [CrossRef]

Neck, Christopher P., and Charles C. Manz. 1996. Thought Self-leadership: The Impact of Mental Strategies Training on Employee Behavior, Cognition, and Emotion. *Journal of Organizational Behavior* 17: 445–67. [CrossRef]

Neck, Christopher P., Charles C. Manz, and Jeffry Houghton. 2019. *Self-Leadership: The Definitive Guide to Personal Excellence*, 2nd ed. New York: Sage Publishers.

O'Gara, Geraldine, and Natalie Pattison. 2015. Information and Psychosocial Needs of Families of Patients with Cancer in Critical Care Units. *Cancer Nursing Practice* 14: 26–30. [CrossRef]

Payne, John W., James R. Bettman, and Eric J. Johnson. 1993. *The Adaptive Decision Maker*. Cambridge: Cambridge University Press.

Protzko, John, Claire M. Zedelius, and Jonathan W. Schooler. 2019. Rushing to Appear Virtuous: Time Pressure Increases Social Desirable Responding. *Psychological Science* 30: 1584–91. [CrossRef]

Prussia, Gregory E., Joe S. Anderson, and Charles C. Manz. 1998. Self-leadership and Performance Outcomes: The Mediating Influence of Self-efficacy. *Journal of Organizational Behavior* 19: 523–38. [CrossRef]

Rand, David G., Alexander Peysakhovich, Gordon T. Kraft-Todd, George E. Newman, Owen Wurzbacher, Martin A. Nowak, and Joshua D. Greene. 2014. Social Heuristics Shape Intuitive Cooperation. *Nature Communications* 5: 3677. [CrossRef]

Rodriguez, Maria A., Frank Tortorella, and Cynthia St. John. 2010. Improving Psychosocial Care for Improved Health Outcomes. *Journal for Healthcare Quality* 32: 3–13. [CrossRef] [PubMed]

Roussel, Linda, Patricia L. Thomas, and James L. Harris. 2020. *Management and Leadership for Nurse Administrators*, 8th ed. Burlington: Jones and Bartlett Learning.

Saintsing, David, Linda M. Gibson, and Anthony Pennington. 2011. The Novice Nurse and Clinical Decision-making: How to Avoid Errors. *Journal of Nursing Management* 19: 354–59. [CrossRef] [PubMed]

Saunders, Elizabeth G. 2014. Front-load your Week and Three Other Stress-busting Time Management Strategies. Available online: http://99u.com/articles/16824/front-load-your-week-3-other-stress-busting-time-management-strategies (accessed on 20 May 2020).

Saunders, Carol, Traci A. Carte, Jon Jasperson, and Brian S. Butler. 2003. Lessons from the Trenches of Metatriangulation Research. *Communications of the Association from Information Systems* 11: 245–70. [CrossRef]

Scott, W. Richard. 1996. The Mandate is still being honored: In Defense of Weber's Disciples. *Administrative Science Quarterly* 41: 163–71. [CrossRef]

Seligman, Martin E. 1991. *Learned Optimism: How to Change Your Mind and Your Life*. New York: Random House Inc.

Soleymani, Fatemeh, Arash Rashidian, Rassoul Dinarvand, Abbas Kebriaeezade, Mostafa Hosseini, and Mohammad Abdollahi. 2011. Assessing the Effectiveness and Cost-effectiveness of Audit and Feedback on Physician's Prescribing Indicators: Study Protocol of a Randomized Controlled Trial with Economic Evaluation. *Journal of Pharmaceutical Sciences* 20: 1–7. [CrossRef]

Teng, Ching I., and Li S. Huang. 2007. Designing Time-limited Cyber Promotions: Effects of Time Limit and Involvement. *Cyber Psychology and Behavior* 10: 141–44. [CrossRef]

Teng, Ching I., Feng Hsio, and Tin Chou. 2010. Nurse-perceived Time Pressure and Patient-perceived Care Quality. *Journal of Nursing Management* 18: 275–84. [CrossRef]

Theorell, Tores, and Robert A. Karasek. 1996. Current Issues Relating to Psychosocial Job Strain and Cardiovascular Disease Research. *Journal of Occupational Health Psychology* 1: 9–26. [CrossRef]

Thompson, Carl, Nicky Cullum, Dorothy McCaughan, Trevor Sheldon, and Pauline Raynor. 2004. Nurses, Information Use, and Clinical Decision Making: The Real World Potential for Evidence-based Decisions in Nursing. *Evidence-Based Nursing* 7: 68–72. [CrossRef]

Thompson, Carl, Len Dalgleish, Tracy Bucknall, Carole Estabrooks, Alison M. Hutchinson, Kim Fraser, Rien de Vos, Jan Binnekade, Gez Barrett, and Jane Saunders. 2008. The Effects of Time Pressure and Experience on Nurses' Risk Assessment Decisions: A Signal Detection Analysis. *Nursing Research* 57: 302–11. [CrossRef]

Tuckett, Anthony, Peta Winters, Fiona Bogossian, and Dip Wood. 2015. Why Nurses are Leaving the Profession . . . Lack of Support from Managers: What Nurses for an E-cohort Study Said. *International Journal of Nursing Practice* 21: 359–66. [CrossRef]

Van Yperen, Nico W., and Tom A. Snijders. 2000. A Multi-level Analysis of the Demands-control Model: Is Stress at Work Determined by Factors at the Group or Individual Level? *Journal of Occupational Health Psychology* 5: 182–90. [CrossRef] [PubMed]

Wall, Toby D., Paul R. Jackson, Sharon K. Mullarkety, and Sean K. Parker. 1996. The Demands-control Model of Job Strain: A More Specific Test. *Journal of Occupational and Organizational Psychology* 69: 153–66. [CrossRef]

Warr, Peter B. 1990. Decision Latitude, Job Demands, and Employee Well-being. *Work and Stress* 4: 285–94. [CrossRef]

Warshawsky, Nurs E., and D. S. Havens. 2014. Nurse Manager Job Satisfaction and Intent to Leave. *Nursing Economics* 32: 32–39. [PubMed]

Waterworth, Susan. 2003. Time Management Strategies in Nursing Practice. *Nursing and Healthcare Management* 43: 432–40. [CrossRef]

Wellens, Benjamin T., and Andrew P. Smith. 2006. Combined Workplace Stressors and Relationship with Mood Physiology, and Performance. *Work and Stress* 20: 345–58. [CrossRef]

Xie, Jia L., and Gary Johns. 1995. Job Scope and Stress. Can Job Scope be Too High? *Academy of Management Journal* 38: 1288–89. [CrossRef]

Ziapour, Arash, Alireza Khatony, Faranak Jafari, and Neda Kianipour. 2015. Evaluation of Time Management Behaviors and its Related Factors in the Senior Nurse Managers, Kermanshah-Iran. *Global Journal of Health Science* 7: 366–73. [CrossRef]

Zijlstra, Fred R. H., Robert A. Roe, Anna B. Leonora, and Irene Krediet. 1999. Temporal Factors in Mental Work: Effects of Interrupted Activities. *Journal of Occupational and Organizational Psychology* 72: 163–85. [CrossRef]

The Influence of Core Self-Evaluations on Group Decision Making Processes: A Laboratory Experiment

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Abstract: The personal trait called Core Self-Evaluations (CSE) has been receiving increasing attention from behavioral strategy scholars due to its ability to predict job performance and to explain some facets of decision-making processes. However, despite previous studies hypothesizing that managers with high values of CSE are intuitive thinkers, beyond any doubt of their capacities and that they significantly lead to positive results for their organization, no one has empirically investigated these assumptions. This gap can be substantiated by the following research question: "*How do high Core Self-Evaluations influence team decision-making processes?*". Answering it provides insights on how the evaluations that decision makers make about situations (and the consequent actions that are implemented) highly depend on decision makers' inner traits and their effect on cognition. To fill this gap, 120 graduate students—divided into groups of four—took part in a simulation game and were asked to make decisions acting the role of General Manager of a small-sized manufacturing firm. Tests aimed at identifying the CSE and intuitive/reflecting thinking approach of participants were administered; moreover, the performance resulting from their decision-making processes and their estimation of reached results were collected. Results show that an average level of CSE is preferable to balance intuitive and reflective thinking, as well as avoiding overconfidence bias and reaching the best performance possible. This work suggests that there is a huge misattribution in considering a high level of CSE as being beneficial for decision-making processes and consequent performance.

Keywords: behavioral strategy; decision-making; core self-evaluations; intuition; overconfidence; performance

1. Introduction

In order to survive in the current competitive environment, both private and public organizations are constantly looking to reach organizational effectiveness and efficiency; however, the achievement of these results depends on organizational agents' level of effectiveness and efficiency (Inuwa 2016) and how good they are at making decisions (Simon 1947). According to the established literature, organizational agents' ability to make successful decision-making processes mainly relies, on the one hand, on the organizational environment (Wu and Lee 2016) and, on the other hand, on individual characteristics, such as emotions (Cristofaro 2019, 2020) and personal traits (Paniccia 2002; Cristofaro 2016, 2017a; Busic-Sontic et al. 2017). Among personal traits, the Core Evaluations (CE) (Judge and Bono 2001), namely the evaluations that individuals make about others, the world, and themselves (in this last case, we mean core self-evaluations, CSE), are those that have been receiving increasing attention from behavioral strategy scholars (Hiller and Hambrick 2005; Powell et al. 2011), due to their ability to predict job performance (Judge and Bono 2001) and to explain some facets of decision-making processes (Hollenbeck et al. 1988; Judge et al. 1998; Silvester et al. 2002).

However, despite previous studies hypothesizing that managers with high values of CSE (assimilated to hubris; see Hiller and Hambrick 2005) are intuitive thinkers, beyond any doubt

of their capacities and that they significantly lead to positive results for their organization (e.g., Claxton et al. 2015), no one has empirically investigated these assumptions. Studies have investigated some trait pillars comprising CSE, such as self-esteem, in relation to decision-making process variables; however, there has not been any investigation at the group level of analysis (e.g., Jordan et al. 2007), even though the level is a common working unit within organizations (Koontz et al. 1980). Filling this gap, which can be substantiated by the research question: *"how do high Core Self-Evaluations influence team decision-making processes?"*, is relevant also from a practical point of view due to the fact that personnel selection managers have been found to be biased and oriented towards selecting people that show high levels of CSE (Cristofaro 2017b).

In order to answer the aforementioned research question, a sample population of 120 graduate students was collected—divided into groups of four—to take part in a simulation game and they were asked to make decisions, in groups, acting the role of General Manager of a small-sized manufacturing firm. Tests aimed at identifying the CSE and intuitive/reflecting thinking approach of participants were administered; moreover, the performance resulting from their decision-making processes and their estimation of reached results were collected. Results of the work show a partial verification of the hypothesis that a high level of CSE leads to an intuitive decision-making process and a high level of performance; meanwhile, they are totally supportive of the positive relationship between a high level of CSE and being victim of overconfidence bias. Yet, results show that the average level of CSE is preferable to balance intuitive and reflective thinking as well as avoiding overconfidence bias and reaching the best performance possible.

Evidence produced really helps to understand the implications of the CSE trait variable for decision-making processes within organizations. Accordingly, prior literature provides evidence of the misattribution in considering a positive value of a high level of CSE as beneficial for performance (Judge et al. 2009; Judge and Hurst 2008). Yet, to the best of the authors' knowledge, this is the first study investigating the CSE trait variable at the group level—apart from also being the first to investigate, in depth, its implications for organizational decision-making processes. These results suggest that, in terms of practical implications, human resource managers track the CSE level of each individual within organizations and suggest composing teams accordingly to achieve better decisional and organizational performance.

The paper is structured as follows. First, readers of *Administrative Sciences* are informed of the basic assumptions behind the Core-Self Evaluation construct and concepts at the basis of decision-making processes. Second, the development of the hypotheses is provided. Third, the methodology is shown with details about the research context, i.e., the simulation game, as well as the data collection and analysis procedures. Fourth, results of the three one-way Analysis of Variance implemented to test developed hypotheses are shown. Fifth and last, discussion of the results in light of prior literature as well as implications for theory and practice are given.

2. Theoretical Background

2.1. Core-Self Evaluation

Judge et al. (1998) distinguished four components (also called *dispositions*) as being the foremost examined in industrial psychology since the 1960s: (i) Self-Esteem—the general esteem an individual has with respect to himself/herself; (ii) generalized Self-Efficacy—the self-estimation of being successful; (iii) Locus of Control—the conviction in controlling life's variables; and (iv) Emotional Stability—the capacity to maintain a low neuroticism level. These four dispositions have been broadly illustrated as influencing decision-making processes; for example, in job interviews, the self-esteem of candidates was found to be an indicator of work execution (Hollenbeck et al. 1988); this is because candidates with high self-esteem are considered as having control of circumstance (Silvester et al. 2002). Moreover, Judge and colleagues illustrated that the four highlighted components are altogether inter-related and can be translated as a special degree of core (fundamental) evaluations (CEs) that individuals make

about others, the world and themselves (in this final case they are called core self-evaluations; CSE) (Judge et al. 1998; Judge and Bono 2001). In practice, the individual who assesses himself/herself extremely high in these four predispositions is certain of his/her capabilities and is predicted to make successful decision-making processes as well as have positive job and life satisfaction (Judge and Bono 2001).

The CE construction encourages the examination of the 'human factor' within the work environment (Judge et al. 2009). From that, researchers distinguished significant scores in CE as being related to high scores in work interest (Erez and Judge 2001), career accomplishment, objective achievement, wage, and job-related status (Judge and Hurst 2008). In practice, this concept illustrated that individuals who are exceedingly sure in their claim capacities and make a maintained exertion over time towards their objectives (in life and at work), are motivated to achieve effective results in their career by picking up noteworthy compensations and prestigious positions in society (Cristofaro 2017b).

However, management scholars interested in the consideration of the self-concept and the impact on decision-making processes contended that CSE ought to be accepted as a powerful, confirmed umbrella that is created to investigate the executive self-concept. In fact, a really high level of CSE (or hyper-CSE) borders closely with what is regularly, colloquially, called "hubris" (Hiller and Hambrick 2005). In particular, Hiller and Hambrick (2005) investigated the links between executive peculiarities and components of organizational strategy, structure, and execution; from that, they expect that hyper-CSE executives—who have preeminent levels of self-confidence, self-potency, and conviction that they will prevail—will show this characteristic in their work behaviors. For example, they state that managers with high values of CSE are beyond any doubt about their capacities, and they consider profoundly that the application of their capacities will bring positive results. They are free of apprehension and have little concern regarding negative results since they have the conviction that they can overcome difficulties and solve all issues. In short, hyper-CSE executives are sure they will prevail in the work environment as well as in society.

Among the few scholars that empirically investigated CSE in business settings, the work of Nag et al. (2020) is worthy of notice. These scholars are interested in understanding the drivers of SMEs' development whilst competing in declining businesses. In particular, Nag et al. (2020) research looks at how CEO scanning behaviors—investigated in terms of scanning intensity and proactiveness—influence self-efficacy and, in turn, influence firm innovation and performance. Results showed that scanning intensity is emphatically related with self-efficacy; in addition, these scholars reinforced the idea for an arbitrative relationship in which CEO self-efficacy moderates the impact of scanning intensity on SME execution and development.

Finally, similarly to the CSE, Zell et al. (2020) introduced the concept of BTAE (Better-Than-Average-Effect), conceptualized as the propensity of individuals to see their capacities, traits, and identity characteristics as predominant compared with their normal peer. They displayed an exhaustive meta-analysis of BTAE investigation, collecting information from 124 scientific empirical articles, including 291 hypothesis tests on more than 950,000 people. Results advised that the BTAE is related with self-esteem and life fulfillment—so, hypothesizing an overlap between CSE and BTAE.

2.2. System Thinking, Biases and Overconfidence

'Biases' are deviations from rational choice, and this umbrella term has been used over time for substantiating both cognitive traps (i.e., mental errors) and heuristics (i.e., cognitive shortcuts) (Cristofaro 2017a, 2018). The first group of biases has been initially and formally defined by Hammond et al. (1998), inspecting cognitive errors behind executive choices. The second specifically comes from the program, primarily conducted through laboratory experiments of Kahneman and Tversky in the 70s on heuristics: rules that are deliberately, or not, used when choice conditions are dubious or complex (due to the massive or scarce amount of information) (Kahneman and Tversky 1974, 1979). However, these shortcuts were expected to be connected with the functioning of the human mind. In fact, Kahneman (2003)—the main theorist of the so-called

dual process theory—described human cognition as working according to two diverse Systems of our intellect: System 1, deputed to cognitive activities that are quick and programmed, and System 2, committed to cognitive activities that are "consciously observed and purposely controlled" (Kahneman 2003, p. 698). From this explanation, System 1 is the primary to be stimulated during our day-by-day tasks; so, human reasoning depends on heuristics for most of our mental procedures (Kahneman 2011).

However, traps and heuristics bring distinctive results on decision making: continuously negative for traps and positive or negative for heuristics. Undoubtedly, despite heuristics having been firstly conceived as the second-best choice approach (Kahneman et al. 2011), the *ecological rationality* aspect of heuristics has assumed and demonstrated as bringing, under some conditions, better choices than would be the case if decision makers utilized one of the more complicated strategies to make a choice (e.g., logistic regression; Luan et al. 2019).

Among traps, one of the most studied has been the overconfidence trap, defined by Bazerman and Moore (2013) as the "mother of all biases", since it activates other biases with dramatic consequences on the entire decision-making process (Abatecola et al. 2018). Overconfidence is the circumstance in which people tend to be overbearing regarding the accuracy of their judgments and it has been found in numerous settings (Cain et al. 2015; Gudmundsson and Lechner 2013). For example, Shiller (2005) illustrates that the stock markets were overestimated both in the case of the dot-com and real estate bubbles, primarily due to the executives' overconfidence in getting large returns, which progressively pushed to bring back and collect only corroborative data. Yet, Chen et al. (2015) examined how overconfidence may happen when executives make a corporate's profit projections. Examining the contrast between, at least, two large companies' earning estimations, made by 217 CEOs in a 14-year time span (1994–2008), Chen and colleagues identified significant steady outcomes about their assumption of the fact that CEOs with more prominent overconfidence are safe against strong remedial criticism. However, as Park et al. (2011) clarified, CEO overconfidence may be crucially decided by high levels of adulation, in terms of approbation and reaction similarity (or affirmation) from other members of the board of directors. These scholars explored this aspect through investigating 451 CEOs of US corporations and 3135 other executives. The outcomes completely bolster the initial theories that CEOs with a high social status are emphatically related with CEO overconfidence; this give-and-take brings a slight recognition of the need to modify procedures in return for mediocre conduct.

Studies on overconfidence have been massive and they have not followed, as demonstrated, the same conceptualization and operationalization of overconfidence. In this vein, Moore and Healy (2008) synthesized these different approaches within three clusters of how overconfidence has been investigated: (i) overestimation of one's substantial conduct (the majority of studies adopted this definition), (ii) overplacement of one's conduct relative to others, and (iii) extreme accuracy in one's convictions. Empirical evidence displays that the inversions of the first two (apparent underconfidence) tend to differently influence organizational tasks. On the one hand, for severe tasks, individuals overestimate their real performance, but also erroneously accept that they are less effective than others; on the other hand, for simple assignments, individuals underestimate their real performance but erroneously believe they are better than others.

From the aforesaid, overconfidence has a great impact on management decisions and, because of that, scholars have tried to explain whether there are some personal and/or contextual variables that may foster or reduce it. In this regard, Croskerry and Norman (2008) found, for example, that overconfidence is related with evidence favoritism—thus, the confirmation bias. In their study of clinical decision making, overconfidence has been generally found acting as deferring and/or missing necessary analysis, highlighting the catastrophic impacts of this decision behavior. In addition, Mata et al. (2013) studied whether the thinking mode—deliberative versus intuitive—that individuals utilize to figure out a dilemma or make a judgment impacts the mindfulness of decision makers' claims and others' conduct. Findings show that contemplative thinkers had a metacognitive superiority over instinctive thinkers. Deliberative individuals are aware of both the deliberative arrangement and the instinctive alternative; realizing that the deliberative arrangement is superior, they are likely to feel

surer and be more precise in how they evaluate their execution. Instinctive thinkers, on the other hand, are aware only about the instinctive explanation; they know only this option, so they are unconcerned of how unaware they were of their conduct and how they rank in relation to others.

3. Hypotheses' Development

Hayward and Hambrick (1997) used intermediary indicators of hubris, which captured a variety of presumed circumstantial and personality aspects, demonstrating the crucial need for a psychometrically grounded and approved construct for studying the extraordinary self-confidence in executives. Later, Hiller and Hambrick (2005) considered hyper-CSE to precisely measure that construct; the upper limit of CSE may be considered as an accurately certified 'hubris factor'. In sum, analysis on the conceptually comparable ideas of executive narcissism and hubris led our understanding of high-CSE executives. Especially, a significant level of CSE may precisely coincide to what is colloquially pointed out as hubris. Hubris, or hyper-CSE, has a great connection with intuitive thinking, as advanced by Claxton et al. (2015) who claimed that hubristic leadership is usually connected with intuition.

Jordan et al. (2007) examined both intuition and the correlation between tacit and explicit self-esteem, one of the four fundamentals of CE, testing whether the grasped effectiveness of the intuition increases the congruity between tacit and explicit self-esteem. It appeared that individuals who persistently consider their instinct as predominant are more inclined to tacit and explicit self-esteem. Contrarily, individuals with moderately intuitive thinking inclination had a negative correlation between tacit and explicit self-esteem, proposing that they may overcorrect their explicit self-views. Translating the above mentioned at the collective level:

Hypothesis 1. *Teams with high CSE are more intuitive compared to teams with low and average CSE.*

Kramer et al. (1993) explored the influence of motivational and emotional mechanism on negotiator judgment. They considered whether positive disposition and the inspiration to preserve high self-esteem lead the negotiator to be overconfident and to make excessively positive self-evaluation. A research test using dyadic bargaining was organized to test this hypothesis and outcomes supported Kramer's forecasts that high self-esteem and positive attitude influenced negotiators' determination and confidence preceding to negotiations, as well as their post-negotiation assessments of conduct. Similarly, Baumeister et al. (1993) analyzed the inclination for individuals with high self-esteem to judge themselves about their ability to make commitments; it resulted that subjects with a high level of self-esteem end up setting inappropriate, risky goals that were beyond their capabilities, so they finished with smaller rewards than subjects with low self-esteem. Yet, Zacharakis and Shepherd (2001) analyzed whether Venture Capitalists (VCs) are victims of overconfidence when evaluating firms' potential, as well as the elements surrounding the choice that lead to overconfidence. The outcomes of their experiment demonstrated that VCs are undoubtedly overconfident (96% of the 51 VCs showed a critical level of overconfidence), which negatively influences VC's decision efficiency. In particular, they found that when VCs are familiar with decision-making processes, such as the evaluation of venture success, and the structure of the data included that choice, they resort to automatic information processing; they rely on limited information, leading them to fall victim to overconfidence. This has also been developed by a few later articles on the relationship of General Managers' dispositions and their capacity to carry on sustainability practices; specifically, Abatecola and Cristofaro (2019) demonstrated, through a literature review, that CEOs with large CSE are mostly certain in their analysis in carrying out unsustainable business practices. Translating the above mentioned at the collective level:

Hypothesis 2. *Teams with high CSE are more inclined to be victims of the overconfidence bias compared to teams with low and average CSE.*

As already mentioned, Hiller and Hambrick (2005) found that a high level of CSE is close with what is routinely called "hubris". They have also explored the connections between executive

distinctiveness and factors of organizational technique, structure, and execution; from that, they anticipate that hyper-CSE managers will display this characteristic in their work attitude. They state that executives with large CSE are beyond any questioning of their skills, and they consider significantly that the application of their competences will bring positive outcomes. CEs outlined that people who are extraordinarily beyond any doubt in their claim abilities, and make continued effort over time towards their targets, are persuaded to get compelling results in their career by picking up essential compensations and important roles in society. Yet, the link between CSE and performance has also been proved to work when judging candidates for job vacancies. In particular, Cristofaro (2017b) found, through a laboratory experiment involving personnel selection executives, that candidates who are perceived to have high CSE are also those that will achieve great performance; in contrast to low CSE candidates that are perceived as low performers. Translating the above mentioned at the collective level:

Hypothesis 3. *Teams with high CSE reach higher positive performance compared to teams with low and average CSE.*

4. Methodology

4.1. Research Context

For several decades, scholars used business games to investigate the accuracy of managerial decisions and their application through an analysis of the performances made by the participants of their experiments (Lainema and Makkonen 2003; Faria et al. 2009; Kim et al. 2013; Henriksen and Børgesen 2016; Korchinskaya et al. 2020). In this section, the simulation game 'General Management Business Game (GMBG)' (provided by Artémat) is briefly explained, which was used during the lectures of a general management course in one large Italian University, for training students in the management of firms as well as for doing this research. In this simulation game, students take the part of a General Manager of a small-sized manufacturing firm specialized in the production of mobile devices (e.g., Tablet.). Players aim to win contracts to manufacture and sell a large selection of articles, while tuning their businesses through the benchmarks of operations governance. This developing organization requires participants to take care of both the human and productive resources tailoring the optimization capacity, and because of this they should make several management decisions that touch all the aspects of the organization. This is proved within a module of the business game in which participants are asked to run all the managerial functions of the firm with the aim of achieving the highest possible performance for the firm—measured in terms of net worth, number of contracts signed, and gratification of clients. Students cross paths through "real-job" alternatives allowing them to work on management decision-making processes by collecting and analyzing data. The main performance indicator used to derive how the simulated firm was conducted is the net worth: the value of all the non-financial and financial assets owned by the firm minus the value of all its outstanding liabilities.

4.2. Experimental Design, Procedure and Measurements of Variables

To test the three developed hypotheses and answer the research paper's aim, 120 graduate students (57 male, 63 female, Average Age = 21.2 years, Standard Deviation (SD) = 1.3 years) following an optional management course in one large Italian University were involved in this research; participants, that can be considered as 'Millennials'; participants were rewarded for the experiment with University credits. The laboratory experiment, then followed by quantitative analysis, is considered as the most suitable research design in research fields that can be considered at a stage of development far from the nascent one (Edmondson and McManus 2007). These intermediate or mature fields of research—like the role of personal traits in decision making processes (see the review by Cristofaro 2017a)—are challenged by "focused questions and/or hypothesis relating existing constructs" (p. 1160).

Sampled students, as gleaned from informal conversation, had no or limited work experience; however, we did not control work experience in an empirical way. The selection of participants followed the convenience sampling approach (Given 2008), which is non-probability sampling that consists of selecting a sample from a part of the population that is close at hand. Despite the fact that a stream of scholars believe that students' samples are not suitable for behavioral research aiming to provide working implications for practitioners (e.g., Gallander Wintre et al. 2001), another equally important stream of research (e.g., Lucas 2003; Thomas 2011) believes that these samples are appropriate in cases of research emphasis on basic psychological processes. Concerning the latter, according to Berkowitz and Donnerstein (1982): "the meaning the subjects assign to the situation they are in and the behavior they are carrying out plays a greater part in determining the generalizability of an experiment's outcome than does the sample's demographic representativeness" (p. 249). So, here it is strongly believed that due to the aim of this research (thus, finding connections among CSE, overconfidence and decision-making performance) and the settings of the laboratory experiment, at least the internal validity of the research is guaranteed. This follows similar contributions on management decisions (see Cristofaro 2016) that consider students' samples and investigate psychological variables against decision-making performance.

At the beginning of the course, each participant was free to form a group with three other members; a total of 30 groups were composed. The experiment took place when participants were asked to run the final module of the simulation game in which they had all the managerial functions under control with the aim of grasping the most elevated conceivable execution for the firm. On the day of the experiment (when students were asked to play this final module of the simulation game), the leading researcher explained the interest in studying the relationship between their personality traits, some behavioral decision variables and their connections with performance in the simulation game.

Before running the final module of the simulation game, each participant was first invited to answer the 12-item CSE Scale (CSES) (Appendix A) and the seven-item Cognitive Reflection Test (CRT) (Appendix B) to measure their CSE degree and tendency to adopt intuitive or reflective thinking (explained later). Then they were asked to perform the last module of the simulation game; this occurred over 3 hours. During this time period, participants were not aware of their performance (in terms of net worth; tracked by the leading researcher). At the end of the simulation game, each individual, within groups, was asked to estimate the final net worth of their firm and to note it on a paper. Variables at the center of the developed hypotheses to be tested were measured as follows.

Core Self-Evaluations: The CSE score of each group was calculated according to the average of the CSE score of its members. The CSE score at the individual level was derived by asking participants to complete the 12-item Core Self-Evaluations Scale (CSE by (Judge et al. 2003) in Appendix A; test-retest accuracy was 0.81 over a one-month span) which, rather than measuring the four characteristics comprised within the CSE independently and weighting the scores, provides an explicit and integrative estimation of a person's core self-perception. Respondents were asked to rank their predisposition on the 12 items according to a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) (see also Joo et al. 2012). It is worth noticing that values assigned to reverse grade questions were subtracted; from that, the maximum and minimum value that can be reached by completing the CSE are, respectively, +24 and −24, with a neutral point at 0. Thanks to the STATA function called 'egen'[1], it was possible to derive three main clusters according to the average CSE value of groups: (i) low CSE groups (whose averages range from −24 to −9), (ii) average CSE groups (whose averages range from −8 to +8), and (iii) high CSE groups (whose averages range from +9 to +24). Thanks to that, the initial 30 groups were reallocated in these three clusters, equating to 10 groups each.

Reflective and intuitive thinking: To assess the cognitive predisposition of respondents between reflective and intuitive thinking, the seven-item CRT by Toplak et al. (2014) was adopted (Appendix B),

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[1]   computed as: egen CSE = cut(CSE), at(−9,8,24).

which extends the three-item CRT formulated by Frederick (2005). The seven questions are constructed such that they have an instinctive but erroneous reply that arises rapidly and an appropriate reply that is simple to catch when it is clarified. Subsequently, the test is presumed to estimate a person's tendency to engage in intuitive or reflective thinking (Patel et al. 2019). Each correct answer was counted as 1, while an incorrect answer was 0; so, the maximum and minimum values that can be reached by completing the CRT are, respectively, 7 and 0. After having calculated the sum of correct and incorrect answers for each individual, this value was summed with the ones of the other members of the group and a final average was derived. Among the participants who did not yield the proper reply, the instinctive one was usually the most given answer.

Overconfidence (overestimation): Moore and Healy (2008), as already introduced, defined that overconfidence usually has been measured in terms of overestimation and this is the definition of overconfidence that has been operationalized for this study. In particular, during the simulation game participants were not made aware of their current net worth; at the end of their performance, each individual, within groups, was asked to make an estimation of their final net worth. After collecting each individual's estimation of their net worth, this value was summed with those of the other members of the group and a final average was derived. To calculate the overestimation of each group, the final average of the estimation of the net worth of the group was compared with the actual net worth and a subtraction was made to find the overall overestimation of their results. This procedure is in line with the one adopted by Hoppe and Kusterer (2011).

Performance. To measure the groups' performance—the outcome of management decisions that have been collectively made by groups—during the simulation game, the net worth variable (as suggested by McGraw Hill's instruction material) was taken as the best representative of performance reached within the simulation game. The net worth is the value of all the non-financial and financial assets owned by the firm minus the value of all its outstanding liabilities; this is automatically calculated by the software. This variable has also been used as an indicator of firms' performance by other authors in the past (Penrose 1956; Carlstrom and Fuerst 1997).

Data analysis: To test the three developed hypotheses, three one-way Analysis of Variance (ANOVA) have been implemented. This is the most suitable statistical technique that can be used in order to compare means of two or more samples to find significant differences, if any (Field 2013). A Tukey post hoc test was conducted after each One-way ANOVA to determine the significant differences among groups.

5. Results

To verify whether teams with high CSE are more inclined to intuitive thinking rather than average and low CSE groups (H1), a one-way ANOVA was firstly implemented considering the different CSE clusters (low, average, high) and their groups' results on the CRT test.

As shown in Table 1, there was a statistically significant difference between groups as determined by the one-way ANOVA ($F(2,27) = 80.510$, $p = 0.000$). A Tukey post hoc test, shown in Table 2, revealed that high CSE groups were more inclined to the average CSE groups for intuitive thinking (−4.2 right answers compared with them; $p = 0.00$), but they were equally inclined to intuitive thinking with respect to low CSE groups ($p = 0.964$) ($p = 0.989$). So, H1 is *partly* verified.

Table 1. ANOVA Table—CSE on intuitive-reflective thinking.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	120.467	2	60.233	80.510	0.000
Within Groups	20.200	27	0.748		
Total	140.667	29			

Table 2. Post-hoc test—CSE on intuitive-reflective thinking.

(I) CSE	(J) CSE	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Low CSE	Average CSE	−4.30000 *	0.38682	0.000	−44.181	−41.819
	High CSE	−0.10000	0.38682	0.964	−0.2181	0.0181
Average CSE	Low CSE	4.30000 *	0.38682	0.000	41.819	44.181
	High CSE	4.20000 *	0.38682	0.000	40.819	43.181
High CSE	Low CSE	0.10000	0.38682	0.964	−0.0181	0.2181
	Average CSE	−4.20000 *	0.38682	0.000	−43.181	−40.819

* The mean difference is significant at the 0.05 level.

In order to verify whether teams with high CSE are more inclined to be victims of the overconfidence bias compared to teams with low and average CSE (H2), a one-way ANOVA was implemented considering the different CSE clusters (low, average, high) and their average teams' estimation of performance.

As shown in Table 3, there was a statistically significant difference between groups as determined by the one-way ANOVA ($F(2,27) = 295.962$, $p = 0.000$). A Tukey post hoc test, shown in Table 4, revealed that high CSE groups were more inclined to the average CSE groups (+$12,000 of net worth overestimation compared with them; $p = 0.00$) and low CSE groups (+$30,000 of net worth overestimation compared with them; $p = 0.00$) to be victims of the overconfidence bias. So, high CSE groups were the ones that overestimated their performance more than other CSE groups, while low CSE groups were the ones that overestimated their performance least compared to other CSE groups. So, H2 is verified.

Table 3. ANOVA Table—CSE on overconfidence.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.560	2	2.280	295.962	0.000
Within Groups	208,000,000	27	7,703,703.70		
Total	4.768	29			

Table 4. Post-hoc test—CSE on overconfidence.

(I) CSE	(J) CSE	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Low CSE	Average CSE	−18,000.00 *	1241.26	0.000	−18,379.008	−17,620.992
	High CSE	−30,000.00 *	1241.26	0.000	−30,379.008	−29,620.992
Average CSE	Low CSE	−18,000.00 *	1241.26	0.000	17,620.992	18,379.0077
	High CSE	−12,000.00 *	1241.26	0.000	−12,379.008	−11,620.9923
High CSE	Low CSE	−30,000.00 *	1241.26	0.000	29,620.9923	30,379.0077
	Average CSE	−12,000.00 *	1241.26	0.000	11,620.9923	12,379.0077

* The mean difference is significant at the 0.05 level.

In order to verify whether teams with high CSE reach higher positive performance compared to teams with low and average CSE (H3), a one-way ANOVA was implemented (see Table 5) considering the different CSE clusters (low, average, high) and their average teams' actual performance in terms of net worth.

Table 5. ANOVA Table—CSE on actual performance.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.388	2	2.694	113.384	0.000
Within Groups	6.415	27	2,376,000,000		
Total	6.030	29			

As shown in Table 5, there was a statistically significant difference between groups as determined by the one-way ANOVA (F(2,27) = 113.384, *p* = 0.000). A Tukey post hoc test, shown in Table 6, revealed that high CSE groups reached greater performance than low CSE groups (+$50,800 of net worth overestimation compared with them; *p* = 0.00), but they reached lower performance than average CSE groups (who, on average, gained +$53,000 of net worth). So, H3 is partly verified.

Table 6. Post-hoc test—CSE on actual performance.

(I) CSE	(J) CSE	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Low CSE	Average CSE	−103,800.00 *	6893.47518	0.000	−105,904.8518	−101,695.1482
	High CSE	−50,800.00 *	6893.47518	0.000	−52,904.8518	−48,695.1482
Average CSE	Low CSE	103,800.00 *	6893.47518	0.000	101,695.1482	105,904.8518
	High CSE	53,000.000 *	6893.47518	0.000	50,895.1482	55,104.8518
High CSE	Low CSE	50,800.000 *	6893.47518	0.000	48,695.1482	52,904.518
	Average CSE	−53,000.00 *	6893.47518	0.000	−55,104.8518	−50,895.1482

* The mean difference is significant at the 0.05 level.

6. Discussion and Implications

This work offers a contribution to the debate about how CSE influences team decision-making processes. In order to do so, the research has been based on the analysis of four variables: CSE, intuitive/reflective thinking, overconfidence, and performance. Accordingly, three hypotheses have been formulated and tested—through one-way ANOVA and Tukey post hoc tests—on a sample population composed of 120 students while taking part in a simulation game in which they were asked to make decisions, in groups, acting in the role of the General Manager of a small-sized manufacturing firm.

The results only partially verified the first hypothesis. In fact, both teams with high and low CSE are equally inclined to intuitive thinking. This aspect deserves particular attention; indeed, if it is true that previous literature on the topic (e.g., Hiller and Hambrick 2005; Jordan et al. 2007; Claxton et al. 2015) has already recognized the existence of a link between high levels of CSE and intuitive thinking, it is surprising to see that also groups with a low level of CSE have the same predisposition to intuitive thinking. Therefore, the high self-consideration by individual/groups seems to lead to the same consequence of having low self-consideration: being inclined to intuitive thinking. Despite that, this result can be considered in line with the study of Rudolph et al. (2009) (see also the similar one by Cristofaro 2016) who found, through a computer-based simulation on data collected in clinical decision making, that the decision-making behavior that usually leads to wrong decision options is usually carried out by people that take too little, or too much, time to make a decision. These results complete these studies by providing the explanation at a personal trait level of why this different decision behavior occurs. The results totally confirm the second hypothesis. In fact, teams with a high CSE level were more predisposed to both average and low CSE groups of falling into the overconfidence trap. This is perfectly in line with previous literature on these topics (e.g., Baumeister et al. 1993; Kramer et al. 1993; Zacharakis and Shepherd 2001) and highlights how high CSE groups, overestimating

their capabilities, tend to "destroy" their decision-making ability (Abatecola et al. 2018; Abatecola and Cristofaro 2019). Lastly, results only partially verified the third hypothesis. In fact, if it is true that high CSE groups reached higher positive performance compared to low CSE groups—as already demonstrated by previous researches (e.g., Hiller and Hambrick 2005; Cristofaro 2017b); it is also (surprisingly) true that average CSE groups reached more positive performance compared to high CSE groups. By linking the results of the test of the first and third hypothesis, it emerges that groups with a high level of intuitive thinking (corresponding to the ones having high or low CSE scores) are not the best performers in decision-making terms. This result contributes to the debate on the consequences of intuition in management decision making. In particular, it supports a stream of prior results highlighting that intuitive thinking leads to poor quality of decisions (Elbanna et al. 2013), which consequently leads to poor firm performance (Goll and Rashe 1997). This happens, as suggested by Elbanna et al. (2013), because intuitive decision makers are impatient with routine or details—i.e., they have a poor systemic search for information—and are pushed, by their nature, to quickly reach conclusions and to ignore negative problems. However, despite reinforcing this stream of works, another important one has found a positive relationship between intuition and firm performance; such as in developing technologies, sizing new opportunities, and providing effective responses to crises (Bullini Orlandi and Pierce 2020). What is the determinant for the success of intuitive thinking seems to be, according to Bullini Orlandi and Pierce (2020), the dynamicity of the industry environment; indeed, in cases of highly dynamic and turbulent environments with the presence of real-time data, intuitive thinking is preferred rather than the reflective one. In sum, despite the confirming results of this work in substantiating a negative role of intuitive thinking in decision making, the rapid change of contextual and environmental variables can lead to positive effects of intuitive thinking—in line with the ecological rationality approach (Gigerenzer and Brighton 2009).

Thanks to this work, the results provided extend those of cited and discussed contributions, offering a more solid base for the highlighted assumptions by providing an empirical assessment of an established personal trait variable, CSE. Indeed, cited studies only assumed this relationship looking at one of the four pillars of the CSE, such as self-esteem (e.g., Kramer et al. 1993; Baumeister et al. 1993; Jordan et al. 2007), or by providing a theoretical explanation (Hiller and Hambrick 2005; Abatecola et al. 2018; Abatecola and Cristofaro 2019). Moreover, this is the first study that investigates the outlined relationship at a group level, practically overcoming the limits of the others that considered only the individual level of analysis.

Based on the exposed results, some important managerial implications can be derived for practitioners, especially the younger ones (Millennials) with a similar age to the sampled students. Firstly, as CSE is a personal trait, it is not possible to suppress it in an absolute sense; or, at least, it is very difficult in a short or medium range timescale. However, practitioners can reduce its value to an average by composing an ad hoc team. They can, in practice, bring together people with different CSE levels so that the CSE average will result as "acceptable"—namely, the score of their CSE needs to be between −8 to +8 points—there will be a balance between intuitive and reflective thinking in the team and, thus, the possibility of avoiding the overconfidence trap and the opportunity of achieving satisfactory performance. Thus, it is fundamental that human resource managers track the CSE level of each individual within organizations. In this way, they also have the possibility of appropriately suggesting—to department or unit heads—the "best team composition" to achieve better decisional and organizational performance. At the same time, if an organization needs to quickly respond to internal or external pressures, such as identifying a commercial strategy to counteract a sudden, huge price cut of a competitor, composing teams of individuals with exclusively high or low CSE levels can be beneficial for the production of intuitive (and quick) responses.

Despite the rigor with which the experiment was conducted, this study has some limitations, which also represent fruitful starting points for future researches on these topics. Firstly, the sample population is composed by students, which means that most have little or no work experience. A second and connected limit is determined by the fact that the experiment was conducted during

course lectures; therefore, participants applied their strategies in an environment in which they were comfortable. In particular, they acted without being subjected to external pressure and this could have biased, for example, their risk orientation—with obvious consequences on the potential performance that would have been attained with another 'purer behavior'. A third and no less important limitation of this research arises from the fact that some variables have not been controlled, for example, work experience and risk orientation, although in real life they obviously affect the behavior and attitude of managers in managing situations and acting upon them. Finally, a fourth and last research limit results from the structure of the platform provided to the students. Indeed, like all simulation games, there are limitations about the representation of all the variables that are played within real world choices. In sum, despite the fact that respondents' decisions have been implemented (and tracked by the researchers) within a very well simulated environment (i.e., the simulation game), which is better than paper-based cases, sampling managers in real life situations would be necessary for extending the generalizability of these results. Future research can surely solidify the results of this work by avoiding the outlined limits; moreover, following Abatecola et al. (2018), future research avenues could investigate if there are other cognitive distortions (e.g., self-serving, emotion and cognition collision) in managerial decision making—in addition to overconfidence—that are linked to and influenced by CSE. Yet, the results of this work should be highly considered by scholars that want to deepen the antecedents of intuition and its outcomes in strategic decision-making (see Elbanna et al. 2013). In particular, future research can test whether trait variables—CSE above all—have more weight than contextual and environmental ones in determining the thinking style of decision makers. Last but not least, the link between CSE and performance could be deepened also by looking at the emotional answers that high, average, and low CSE groups have when facing some decisional situations. These can reinforce the debate and operationalization of intuitive thinking which, nowadays, still does not take the role of emotions in substantiating intuitive answers into very high consideration.

The originality of this work is threefold. Firstly, we are not aware of any study that has investigated the influence exercised on decision-making processes by CSE in relation to reflective/intuitive thinking, overconfidence, and performance. Secondly, these relationships have always been investigated at the "individual level". However, most of the tasks in an organization are performed at team level and decisions are rarely made individually; thus, this study adopts a "team/group level" to evaluate the importance and the influence of these aspects on organizations. Thirdly and lastly—despite the limitations previously exposed—this paper gives evidence of what really happens within organizations without resorting to case studies but, instead, is shown through the direct participation of individuals—i.e., students—acting as General Managers.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A Core-Self Evaluation Scale

1. _____ I am confident I get the success I deserve in life.
2. _____ Sometimes I feel depressed. (reverse grade)
3. _____ When I try, I generally succeed.
4. _____ Sometimes when I fail, I feel worthless. (reverse grade)
5. _____ I complete tasks successfully.
6. _____ Sometimes I do not feel in control of my work. (reverse grade)
7. _____ Overall, I am satisfied with myself.
8. _____ I am filled with doubts about my competence. (reverse grade)
9. _____ I determine what will happen in my life.

10.   _____ I do not feel in control of my success in my career. (reverse grade)

11.   _____ I am capable of coping with most of my problems.

12.   _____ There are times when things look pretty bleak and hopeless to me. (reverse grade)

Appendix B Seven-Item Cognitive Reflection Test

1.   A bat and a ball together cost 110 cents. The bat costs 100 cents more than the ball. How much does the ball cost? (intuitive answer: 10 cents; reflective answer: 5 cents).

2.   If it takes 5 machines 5 min to make 5 widgets, how long would it take 100 machines to make 100 widgets? (intuitive answer: 100 min; reflective answer: 5 min).

3.   In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? (intuitive answer: 24 days; reflective answer: 47 days).

4.   If John can drink one barrel of water in 6 days, and Mary can drink one barrel of water in 12 days, how long would it take them to drink one barrel of water together? (intuitive answer: 9; reflective answer: 4).

5.   Jerry received both the 15th highest and the 15th lowest mark in the class. How many students are in the class? (intuitive answer: 30; reflective answer: 29).

6.   A man buys a pig for £60, sells it for £70, buys it back for £80, and sells it finally for £90. How much has he made? (intuitive answer: £10; reflective answer: £20).

7.   Simon decided to invest £8000 in the stock market one day early in 2008. Six months after he invested, on July 17, the stocks he had purchased were down 50%. Fortunately for Simon, from July 17 to October 17, the stocks he had purchased went up 75%. At this point, Simon has: a. broken even in the stock market. b. is ahead of where he began. c. has lost money. (intuitive answer: b; reflective answer: c value is £7000).

References

Abatecola, Gianpaolo, and Matteo Cristofaro. 2019. Ingredients of Sustainable CEO Behavior: Theory and Practice. *Sustainability* 11: 1950. [CrossRef]

Abatecola, Gianpaolo, Andrea Caputo, and Matteo Cristofaro. 2018. Reviewing cognitive distortions in managerial decision making. Toward an integrative co-evolutionary framework. *Journal of Management Development* 37: 409–24. [CrossRef]

Baumeister, Roy F., Todd F. Heatherton, and Dianne M. Tice. 1993. When ego threats lead to self-regulation failure: Negative consequences of high self-esteem. *Journal of Personality and Social Psychology* 64: 141–56. [CrossRef]

Bazerman, Max H., and Don A. Moore. 2013. *Judgment in Managerial Decision Making*. New York: Wiley.

Berkowitz, Leonard, and Edward Donnerstein. 1982. External validity is more than skin deep: Some answers to criticisms of laboratory experiments. *American Psychologist* 37: 245–57. [CrossRef]

Bullini Orlandi, Ludovico, and Paul Pierce. 2020. Analysis or intuition? Reframing the decision-making styles debate in technological settings. *Management Decision* 58: 129–45. [CrossRef]

Busic-Sontic, Ante, Natalia V. Czap, and Franz Fuerst. 2017. The role of personality traits in green decision-making. *Journal of Economic Psychology* 62: 313–28. [CrossRef]

Cain, Daylian M., Don A. Moore, and Uriel Haran. 2015. Making sense of overconfidence in market entry. *Strategic Management Journal* 36: 1–18. [CrossRef]

Carlstrom, Charles T., and Timothy S. Fuerst. 1997. Agency costs, net worth, and business fluctuations: A computable general equilibrium analysis. *The American Economic Review* 87: 893–910.

Chen, Guoli, Craig Crossland, and Shuqing Luo. 2015. Making the same mistake all over again: CEO overconfidence and corporate resistance to corrective feedback. *Strategic Management Journal* 36: 1513–35. [CrossRef]

Claxton, Guy, David Owen, and Eugene Sadler-Smith. 2015. Hubris in leadership: A peril of unbridled intuition? *Leadership* 11: 57–78. [CrossRef]

Cristofaro, Matteo. 2016. Cognitive styles in dynamic decision making. A laboratory experiment. *International Journal of Management and Decision Making* 15: 53–82.

Cristofaro, Matteo. 2017a. Herbert Simon's Bounded Rationality: its Evolution in Management and Cross-feritilizing Contribution. *Journal of Management History* 23: 170–90. [CrossRef]

Cristofaro, Matteo. 2017b. Candidates' Attractiveness in Selection Decisions: A Laboratory Experiment. *Baltic Journal of Management* 12: 390–407. [CrossRef]

Cristofaro, Matteo. 2018. *Processi cognitivi e decisioni aziendali. Evidenze di razionalità limitata*. Roma: Aracne.

Cristofaro, Matteo. 2019. The role of affect in management decisions: A systematic review. *European Management Journal* 37: 6–17. [CrossRef]

Cristofaro, Matteo. 2020. "I feel and think, therefore I am": An Affect-Cognitive Theory of management decisions. *European Management Journal* 8: 344–55. [CrossRef]

Croskerry, Pat, and Geoff Norman. 2008. Overconfidence in clinical decision making. *The American Journal of Medicine* 121: S24–S29. [CrossRef]

Edmondson, Amy C., and Stacy E. McManus. 2007. Methodological fit in management field research. *Academy of Management Review* 32: 1246–64. [CrossRef]

Elbanna, Said, John Child, and Mumin Dayan. 2013. A model of antecedents and consequences of intuition in strategic decision-making: Evidence from Egypt. *Long Range Planning* 46: 149–76. [CrossRef]

Erez, Amir, and Timothy A. Judge. 2001. Relationship of core self-evaluations to goal setting, motivation, and performance. *Journal of Applied Psychology* 86: 1270–79. [CrossRef]

Faria, Anthony J., David Hutchinson, William J. Wellington, and Steven Gold. 2009. Developments in business gaming: A review of the past 40 years. *Simulation & Gaming* 40: 464–87.

Field, Andy. 2013. *Discovering Statistics Using IBM SPSS Statistics*. London: Sage Publications.

Frederick, Shane. 2005. Cognitive reflection and decision making. *Journal of Economic Perspectives* 19: 25–42. [CrossRef]

Gallander Wintre, Maxine, Cristopher North, and Lorne A. Sugar. 2001. Psychologists' response to criticisms about research based on undergraduate participants: A developmental perspective. *Canadian Psychology/Psychologie Canadienne* 42: 216–25. [CrossRef]

Gigerenzer, Gerd, and Henry J. Brighton. 2009. Homo heuristicus: Why biased minds make better inferences. *Topics in Cognitive Science* 1: 107–43. [CrossRef] [PubMed]

Given, Lisa. 2008. *Convenience Sample*. London: SAGE Publications.

Goll, Irene, and Abdul M. A. Rashe. 1997. Rational decision-making and firm performance: The moderating role of environment. *Strategic Management Journal* 18: 583–91. [CrossRef]

Gudmundsson, Sveinn V., and Christian Lechner. 2013. Cognitive biases, organization, and entrepreneurial firm survival. *European Management Journal* 31: 278–94. [CrossRef]

Hammond, S. John, Ralph L. Keeney, and Howard Raiffa. 1998. The hidden traps in decision making. *Harvard Business Review* 76: 47–58.

Hayward, Mathew L., and Donald C. Hambrick. 1997. Explaining the premiums paid for large acquisitions: Evidence of CEO hubris. *Administrative Science Quarterly* 42: 103–27. [CrossRef]

Henriksen, Thomas D., and Kristine Børgesen. 2016. Can good leadership be learned through business games? *Human Resource Development International* 19: 388–405. [CrossRef]

Hiller, Nathan J., and Donald C. Hambrick. 2005. Conceptualizing executive hubris: the role of. hyper-) core self-evaluations in strategic decision-making. *Strategic Management Journal* 26: 297–319. [CrossRef]

Hollenbeck, John R., Ellen M. Whitener, and Karen E. Pauli. 1988. An empirical note on the interaction of personality and aptitude in personnel selection. *Journal of Management* 14: 441–51. [CrossRef]

Hoppe, Eva I., and David J. Kusterer. 2011. Behavioral biases and cognitive reflection. *Economics Letters* 110: 97–100. [CrossRef]

Inuwa, M. 2016. Job satisfaction and employee performance: An empirical approach. *The Millennium University Journal* 1: 90–103.

Joo, Bryan Baek-Kyoo, Hea Jun Yoon, and Chang-Wook Jeung. 2012. The effects of core self-evaluations and transformational leadership on organizational commitment. *Leadership & Organization Development Journal* 33: 564–82.

Jordan, Christian H., Mervyn Whitfield, and Zeigler-Hill Virgil. 2007. Intuition and the correspondence between implicit and explicit self-esteem. *Journal of Personality and Social Psychology* 93: 1067–79. [CrossRef] [PubMed]

Judge, Timothy A., and Joyce E. Bono. 2001. Relationship of core self-evaluations traits: self-esteem, generalized self-efficacy, locus of control, and emotional stability with job satisfaction and job performance: A meta-analysis. *The Journal of Applied Psychology* 86: 80–92. [CrossRef]

Judge, Timothy A., and Charlice Hurst. 2008. How the rich and happy get richer and happier: Relationship of core self-evaluations to trajectories in attaining work success. *Journal of Applied Psychology* 93: 849–63. [CrossRef] [PubMed]

Judge, Timothy A., Edwin A. Locke, and Cathy C. Durham. 1998. The dispositional causes of job satisfaction: A core evaluations approach. *Journal of Applied Psychology* 83: 17–34. [CrossRef] [PubMed]

Judge, Timothy A., Amir Erez, Joyce E. Bono, and Carl J. Thoresen. 2003. The Core Self-Evaluations scale. CSE): Development of a measure. *Personnel Psychology* 56: 303–31. [CrossRef]

Judge, Timothy A., Charlice Hurst, and Lauren S. Simon. 2009. Does it pay to be smart, attractive, or confident. or all three)? Relationships among general mental ability, physical attractiveness, core self-evaluations, and income. *The Journal of Applied Psychology* 94: 742–55. [CrossRef]

Kahneman, Daniel. 2003. A perspective on judgment and choice: Mapping bounded rationality. *American Psychologist* 58: 697–720. [CrossRef]

Kahneman, Daniel. 2011. *Thinking, Fast and Slow*. New York: Macmillan.

Kahneman, Daniel, and Amos Tversky. 1974. Subjective probability: A judgment of representativeness. In *The Concept of Probability in Psychological Experiments*. Edited by Carl-Alex Axen and Stael Von Holstein. Heidelberg: Springer, pp. 25–48.

Kahneman, Daniel, and Amos Tversky. 1979. Prospect theory: An analysis of decisions under risk. *Econometrica* 47: 263–91. [CrossRef]

Kahneman, Daniel, Dan Lovallo, and Oliver Sibony. 2011. The big idea. Before you make that big decision. *Harvard Business Review* 89: 50–60. [PubMed]

Kim, Hyunjung, Roderick H. MacDonald, and David F. Andersen. 2013. Simulation and managerial decision making: a double-loop learning framework. *Public Administration Review* 73: 291–300. [CrossRef]

Koontz, Harold, Ciryl O'Donnell, and Heins Weihrich. 1980. *Management*. New York: Mc-Graw-Hill.

Korchinskaya, Olga, Irina Ivanova, Natalia Shchukina, and Marjana Mendziv. 2020. Business Games as a Teaching Strategy for Delivering a Practice-Oriented Course in Mathematics at Agricultural University. In *International Scientific Conference The Fifth Technological Order: Prospects for the Development and Modernization of the Russian Agro-Industrial Sector. TFTS 2019*. Paris: Atlantis Press, pp. 355–61.

Kramer, Roderick M., Elizabeth Newton, and Pamela L. Pommerenke. 1993. Self-enhancement biases and negotiator judgment: Effects of self-esteem and mood. *Organizational Behavior and Human Decision Processes* 56: 110–33. [CrossRef]

Lainema, Timo, and Pekka Makkonen. 2003. Applying constructivist approach to educational business games: Case REALGAME. *Simulation & Gaming* 34: 131–49.

Luan, Shenghua, Jochen Reb, and Gerd Gigerenzer. 2019. Ecological rationality: Fast-and-frugal heuristics for managerial decision making under uncertainty. *Academy of Management Journal* 62: 1735–59. [CrossRef]

Lucas, Jeffrey W. 2003. Theory-testing, generalization, and the problem of external validity. *Sociological Theory* 21: 236–53. [CrossRef]

Mata, André, Mario B. Ferreira, and Seven J. Sherman. 2013. The metacognitive advantage of deliberative thinkers: A dual-process perspective on overconfidence. *Journal of Personality and Social Psychology* 105: 353–73. [CrossRef]

Moore, Don A., and Paul J. Healy. 2008. The trouble with overconfidence. *Psychological Review* 115: 502–17. [CrossRef]

Nag, Rajiv, Francois Neville, and Nikolaos Dimotakis. 2020. CEO scanning behaviors, self-efficacy, and SME innovation and performance: An examination within a declining industry. *Journal of Small Business Management* 58: 164–99. [CrossRef]

Paniccia, Paola M. A. 2002. *Dinamiche temporali e cognitive nell'approccio sistemico al governo dell'impresa*. Padova: Cedam.

Park, Sun H., James D. Westphal, and Ithai Stern. 2011. Set up for a fall: The insidious effects of flattery and opinion conformity toward corporate leaders. *Administrative Science Quarterly* 56: 257–302. [CrossRef]

Patel, Niraj, Glenn Baker, and Laura Scherer. 2019. Evaluating the cognitive reflection test as a measure of intuition/reflection, numeracy, and insight problem solving, and the implications for understanding real-world judgments and beliefs. *Journal of Experimental Psychology: General* 148: 2129–53. [CrossRef]

Penrose, Edith T. 1956. Foreign investment and the growth of the firm. *The Economic Journal* 66: 220–35. [CrossRef]

Powell, Thomas C., Dan Lovallo, and Craig R. Fox. 2011. Behavioral strategy. *Strategic Management Journal* 32: 1369–86. [CrossRef]

Rudolph, Jenny W., Bradley Morrison, and John S. Carroll. 2009. The dynamics of action-oriented problem solving linking interpretation and choice. *Academy of Management Review* 34: 733–56.

Shiller, Robert J. 2005. *Irrational Exuberance*, 2nd ed. Princeton: Princeton University Press.

Silvester, Joanne, Fiona M. Anderson-Gough, Neil R. Anderson, and Afandi R. Moham. 2002. Locus of control, attributions and impression management in the selection interview. *Journal of Occupational and Organizational Psychology* 75: 59–76. [CrossRef]

Simon, Herbert A. 1947. *Administrative Behavior*. New York: The Free Press.

Thomas, Rodney W. 2011. When student samples make sense in logistics research. *Journal of Business Logistics* 32: 287–90. [CrossRef]

Toplak, Meggie E., Richard F. West, and Keith E. Stanovich. 2014. Assessing miserly information processing: An expansion of the Cognitive Reflection Test. *Thinking & Reasoning* 20: 147–68.

Wu, Wei-Lee, and Yi-Chin Lee. 2016. Do employees share knowledge when encountering abusive supervision? *Journal of Managerial Psychology* 31: 154–68. [CrossRef]

Zacharakis, Andrew L., and Dean A. Shepherd. 2001. The nature of information and overconfidence on venture capitalists' decision making. *Journal of Business Venturing* 16: 311–32. [CrossRef]

Zell, Ethan, Jason E. Strickhouser, Constantine Sedikides, and Mark D. Alicke. 2020. The better-than-average effect in comparative self-evaluation: A comprehensive review and meta-analysis. *Psychological Bulletin* 146: 118–49. [CrossRef] [PubMed]

Managerial Decision Making in Indicating a Disruption of Critical Infrastructure Element Resilience

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Abstract: Managerial decision making is an integral process used in public and private organizations. Critical infrastructure entities are a strategically significant group dependent on the quality of decision-making processes. They aim to provide services necessary to ensure state security and to satisfy basic human needs. The quality of decision making is an important factor in the management of these entities. The quality level is determined by many factors, the key of which is risk management. For this reason, it is necessary for the operators to minimize risks affecting the elements of the critical infrastructure through which these services are provided. Risk management is commonly used for this purpose, making it possible to assess and manage these risks. However, there is a specific group of threats that affects the resilience of these elements. The indication of these threats is not possible through common risk management. Therefore, it is necessary to develop specific scenarios of negative impacts and procedures for assessing their impact on the resilience of elements of the critical infrastructure. To this end, this conceptual article introduces an entirely new managerial decision-making process for indicating the resilience of critical infrastructure elements.

Keywords: managerial process; decision making; critical infrastructure elements; resilience; disruption; indication

1. Introduction

As infrastructures are crucial for the functioning of the state and are irreplaceable or difficult to replace, they are referred to as systems of critical infrastructure. Currently, systems of critical infrastructure are being widely discussed due to growing threats. In terms of maintaining the operability and continuity of this system, it is important to focus on their protection. Therefore, it is necessary to create measures which secure the functionality, the continuity of operation and also such measures which minimize the risks of disrupting the function of individual infrastructures (Rehak et al. 2019; Ristvej et al. 2013).

Infrastructures that are highly interconnected with dependent systems are considered especially important. The disruption or failure of these infrastructures would have far-reaching consequences for the security and economy of the state and basic human needs (European Council 2008). This is why it is necessary to especially protect these infrastructures by way of preventive measures in combination with the subsequent strengthening of their resilience towards specific threats. Resilience in the context of critical infrastructure can be perceived as the ability to reduce the magnitude, impact, or duration of a disruption. The effectiveness of a resilient infrastructure depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event (NIAC 2009). In the context of this

definition, the disruption of resilience can be understood as a degradation in the above-mentioned capabilities of critical infrastructure.

Managerial decision making plays an important role in the protection of critical infrastructure from the very beginning of solving the problem (Zimmerman 2004). Management is an integral part of economic, social and also technical solutions that help increase the resilience of critical infrastructure (Imani et al. 2020). The current critical infrastructure elements are managed by both the public and private sectors. As a result, the decision-making processes of public and private managers are also different (Nutt 2005). For this reason, the problem is focused only on managers of public operators of critical infrastructure (Bozeman and Pandey 2004), with whom the authors have been cooperating for a long time.

Risk management (ISO 2018) is commonly used for critical infrastructure element protection, making it possible to assess and manage these risks. This complex methodological overview was created as part of the publication Risk Assessment Methodologies for Critical Infrastructure Protection-Part I: A State of the Art (Giannopoulos et al. 2012) and Part II: A New Approach (Theocharidou and Giannopoulos 2015). The presented risk assessment methods are an effective preventive tool of a general nature, as they allow early identification of the risk, thus preventing the occurrence of adverse events (ISO 2018). However, these methods lack a link to the specifics related to resilience in a critical infrastructure system. By linking risk management and strengthening resilience, the protection of critical infrastructure is extended by the repressive part, i.e., the response to already-occurring adverse events (NIAC 2009).

For this reason, in recent years, particular attention has been paid to research into methods for assessing and strengthening critical infrastructure resilience, as resilience goes beyond traditional risk management (Petersen et al. 2020). This fact is evidenced, in particular, by articles dealing with resilience in the context of entire cities or urban areas (Chen et al. 2020; Li et al. 2020; Lu et al. 2020; Rehak et al. 2019) of their transport systems (Argyroudis et al. 2020; Machado-León and Goodchild 2017; Dvorak et al. 2017) or individual urban networks (Alizadeh and Sharifi 2020; Liu and Song 2020; Quitana et al. 2020; Shandiz et al. 2020). These approaches are realistically applicable and contribute to strengthening the resilience of critical infrastructure, but do not allow for the early indication of resilience disruption.

It can therefore be stated that there is currently no appropriate managerial tool that would explicitly deal with preventive measures for the protection of critical infrastructure elements. For this reason, the authors of this article have designed an entirely new process of managerial decision making for indicating a disruption in the resilience of critical infrastructure elements, which allows for the early identification of a potential disruption of the resilience of these elements. The added value of this proposal can be seen on two levels. At a theoretical level, it is an interdisciplinary integration of managerial decision making in the field of preventive protection of critical infrastructure elements. At a practical level, it is a matter of creating a new tool that will enable security managers to increase the preventive protection of critical infrastructure elements.

In conclusion, it is necessary to note that the presented article has the character of a conceptual document, which brings a possible solution forming the basic building blocks of the issue. This is a methodological procedure suitable for managerial decision making, the aim of which is to proactively increase the protection of critical infrastructure. Based on this fact, the authors defined the following research question: "Is it possible to preventively indicate a potential disruption of the critical infrastructure elements' resilience before the actual occurrence of the adverse event?"

Based on the above, the article is designed into four consecutive sections. The first section presents the critical infrastructure system and its resilience in the context of threats and the occurrence of adverse events that disrupt this resilience. Subsequently, attention is paid to the application of managerial decision making in the critical infrastructure system. The main part of the article is the third section, which presents the created process for indicating the disruption of the resilience of critical infrastructure elements. The last section then demonstrates the practical use of this process in the form of a case study.

2. Perception of Critical Infrastructure and Its Resilience

Critical infrastructure (CI) means an asset, system or part thereof located within Member States that is essential for the maintenance of vital societal functions and the health, safety, security, economic or social wellbeing of people, the disruption or destruction of which would have a significant impact on a Member State as a result of the failure to maintain those functions (European Council 2008). Critical infrastructure entities are understood to be owners/operators of CI elements responsible for investments in, and/or day-to-day operation of, a particular asset, system or part (European Council 2008).

The elements of critical infrastructure are, in particular, the buildings, facilities, resources or public infrastructure, which are designated according to cross-cutting and sectoral criteria.

2.1. Critical Infrastructure System

The purpose of the critical infrastructure system is to protect the critical infrastructure elements and to ensure the continuity of their operation, i.e., the provision of critically important services. To this end, an infrastructure element protection management process was created (see Figure 1), which shows the principles of the continual management cycle, e.g., the Plan–Do–Check–Act Cycle—PDCA (Tague 2005)—adapted to the conditions of the critical infrastructure system.
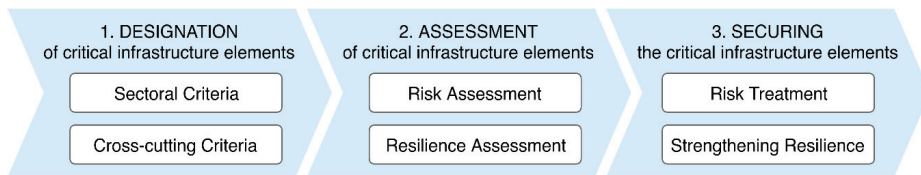
1. DESIGNATION of critical infrastructure elements	2. ASSESSMENT of critical infrastructure elements	3. SECURING the critical infrastructure elements
Sectoral Criteria	Risk Assessment	Risk Treatment
Cross-cutting Criteria	Resilience Assessment	Strengthening Resilience

Figure 1. Critical infrastructure element protection management process (Rehak et al. 2018a).

The first sub-process of protection management is the designation of critical infrastructure elements. This sub-process consists of correctly setting criteria for the identification of elements on the European, national, but also regional level. Within this process phase, it is also necessary to consider the suitability of the corresponding method for the identification of elements, which can be based on either the top-down or bottom-up principle (Twidale and Floyd 2008).

The second sub-process of protection management consists of the assessment of critical infrastructure elements. This sub-process consists of the risk assessment of relevant disruptive events (ISO 2018; IEC 2019; Bernatik et al. 2013) and the resilience assessment of an element of interest, its robustness, recoverability and adaptability (NIAC 2009).

The securing of critical infrastructure elements is the last sub-process in protection management and consists of managing risks and strengthening resilience. Risk management consists of the selection and implementation of one or more options in order to minimize risks, i.e., risk retention, risk transfer, risk reduction and/or risk avoidance (see e.g., ISO/IEC 2013). Strengthening resilience (e.g., Government of Canada 2014; Labaka et al. 2015) minimizes the vulnerability of subsystems, which in turn minimizes the occurrence, intensity and spread of failures and their impact on the critical infrastructure system and on society.

2.2. Resilience in a Critical Infrastructure System

The protection of critical infrastructure elements from the impacts of disruptive events is achieved through resilience. The effectiveness of a resilient infrastructure or enterprise depends upon its ability to anticipate, absorb, adapt to and/or rapidly recover from a potentially disruptive event (NIAC 2009).

Resilience in a critical infrastructure system that must necessarily be understood as a cyclical process of continual improvement of the prevention, absorption, recovery and adaptation of the system. Figure 2 presents a cycle showing the strengthening of resilience from the original level (i.e., the black

dashed line) to a new level (i.e., the red dashed line). The difference between these levels Δ is the degree of resilience strengthening.
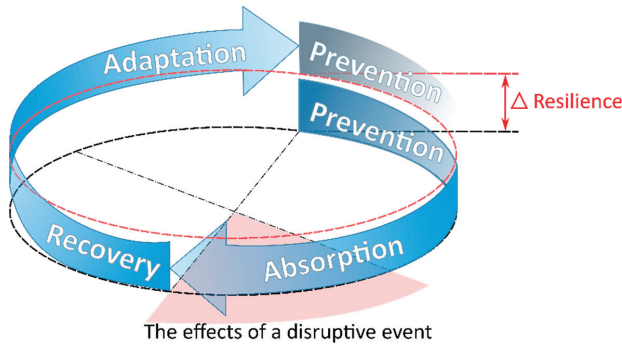

Figure 2. Critical Infrastructure Resilience Cycle (Rehak et al. 2018a).

In reference to the above, it can be noted that the resilience of critical infrastructure elements is determined by four components, which are resistance, robustness, recoverability and adaptability (NIAC 2009). Resistance is the ability of an element to protect itself from the occurrence of a disruptive event, i.e., prevention (Sugden 2001). Robustness is the ability of an element to absorb the impacts of a disruptive event without experiencing fluctuations in the provision of services, i.e., absorption (Stochino et al. 2019). Recoverability is the ability of an element to recover its activity to its original state or required operation level, i.e., recovery (Slivkova et al. 2017). Adaptability is the ability of an organization to adapt its element to the recurrence of an already occurred disruptive event-to learn from the past addressed disruptive events, i.e., adaptation (Denyer 2017). These components are further determined by individual variables, which are presented in Table 1.

Table 1. Components and variables determining the resilience of critical infrastructure elements (adjusted according to Rehak et al. 2018a).

Areas	Technical Resilience			Organizational Resilience
Components	**Resistance**	**Robustness**	**Recoverability**	**Adaptability**
Variables	Crisis preparedness Physical robustness	Redundancy Detection ability Responsiveness	Material resources Financial resources Human Resources Recovery processes	Risk management Innovation processes Educational and development processes

Resistance, robustness and recoverability are the foundation blocks of the technical resilience of critical infrastructure elements. These three components are determined in each element by three basic factors, which are the technological structure of the element, the element security measures and disruptive events, which are affected by resilience (Rehak et al. 2019).

Aside from technical resilience, the protection of critical infrastructure elements is also ensured by organizational resilience, which is created uniformly for all elements of the given operating organization (Rehak 2020). The organization's management assesses and strengthens this type of resilience from the prevention phase onward, and uses previous experience from dealing with elimination and recovery work processes to adjust the level of internal processes that are necessary in the critical infrastructure element adaptation phase.

2.3. Disruption of Resilience of Critical Infrastructure Elements

The technical organizational level of resilience of critical infrastructure elements can be disrupted by the impact of a disruptive event. Disruptive events are the harmful effects of forces and phenomena

caused by human activity and natural events, but also technical accidents that can endanger an element of the critical infrastructure. Within the context of the critical infrastructure, these disruptive events are caused by the negative impacts of threats, which can be classified into six basic categories (see Table 2).

Table 2. Classification of categories of threats to critical infrastructure elements (Rehak et al. 2019).

	Naturogenic	Technogenic	Anthropogenic
Internal threats	-	Technological	Personal
External threats	Geological, Meteorological	Cascading	Cybernetic, Physical

These threats are divided into internal and external, depending on the environment. Further division is then made based on the type of impact, naturogenic, technogenic or anthropogenic. This threat classification is based primarily on the Peril Classification and Hazard Glossary (IRDR 2014). The cascading threats category was added to the existing list due to the possibility of tracking the spread of failures across the critical infrastructure system due to cascading effects (Rinaldi et al. 2001; Rehak et al. 2018b).

During the course of an ongoing threat, the purpose of resilience is to protect the critical infrastructure element from the disruption of its function and to aid it in its recovery and adaptation to this event. During the threat's impact, however, it is being gradually weakened, which may lead to the disruption of the resilience itself. This state occurs mainly in the prevention phase, when the resistance of an element protects it from the occurrence of a disruptive event, and in the absorption phase, when the robustness of an element absorbs the impacts of an ongoing disruptive event.

3. Managerial Decision Making in the Critical Infrastructure System

The same rules for managerial decision making in critical infrastructure entities apply as in other organizations. Managerial decision making is a process which consists of six basic steps, namely setting managerial objectives, searching for alternatives, comparing and evaluating alternatives, the act of choice, implementing decisions and follow-up and control (Harrison 1999; Cifuentes 1972). This process is used for both general and specific activities. The general activities particularly include the decision making associated with the everyday management of the organization, planning or problem-solving. On the other hand, specific activities are those associated with the organization's specific focus.

The critical infrastructure entities' main activity is to provide services necessary for ensuring the security of the state and satisfying basic human needs (European Council 2008). Managerial decision making is implemented primarily in the phase of the identification and determination of critical infrastructure elements and their subsequent protection. For example, in the Czech Republic, critical infrastructure protection falls within the domain of crisis management (Rehak et al. 2016; Bartosikova et al. 2014). The main goal of critical infrastructure element protection is the management of such risks that can cause the disruption or failure of the function of these elements.

Risk management, within critical infrastructure protection, is based on general risk management principles (ISO 2018). The basic activities within risk management are the assessment and management of risks affecting the functioning of the critical infrastructure element (Rehak et al. 2016). Important work is continuously being published about this area, e.g., Risk assessment methodologies for critical infrastructure protection (Giannopoulos et al. 2012; Theocharidou and Giannopoulos 2015), Risk management goals and identification of critical infrastructures (Fekete et al. 2012), Risk management in critical infrastructure—Foundation for its sustainable work (Bialas 2016) and Applying risk management process in critical infrastructure protection (Luskova and Dvorak 2019). These publications focus primarily on the risk management process and the methodology of risk assessment and management.

However, the development of security engineering is accompanied by the identification of new possible approaches to protecting critical infrastructure elements, e.g., in the area of Indication of critical infrastructure resilience failures (Rehak et al. 2017). The disruption of resilience causes the weakening

of the protection of the critical infrastructure elements, due to which they are more vulnerable, leading to the possibility of their disruption or failure of their function. Due to this, the predictive identification process is a very beneficial approach, but has not yet been properly defined. At the same time, it is worth noting that the implementation of risk management in decision-making processes leads to the timely identification of potential risks, which can then be taken into account in individual phases of the decision-making process, especially in finding, comparing and evaluating alternatives to security measures (ISO 2018).

4. The Process of Indicating the Disruption of the Resilience of Critical Infrastructure Elements

The indication process consists of eight interconnected steps (see Figure 3), which provide the assessor with comprehensive instructions for assessing a possible disruption of the resilience of critical infrastructure elements. At the same time, it enables the assessment of the element's current level of resilience to disruptive elements and forms the basis for the decision to implement a security measure, which will make it possible to mitigate the impacts of the disruptive events weakening the resilience of the element. The resilience disruption indication process, among other things, sets the limit of exhaustion of the resilience absorption capacity, i.e., the limit beyond which the function of the element fails or is disrupted.
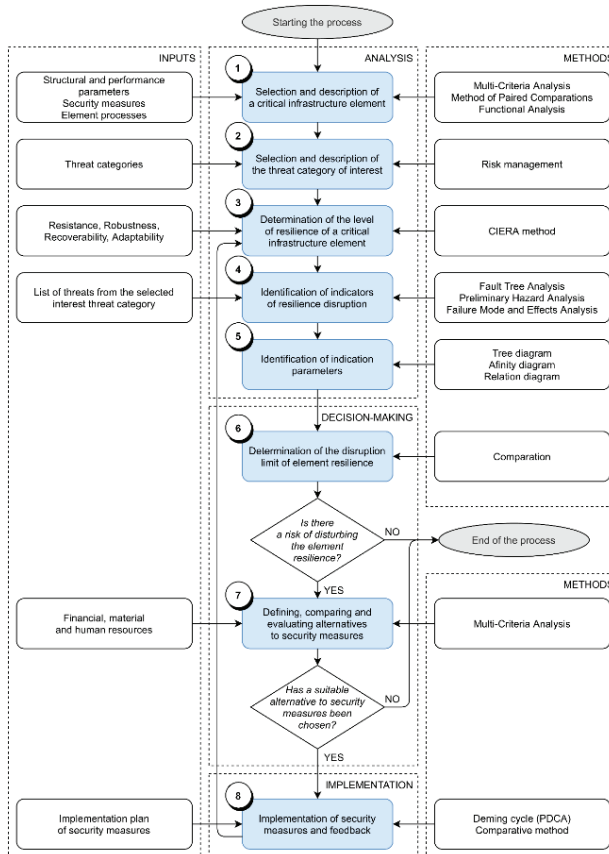

Figure 3. The process of indicating the disruption of the resilience of critical infrastructure elements.

The starting point for the creation of this process was to identify the absence of an approach suitable for indicating the disruption of the critical infrastructure elements' resilience. The current approaches are focused only on the assessing and strengthening of critical infrastructure resilience. Based on this fact, the authors created the process presented below, the essence of which is the analysis of the current state of interest of critical infrastructure and the subsequent introduction of optimal security measures contributing to good governance and cost-effective use of institutional funds. The methodological basis of this process is mainly the managerial and engineering methods presented in Figure 3.

4.1. Step 1: Selection and Description of a Critical Infrastructure Element

The first step of the process of indicating the disruption of the resilience of a critical infrastructure element is selection and subsequent description. The selection of the element is based on the participative decision making of interested parties, i.e., owners and operators of the critical infrastructure. In this step, it is appropriate to use methods which consist in the identification, assessment, assignment of weight and determination of the best possible option out of the selection. For this purpose can be used e.g., Multi-Criteria Analysis (Figueira et al. 2005), Method of Paired Comparations (David 1969) or methods of data mining and machine learning (Zagorecki et al. 2013). These methods take into account the type of element, its strategic significance, substitutability, security or its main vulnerability.

The aim of multi-criteria decision making is to determine one specific critical infrastructure element of the same type, which will be analyzed in detail. To this end, there are decision criteria made, i.e., properties of the element (quantitative or qualitative), according to which the individual or team will assess the element. The portfolio of criteria is based on the preferences of the assessor. Each criterion is assigned a weighting factor which expresses the importance of the individual criteria in comparison to others.

After selecting an element, it is necessary to characterize it, for example, with the help of functional analysis (Kantorovich and Akilov 1982), to provide a comprehensive identification of the element, define and describe its individual functions that are key to the operation of the element. The analysis must be made with regard to the element's ability to absorb the impact of disruptive events. It is important to focus on the selected element's structural and performance parameters, i.e., its topological structure (point, linear or planar element) and key technologies (number and performance of the element's crucial processes and technologies).

4.2. Step 2: Selection and Description of the Threat Category of Interest

The threats which negatively impact the element can be grouped into a number of categories depending on the environment in which they occur and their nature (see Table 2). Within this step, it is necessary to select and then describe the specific threat category. It is appropriate to apply risk management in this selection process (ISO 2018), which will help to identify the threat category to which the examined element is most vulnerable.

4.3. Step 3: Determination of the Level of Resilience of a Critical Infrastructure Element

Determining the level of resilience of a critical infrastructure element is a crucial step in the process. This step provides information about the realistic level of resilience to a specific threat and is the basis for setting security measures. The resulting element resilience level is used as a basis for selecting indicators and setting the limit of the exhaustion of the absorption abilities of resilience.

The level of resilience of the selected element is determined with the help of specific methods (Rehak et al. 2019; Alheib et al. 2016; Bertocchi et al. 2016; Petit et al. 2013). It is appropriate to use the Critical Infrastructure Elements' Resilience Assessment (CIERA) method (Rehak et al. 2019), which provides an overall picture of the element's resilience, its components and variables. This method systematically assesses individual measurable variable items with respect to the threat category. One of the outputs of the CIERA method is data sheets of measurable items which are divided into sections

according to their resilience level. These data sheets can be used as a basis for creating a proposal for measures for strengthening the resilience of the element. The resulting resilience levels are subdivided according to the CIERA methodology (Rehak et al. 2019) into five levels (see Table 3).

Table 3. Comparative table for the assessment of the element's resilience level (Rehak et al. 2019).

Element Resilience Level	Percentage
High level of resilience	85–100%
Acceptable level of resilience	69–84%
Low level of resilience	53–68%
Insufficient level of resilience	37–52%
Critical level of resilience	≤36%

4.4. Step 4: Identification of Indicators of Resilience Disruption

The fourth step of the process is the identification of indicators, i.e., indicators signalizing the disruption of resilience, most likely causing the degradation or failure of the element's key functions. These indicators are the individual security threats that are classified on the basis of Table 2. The threats may be identified using specially designed methods (IEC 2019). Examples of these include Fault Tree Analysis—FTA (IEC 2006a), Preliminary Hazard Analysis—PHA (Ericson 2005), Failure Mode and Effects Analysis—FMEA (IEC 2006b) or a combination thereof.

In the first phase of this step, the FTA method can be used, which finds the possible causes of the degradation of the element's resilience by gradually dividing and analyzing the peak event. Subsequently, it is appropriate to use PHA or FMEA methods, which provide information on the severity or consequences of the threat. Among other things, they provide the possibility of assigning possible measures to individual threats. The assessor will thus have a summary document on security threats.

4.5. Step 5: Identification of Indication Parameters

Indicators must be functional, meet certain conditions and, above all, must provide informative values. So-called indication parameters of individual threats are set to meet these conditions. In the fifth step, in the process of indication of the disruption of an element's resilience, a detailed analysis of individual threats must be performed. Each identified threat has specific properties, such as its character, degree or level of danger, according to which they can be measured, assessed and compared or their level of danger to the element. These values, i.e., indicative threat parameters, are compared with the element's resilience level in Step 6. For example, extreme wind, which falls into the group of meteorological threats, is measured using the Beaufort scale (RMetS 2018). The individual values of this scale determine the indication parameters of this threat. An example of the classification of indication parameters for the threat of "extreme wind" is presented in Table 4.

Table 4. Example of classification of indication parameters for the threat of "extreme wind".

Threat Indication Parameters	Impacts of the Threat on the Critical Infrastructure Element	Percentage Expression of Indication Parameters
Hurricane (118 and more km/h)	Absolute failure of the element's basic functions, high probability of its destruction.	81–100%
Violent Storm (103–117 km/h)	Disruption or failure of basic functions, extensive damage to property, significant disruption of the statics of the element.	61–8%
Storm (89–102 km/h)	Limitations of basic functions, great damage to property, violation of statics of the whole element.	41–60%
Strong Gale (75–88 km/h)	Violation of support functions, damage to property, violation of statics of part of the element.	21–40%
Gale (62–74 km/h)	Element is inaccessible, minor damage to property.	≤20%

The percentage expression of threat indication parameters is organized into five levels based on the impacts of these threats on the critical infrastructure element. While the 0% level of the indication parameter represents no threat to the element, 100% is critical for the element and the failure of the function of the element is assumed with fatal consequences. The example presented above shows that the indication parameters are defined only for those threat levels which can potentially disrupt the function of the critical infrastructure element. For this reason, levels below 62 km/h on Beaufort's scale are not included in the extreme wind indication parameters (RMetS 2018).

Indication parameters can be identified through a graphical–analytical technique known as a Tree Diagram (Salkind 2007). This is a systematic tool which determines detailed information characterizing a threat (e.g., its intensity, danger level, frequency of occurrence) by gradual linear processing. Subsequently, it is possible to set specific values for the indication parameters in the context of the expected impacts with the use of an Affinity Diagram or Relation Diagram (Graham and Cleary 2000).

4.6. Step 6: Determination of the Disruption Limit of Element Resilience

The threat indication parameters themselves can only tell us about threats. Therefore, it is necessary to compare these threat parameters with the corresponding resilience of the element and to set a certain limit. The limit is the maximum threat level that the element's resilience is able to absorb (Rehak et al. 2019). If this limit is exceeded, it is assumed that the element's resilience is disrupted, which may result in the failure of its function. This limit is determined based on a comparison of the already-calculated level of resilience (Step 3) and the indication parameters of the threats (Step 5), i.e., their value, nature, degree or level of danger.

The resulting limit varies depending on the level of resilience of the critical infrastructure element. The higher the element resilience level, the higher this limit is (Rehak et al. 2019). This means that the element is able to withstand a higher impact of a given threat, up to the level of the corresponding relevant indication parameter (Rehak et al. 2018a). For example, an element with an acceptable level of resilience (i.e., 69–84%) is able to withstand the effects of a violent storm (i.e., 61–80%). Exceeding the set limit indicates an insufficient level of resilience and the subsequent disruption or failure of the critical infrastructure element.

4.7. Step 7: Defining, Comparing and Evaluating Alternatives to Security Measures

If there is a risk of disrupting the element's resilience, it is necessary to perform this next step, which is the definition, comparison and evaluation of security measures. The first phase of this step is to clearly define security measures, i.e., define their character (suitability of a measure, acceptability feasibility, does the element have the necessary requirements for implementing the security measure, etc.). Subsequently, it is necessary to compare and evaluate the identified alternatives. The most suitable method for this phase is Multi-Criteria Analysis (Figueira et al. 2005) where, provided with a set of decision criteria and the linkages between them, it is possible to find the option which scores the highest in each criterion (see Figure 4). It is important to set security measures after consulting critical infrastructure operators and other competent persons who have the exclusive decision making right over the entire element. For this purpose, it is appropriate to use the Brainstorming method (Curedale 2013).

	Investment Low effect Solution in days (immediately)	Investment Low effect Solutions in weeks	Investment Low effect Solutions in months (years)
Cost and efficiency	Current operating costs Medium effect Solution in days (immediately)	Current operating costs Medium effect Solutions in weeks	Current operating costs Medium effect Solutions in months (years)
	Minimum costs (current) High effect Solution in days (immediately)	Minimum costs (current) High effect Solutions in weeks	Minimum costs (current) High effect Solutions in months (years)

Time

Figure 4. Comparison and evaluation of security measures on decision-making criteria (IEC 2005).

The comparison and evaluation of possible alternatives to security measures are carried out on the basis of the three key decision criteria listed in Figure 4. The cells in red represent those measures that are unsuitable to implement due to the excessive financial costs for the critical infrastructure entity and due to the time needed to implement these security measures being disproportionate to their effectivity. The orange cells represent those types of security measures whose effectiveness is acceptable in terms of the time needed for implementation, and the financial costs are comparable with current operational costs. The green cells represent the security measures that can be implemented immediately or within a few days with high effect and minimum costs.

4.8. Step 8: Implementation of Security Measures and Feedback

If a suitable security measure option is chosen, it is possible to continue to the last step of the process of indicating a disruption of resilience. The implementation of measures, i.e., the process of preparation of the implementation of security measures set out in Step 7, will be carried out with the help of a so-called implementation plan (see Figure 5). This plan consists of a set of activities with the aim of effectively and systematically implementing measures in a pre-determined time.
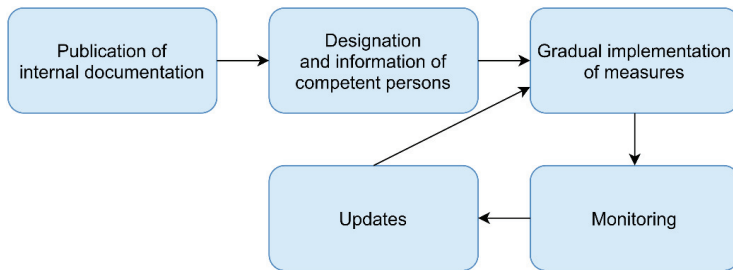

Figure 5. Sub-process of implementation of security measures (Blumenthal and Stoddard 1999).

The first step of the implementation sub-process is the publication of internal documentation (policy, regulation, rule). Then, it is necessary to designate and inform competent persons about the changes which are to be carried out. Then, the implementation of the measure itself can begin. It shall be continuously monitored, and in the event of deficiencies, this step will be adapted to the current conditions (updated). This update step retroactively adjusts the gradual implementation of the measures.

The process of indicating a disruption of a critical infrastructure element is based on the PDCA method (Tague 2005). It is precisely the principle of this method which makes it possible to review the effectiveness of the implemented security measures. Their effectiveness can be evaluated on the basis of an internal audit (Institute of Internal Auditors 2020) of the critical infrastructure element and on a subsequent Comparative Method (Collier 1993), the purpose of which is to compare the

assumed requirements of the security measure with the actual state. The result is a table that provides an overall picture of fulfilled expectations. If these expectations are not fulfilled, this implementation process becomes insufficient. This is why it is suitable to reevaluate the element's resilience level by re-performing Step 3, in which specific deficiencies of the security measures and associated risks can be identified. This step completes the entire process of the indication of the critical infrastructure element's resilience.

5. Case Study

The pilot verification of the proposed process was performed by analyzing the results of case studies that were prepared for the electricity sector (transmission and distribution system), transport (road and railway network) and emergency services (fire stations). The results were then discussed with the operators of the evaluated elements and used to calibrate the method. The anonymized result of one of the evaluations (i.e., fire rescue service station) is presented in the following text to help explain how the proposed process works. This assessment was carried out by the security manager of the Fire and Rescue Service of the territorially relevant region in cooperation with the crisis manager of the same fire and rescue service. The crisis manager then developed recommended solutions, the implementation of which in the final phase of the process was decided by the director of the Fire and Rescue Service of the territorially relevant region.

An anonymized fire rescue service (FRS) station was selected for the process of indicating a disruption of the critical infrastructure element's resilience (Step 1). The station belongs to the emergency service sector and is located in an unnamed region of the Czech Republic. Subsequently, a description of this station was made, which consisted in determining its position in the critical infrastructure structure and the definition of its structural and performance parameters. The structural parameters of this station are specified by its topological structure and in the case of planar elements, by a list of key technologies. The fire station's performance parameter is the number of protected inhabitants (Vichova et al. 2017). These data are presented in Table 5.

Table 5. Description of the assessed element of emergency services of critical infrastructure.

Element Name:	Fire and Rescue Service Station of the Czech Republic
Sector/sub-sector:	Emergency services/integrated rescue system
Topological structure:	Planar element
List of key technologies:	Firefighting means; activation system of firefighting means; information reception dispatch
Number of protected inhabitants:	290 thousand

The indication of resilience disruption of the selected element was carried out as part of the risk management (ISO 2018) against three threat categories (Step 2). However, due to the extent of the results, this article will only present the result of one of the assessed categories of impacts, cascading threats. Cascading threats are threats that cause a disruption of the critical infrastructure element, the effects of which further spread across the critical infrastructure and cause the failure of dependent elements (Rehak et al. 2018b).

Next, the selected critical infrastructure element resilience level was determined (Step 3). The assessment of the fire station's resilience was carried out using the CIERA method (Rehak et al. 2019) and it consisted of the measurement of its levels of robustness, recoverability and adaptability in terms of the selected threat. The assessment of the resilience of this station was done in cooperation with the commander and the security manager of the FRS of the given region. The results of the assessment are presented in Figure 6.
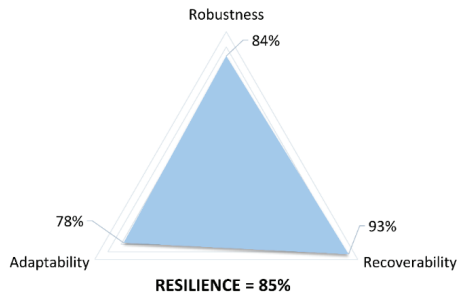
Figure 6. The fire station's level of resilience to the impacts of cascading threats.

The resulting resilience of the fire station to the impact of cascade threats reached the level of 85%, which represents the lower end of high-level resilience.

The next step in indicating a disruption of the resilience of the selected element was the identification of resilience disruption indicators (Step 4). The identification of indicators was carried out using the Fault Tree Analysis method (IEC 2006a) and the results of the identification are presented in Figure 7.
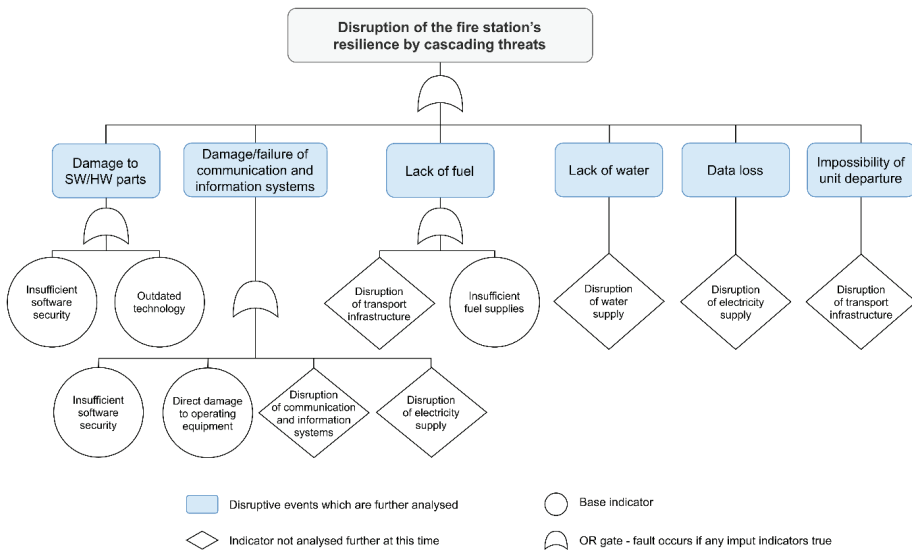

Figure 7. Identification of indicators of disruption of resilience.

The threat of the disruption of the electric energy supply was selected for further analysis based on the results of the identification of the indicators in Figure 7. The reason for this selection is that it was proven that the fire station depends heavily on a supply of electricity. The description of this threat is present in Table 6.

Table 6. Description of the selected threat.

Threat category:	Cascading threats
Threat Name:	Disruption of electricity supply
Threat specification:	Disruption of electricity supply to the fire station

Next, it is possible to proceed to the identification of indication parameters of the selected threat (Step 5). The identification of indication parameters is based on the National Energy Resistance Program of the Czech Republic (MIT 2019) and was performed using graphical–analytical methods, e.g., the Tree Diagram (Salkind 2007). An overview of the indication parameters of the threat of interest is presented in Table 7.

Table 7. Classification of indication parameters for the threat of "disruption of electricity supply".

Threat Indication Parameters	Impacts of the Threat on the Critical Infrastructure Element	Percentage Expression of Indication Parameters
Critical disruption of electricity supply (over 36 h)	Failure of all key technologies	81–100%
Long-term disruption of electricity supply (up to 36 h)	Failure of some key technologies (i.e., firefighting means, firefighting activation system)	61–80%
Medium-term disruption of electricity supply (up to 24 h)	Failure of some non-key technologies (e.g., air conditioning, heating, lighting)	41–60%
Short-term disruption of electricity supply (up to 12 h)	Minor impact on non-key technologies (e.g., air conditioning, heating, lighting)	21–40%
Very short-term disruption of electricity supply (up to 1 h)	No impact on key and non-key technologies.	≤20%

The next step in the process of indicating a disruption of the resilience of critical infrastructure elements is the determination of the limit of disruption of the element's resilience (Step 6). This limit is based on a comparison of the already-calculated level of resilience (Step 3) and the indication parameters of threats (Step 5). In this case, the resilience level of the fire station was set at 85%, which is the lower limit of high-level resilience. In this case, the fire station would be able to operate in a limited mode even in the event of a power failure lasting over 36 h. The reason is mainly its high recoverability level, especially due to redundant capacities. Specifically, the station is equipped with a spare stationary electricity source (i.e., diesel generator) and has spare mobile sources of electricity available and a high area coverage of the Fire and Rescue Service units in the region.

The next step is to define, compare and evaluate alternatives to security measures (Step 7). Weak points in the fire station's resilience were identified using the CIERA method (Rehak et al. 2019). These are the (1) low level of indication of power failure, (2) low physical resilience of technical equipment to the effects of power failure, and (3) lack of funds for security measure innovation. Within the context of these results, it is possible to define adequate security measures and evaluate the suitability of their implementation based on comparison. A Multi-Criteria Analysis (Figueira et al. 2005) was used for this purpose where provided with a set of decision criteria and the linkages between them, it is possible to find the option which scores the highest in each criterion (see Figure 4). Security measures and individual criteria were consulted with the commander of the fire station and the security manager of the FRS of the region. The results of the evaluation of safety measures to increase the physical resistance of technical devices to the effects of power failure (i.e., weakness of resilience No. 2) are presented in Table 8.

Table 8. Evaluation of the suitability of the implementation of security measures to increase the physical resistance of technical means on the impact of power outages.

Security Measure Options	Evaluation Criteria			Evaluation Results
	Financial Costs	Effectiveness	Time Required for Implementation	
Creation of a second replacement stationary source of electricity	Investment	Medium effect	Solution in days	2.
Creating a connection point for a mobile power source	Current operating costs	High effect	Solution in days	1.
Use of renewable electricity sources (e.g., installation of solar panels or wind turbines)	Investment	Low effect	Solution in days	3.

Based on the results of the evaluation, the second option was selected (i.e., the creation of a connection point for a mobile source of electricity), for which the process of implementation and feedback had subsequently been started (Step 8). The implementation process was carried out in accordance with the implementation plan (see Figure 5), which includes a set of activities aimed at the effective and systematic implementation of measures at a pre-determined time. Feedback was provided at the end of the process of indicating the disruption of the resilience of critical infrastructure elements, which allowed us to review the effectiveness of the implemented security measures. For this purpose, the level of resilience of the critical infrastructure element was reassessed (Step 3), reaching the level of 93% after the implementation of the selected security measure. This step finalizes the entire process of indication of the critical infrastructure element's resilience.

6. Discussion and Conclusions

This article offers a contribution to the debate on the need to address the predictive disruption of critical infrastructure elements' resilience. Throughout the work, the authors asked themselves the following question: is the current managerial decision making in the area of the researched problem, i.e., critical infrastructure protection, sufficient? A literature search has shown that in such a specific area as the disruption of critical infrastructure elements' resilience, common decision-making methods are used, lacking a systematic arrangement. For this purpose, a special procedure was created to indicate the violation of the resilience of critical infrastructure elements. The work and the proposed procedure was limited to the area of critical infrastructure in the electricity, transport and emergency services sectors. However, with the elaboration and light transformation, this approach can be used in other areas of critical infrastructure; however, this option is a matter for future research and detailed analysis of other areas.

Risk management is currently being used in most cases of the preventive protection of critical infrastructure elements, making it possible to assess and manage risks (ISO 2018). The current risk assessment methods are an effective general preventive tool (Giannopoulos et al. 2012; Theocharidou and Giannopoulos 2015); however, they lack linkages to the specifics associated with the resilience of the critical infrastructure systems. By linking risk management and strengthening resilience, the protection of critical infrastructure is extended by the repressive part, i.e., the reaction to already occurring adverse events (NIAC 2009). However, current approaches in various areas focus only on assessing and strengthening critical infrastructure resilience (Alizadeh and Sharifi 2020; Argyroudis et al. 2020; Quitana et al. 2020; Li et al. 2020; Shandiz et al. 2020) even though resilience goes beyond traditional risk management (Petersen et al. 2020). Therefore, it can be stated that there is currently no appropriate managerial tool that would explicitly deal with preventive measures for the protection of critical infrastructure elements. For this reason, the authors of this article have designed an entirely new process of managerial decision making for indicating the disruption of the resilience of critical infrastructure elements, which allows for the early identification of a potential resilience disruption of these elements and subsequent setting of the framework for improving the elements' resilience (Labaka et al. 2015).

The indication process consists of eight interconnected steps, which provide the assessor with comprehensive instructions for the indication of a possible disruption of the resilience of critical infrastructure elements. This enables the assessment of the current level of the element's resilience to disruptive events evaluated according to available methods (ISO 2018; IEC 2019; Bernatik et al. 2013) and serves as a basis for the decision to implement security measures and mitigate the impacts of the disruptive events weakening the resilience of the element (Blumenthal and Stoddard 1999). The resilience disruption indication process, among other things, sets the limit of exhaustion of the resilience absorption capacity, i.e., the limit beyond which the function of the element fails or is disrupted.

This information is valuable to security managers of critical infrastructure entities, as it enables them to rapidly indicate disruptions of the resilience of critical infrastructure elements. With this information, managers can make adequate security measures to strengthen the resilience of these elements. The pilot verification of the proposed process was performed by analyzing the results of

case studies, which were prepared for the electricity sector (transmission and distribution system), transport (road and railway network) and emergency services (fire stations). The results were then discussed with the operators of the evaluated elements and used to calibrate the method. Currently, the method can be used for the predictive indication of the resilience of elements of all technical sectors (i.e., energy, transport, information and communication systems and water management) and selected socio-economic sectors (i.e., emergency services and health) of the critical infrastructure.

The process of indicating the disruption of the critical infrastructure elements' resilience was designed from a managerial point of view, so its use in the top management of state institutions is very likely. In particular, it is suitable as a support tool when deciding on investments in strategic public infrastructures and their development. It is also expected that the proposed process will be used in the modernization of public infrastructures to increase their resilience to predicted threats. The proposed process is a comprehensive procedure that supports decision making in the implementation of optimal security measures, and in the context of step seven (i.e., defining, comparing and evaluating alternatives to security measures), contribution to good governance and the economical drawing of institutional funds.

The process of indicating disruption of resilience was created as a support tool for managerial decision making in the critical infrastructure elements protection management. The theoretical benefit of this tool is the interdisciplinary integration of managerial decision making in the field of preventive protection of critical infrastructure elements. This expands the portfolio of the currently available literature dealing with the use of managerial decision making in the field of critical infrastructure protection. At a practical level, it is a matter of creating a new tool that will enable security managers to increase the preventive protection of critical infrastructure elements. This also answers the research question, as the created tool allows us to preventively indicate the potential disruption of the critical infrastructure elements' resilience before the actual occurrence of the adverse event. In the context of practical use, this tool was created primarily for managers of public critical infrastructure operators, with whom the authors have been cooperating for a long time. The tool can also be used in the private sector, but without the possibility of considering the market environment.

The future development of this instrument could therefore not only consider the needs of the private sector, but could also include economic factors to minimize costs. Furthermore, it is appropriate to pay attention to the research of the indicators themselves, which could be structured in more detail, based on functional parameters (i.e., indicators considering structural and performance parameters of critical infrastructure elements) and indication parameters (i.e., indicators of changes in internal but also external environment of critical infrastructure elements).

References

Alheib, M., G. Baker, C. Bouffier, G. Cadete, E. Carreira, P. Gattinesi, F. Guay, D. Honfi, K. Eriksson, K. Lange, and et al. 2016. *Report of Criteria for Evaluating Resilience*. Göteborg: SP Technical Research Institute of Sweden.

Alizadeh, Hadi, and Ayyoob Sharifi. 2020. Assessing Resilience of Urban Critical Infrastructure Networks: A Case Study of Ahvaz, Iran. *Sustainability* 12: 3691. [CrossRef]

Argyroudis, A. Sotirios, Stergios A. Mitoulis, Lorenzo Hofer, Mariano Angelo Zanini, Enrico Tubaldi, and Dan M. Frangopol. 2020. Resilience assessment framework for critical infrastructure in a multi-hazard

environment: Case study on transport assets. *Science of the Total Environment* 714: 136854. [CrossRef] [PubMed]

Bartosikova, Romana, Jana Bilikova, Jan Strohmandl, and Vladimir Sefcik. 2014. Modelling of Decision-making in Crisis Management. Paper presented at the 24th International-Business-Information-Management-Association Conference, Milan, Italy, November 6–7; pp. 1479–83.

Bernatik, Ales, Pavel Senovsky, Michail Senovsky, and David Rehak. 2013. Territorial Risk Analysis and Mapping. *Chemical Engineering Transactions* 31: 79–84. [CrossRef]

Bertocchi, Glauco, Sandro Bologna, Giulio Carducci, Luigi Carrozzi, Simona Cavallini, Alessandro Lazari, Gabriele Oliva, and Alberto Traballesi. 2016. *Guidelines for Critical Infrastructure Resilience Evaluation*. Roma: Italian Association of Critical Infrastructures' Experts.

Bialas, Andrzej. 2016. Risk Management in Critical Infrastructure—Foundation for Its Sustainable Work. *Sustainability* 8: 240. [CrossRef]

Blumenthal, David, and Ray Stoddard. 1999. Implementation Planning: The Critical Step. *PM Network* 13: 80–86.

Bozeman, Barry, and Sanjay K. Pandey. 2004. Public Management Decision Making: Effects of Decision Content. *Public Administration Review* 64: 553–65. [CrossRef]

Cifuentes, Carlos Llano. 1972. Fundamentals of the Managerial Decision-Making Process. *International Studies of Management & Organization* 2: 213–21. [CrossRef]

Collier, David. 1993. The Comparative Method. In *Political Science: The State of the Discipline II*. Washington: American Political Science Association, pp. 105–19.

Curedale, A. Robert. 2013. *50 Brainstorming Methods: For Team and Individual Ideation*. Topanga: Design Community College Inc.

David, H. A. 1969. *Method of Paired Comparations*, 2nd ed. Port Jervis: Griffin & Company.

Denyer, David. 2017. *Organizational Resilience: A Summary of Academic Evidence, Business Insights and New Thinking*. Cranfield: BSI and Cranfield School of Management.

Dvorak, Zdenek, Eva Sventekova, David Rehak, and Zoran Cekerevac. 2017. Assessment of Critical Infrastructure Elements in Transport. *Procedia Engineering* 187: 548–55. [CrossRef]

Ericson, A. Clifton. 2005. *Hazard Analysis Techniques for System Safety*. Fredericksburg: John & Wiley Sons. [CrossRef]

European Council. 2008. *Council Directive 2008/114/EC of 8 December 2008 on the Identification and Designation of European Critical Infrastructures and the Assessment of the Need to Improve their Protection*. Brussels: European Union.

Fekete, Alexander, Peter Lauwe, and Walfram Geier. 2012. Risk Management Goals and Identification of Critical Infrastructures. *International Journal of Critical Infrastructures* 8: 336–53. [CrossRef]

Figueira, Jose, Salvatore Greco, and Matthias Ehrgott. 2005. *Multiple Criteria Decision Analysis: State of the Art Surveys*. New York: Springer. [CrossRef]

Giannopoulos, Giorgios, Roberto Filippini, and Muriel Schimmer. 2012. *Risk Assessment Methodologies for Critical Infrastructure Protection. Part I: A state of the Art*. Ispra: European Commission, Joint Research Centre.

Government of Canada. 2014. *Action Plan for Critical Infrastructure (2014–2017)*; Ottawa: Public Safety Canada.

Graham, D. Jackie, and Michael J. Cleary. 2000. *Practical Tools for Continuous Improvement: Problem-Solving and Planning Tools*. Dayton: PQ Systems, vol. 2.

Harrison, E. Frank. 1999. *The Managerial Decision-Making Process*. Boston, MA: Houghton Mifflin.

Chen, Changkun, Lili Xu, Dongyue Zhao, Tong Xu, and Peng Lei. 2020. A new model for describing the urban resilience considering adaptability, resistance and recovery. *Safety Science* 128: 104756. [CrossRef]

IEC 17799. 2005. *Information Technology—Security Techniques—Code of Practice for Information Security Management*. Geneva: ISO/IEC.

IEC 31010. 2019. *Risk Management—Risk Assessment Techniques*. Geneva: International Organization for Standardization.

IEC 61025. 2006a. *Fault Tree Analysis (FTA)*. Geneva: International Electrotechnical Commission.

IEC 60812. 2006b. *Procedure for Failure Mode and Effects Analysis (FMEA)*. Geneva: International Electrotechnical Commission.

Imani, Maryam, Donya Hajializadeh, and Vasos Christodoulides. 2020. Towards Resilience-Informed Decision-Making in Critical Infrastructure Networks. In *Frontiers in Water-Energy-Nexus—Nature-Based*

Solutions, Advanced Technologies and Best Practices for Environmental Sustainability. *Advances in Science, Technology & Innovation (IEREK Interdisciplinary Series for Sustainable Development).* Edited by Naddeo V. M. Balakrishnan and K. H. Choo. Cham: Springer. [CrossRef]

Institute of Internal Auditors. 2020. *What is Internal Audit?* Available online: https://www.iia.org.uk/about-us/what-is-internal-audit/ (accessed on 9 July 2020).

IRDR. 2014. *Peril Classification and Hazard Glossary.* Beijing: Integrated Research on Disaster Risk IPO.

ISO/IEC 27001. 2013. *Information Technology—Security Techniques—Information Security Management Systems—Requirements.* Geneva: International Organization for Standardization.

ISO 31000. 2018. *Risk Management–Guidelines.* Geneva: International Organization for Standardization.

Kantorovich, Leonard V., and G. P. Akilov. 1982. *Functional Analysis.* Amsterdam: Elsevier.

Labaka, Leire, Josune Hernantes, and Jose Mari Sarriegi. 2015. A framework to improve the resilience of critical infrastructures. *International Journal of Disaster Resilience in the Built Environment* 6: 409–23. [CrossRef]

Li, Guijun, Chenhuan Kou, Yongsheng Wang, and Hongtao Yang. 2020. System dynamics modelling for improving urban resilience in Beijing, China. *Resources Conservation and Recycling* 161: 104954. [CrossRef]

Liu, Wei, and Zhaoyang Song. 2020. Review of studies on the resilience of urban critical infrastructure networks. *Reliability Engineering and System Safety* 193: 106617. [CrossRef]

Lu, Xinzheng, Liao Wenkie, Fang Dongping, Lin Kaiqi, Tian Yuan, Zhang Chi, Zheng Zhe, and Zhao Pengju. 2020. Quantification of disaster resilience in civil engineering: A review. *Journal of Safety Science and Resilience* 1: 19–30. [CrossRef]

Luskova, Maria, and Zdenek Dvorak. 2019. Applying Risk Management Process in Critical Infrastructure Protection. *Interdisciplinary Description of Complex Systems* 17: 7–12. [CrossRef]

Machado-León, Jose Luis, and Anne Goodchild. 2017. Review of Performance Metrics for Community-Based Planning for Resilience of the Transportation System. *Transportation Research Record* 2604: 44–53. [CrossRef]

MIT. 2019. *National Energy Resilience Program of the Czech Republic*; Prague: Ministry of Industry and Trade.

NIAC (National Infrastructure Advisory Council). 2009. *Critical Infrastructure Resilience: Final Report and Recommendations.* Washington: U.S. Department of Homeland Security.

Nutt, Paul C. 2005. Comparing Public and Private Sector Decision-Making Practices. *Journal of Public Administration Research and Theory* 16: 289–318. [CrossRef]

Petersen, Laura, David Lange, and M. Theocharidou. 2020. Who cares what it means? Practical reasons for using the word resilience with critical infrastructure operators. *Reliability Engineering and System Safety* 199: 106872. [CrossRef]

Petit, Frederic, Gilbert Bassett, R. Black, W. Buehring, M. Collins, D. Dickinson, R. Fisher, R. Haffenden, A. Huttenga, M. Klett, and et al. 2013. *Resilience Measurement Index: An Indicator of Critical Infrastructure Resilience.* Chicago: Argonne National Laboratory.

Quitana, Gabriela, Maria Molinos-Senante, and Alondra Chamorro. 2020. Resilience of critical infrastructure to natural hazards: A review focused on drinking water systems. *International Journal of Disaster Risk Reduction* 48: 101575. [CrossRef]

Rehak, David. 2020. Assessing and Strengthening Organisational Resilience in a Critical Infrastructure System: Case Study of the Slovak Republic. *Safety Science* 123: 104573. [CrossRef]

Rehak, David, Martin Hromada, and Petr Novotny. 2016. European Critical Infrastructure Risk and Safety Management: Directive Implementation in Practice. *Chemical Engineering Transactions* 48: 943–48. [CrossRef]

Rehak, David, Martin Hromada, and Jozef Ristvej. 2017. Indication of Critical Infrastructure Resilience Failure. In *Safety and Reliability–Theory and Application (ESREL).* Edited by M. Čepin and R. Briš. Cleveland: CRC Press, pp. 963–70.

Rehak, David, Pavel Senovsky, Martin Hromada, and T. Lovecek. 2019. Complex Approach to Assessing Resilience of Critical Infrastructure Elements. *International Journal of Critical Infrastructure Protection* 25: 125–38. [CrossRef]

Rehak, David, Pavel Senovsky, and Simona Slivkova. 2018a. Resilience of Critical Infrastructure Elements and its Main Factors. *Systems* 6: 21. [CrossRef]

Rehak, David, Pavel Senovsky, Martin Hromada, Tomas Lovecek, and Petr Novotny. 2018b. Cascading Impact Assessment in a Critical Infrastructure System. *International Journal of Critical Infrastructure Protection* 22: 125–38. [CrossRef]

Rinaldi, S. M., James P. Peerenboom, and T. K. Kelly. 2001. Identifying, Understanding and Analyzing Critical Infrastructure Interdependencies. *IEEE Control Systems Magazine* 21: 11–25. [CrossRef]

Ristvej, Jozef, A. Zagorecki, Katarina Holla, Ladislav Simak, and Michal Titko. 2013. Modelling, Simulation and Information Systems as a Tool to Support Decision-Making Process in Crisis Management. Paper presented at the 27th European Simulation and Modelling Conference (ESM 2013), Lancaster, UK, October 23–25; pp. 71–76.

RMetS. 2018. *The Beaufort Scale: How is Wind Speed Measured?* Available online: https://www.rmets.org/resource/beaufort-scale (accessed on 19 June 2020).

Salkind, J. Neil. 2007. *Encyclopedia of Measurement and Statistics*. California: Sage Publications.

Shandiz, Saeid Charani, Greg Foliente, Behzad Rismanchi, Amanda Wachtel, and Robert F. Jeffers. 2020. Resilience framework and metrics for energy master planning of communities. *Energy* 203: 117856. [CrossRef]

Slivkova, Simona, David Rehak, Veronika Nesporova, and Michaela Dopaterova. 2017. Correlation of Core Areas Determining the Resilience of Critical Infrastructure. Paper presented at the 12th International Scientific Conference on Sustainable, Modern and Safe Transport (TRANSCOM 2017). Procedia Engineering, High Tatras, Slovakia, May 31–June 2; vol. 192, pp. 812–17. [CrossRef]

Stochino, Flavio, Chiara Bedon, Juan Sagaseta, and Daniel Honfi. 2019. Robustness and Resilience of Structures under Extreme Loads. *Advances in Civil Engineering* 2019: 4291703. [CrossRef]

Sugden, M. Andrew. 2001. Resistance and Resilience. *Science* 293: 1731. [CrossRef]

Tague, R. Nancy. 2005. *Quality Toolbox*, 2nd ed. Milwaukee: ASQ Quality Press.

Theocharidou, Marianthi, and Georgios Giannopoulos. 2015. *Risk Assessment Methodologies for Critical Infrastructure Protection. Part II: A New Approach*. Ispra: European Commission, Joint Research Centre.

Twidale, B. Michael, and Ingbert R. Floyd. 2008. Infrastructures from the bottom-up and the top-down: Can they meet in the middle? Paper presented at the Tenth Anniversary Conference on Participatory Design (PDC '08), Bloomington, IN, USA, October 1–4; pp. 238–41.

Vichova, Katerina, Martin Hromada, and David Rehak. 2017. The Use of Crisis Management Information Systems in Rescue Operations of Fire and rescue system in the Czech Republic. Paper presented at the 12th International Scientific Conference on Sustainable, Modern and Safe Transport (TRANSCOM 2017). Procedia Engineering, High Tatras, Słowacja, May 31–June 2; vol. 192, pp. 947–52. [CrossRef]

Zagorecki, Adam T., David E. A. Johnson, and Jozef Ristvej. 2013. Data Mining and Machine Learning in the Context of Disaster and Crisis Management. *International Journal of Emergency Management* 9: 351–65. [CrossRef]

Zimmerman, Rae. 2004. Decision-making and the vulnerability of interdependent critical infrastructure. Paper presented at the 2004 IEEE International Conference on Systems, Man and Cybernetics, The Hague, The Netherlands, October 10–13; pp. 4059–63. [CrossRef]

Article

Trusted Decision-Making: Data Governance for Creating Trust in Data Science Decision Outcomes

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Abstract: Organizations are increasingly introducing data science initiatives to support decision-making. However, the decision outcomes of data science initiatives are not always used or adopted by decision-makers, often due to uncertainty about the quality of data input. It is, therefore, not surprising that organizations are increasingly turning to data governance as a means to improve the acceptance of data science decision outcomes. In this paper, propositions will be developed to understand the role of data governance in creating trust in data science decision outcomes. Two explanatory case studies in the asset management domain are analyzed to derive boundary conditions. The first case study is a data science project designed to improve the efficiency of road management through predictive maintenance, and the second case study is a data science project designed to detect fraudulent usage of electricity in medium and low voltage electrical grids without infringing privacy regulations. The duality of technology is used as our theoretical lens to understand the interactions between the organization, decision-makers, and technology. The results show that data science decision outcomes are more likely to be accepted if the organization has an established data governance capability. Data governance is also needed to ensure that organizational conditions of data science are met, and that incurred organizational changes are managed efficiently. These results imply that a mature data governance capability is required before sufficient trust can be placed in data science decision outcomes for decision-making.

1. Introduction

Over the last few years it has become more common for organizations to implement data science initiatives to support the digital transformation of their business (Provost and Fawcett 2013). However, organizations continue to find it difficult to trust data science outcomes for decision-making purposes, as the data is often found to be lacking the required quality (Lin et al. 2006), and it is often unclear how compliant the use of the data and the algorithms are with regards to relevant legal frameworks and societal norms and values (Nunn 2009; van den Broek and van Veenstra 2018). These uncertainties are a barrier to the acceptance and use of data science outcomes due to the possibility of financial risk and damage to an organization's reputation. For example, when making decisions regarding the management of physical assets, asset managers need to be able to trust the data science outcomes before they are confident enough to use these outcomes. Examples of these decisions include when and where to perform maintenance on highways or when to replace a bridge. Erring on the side of caution can be unnecessarily expensive whilst irresponsible delay of maintenance can put public safety at risk. In order for data science to be successfully adopted, it is therefore vital that organizations are able to trust the integrity of the data science outcomes (Council on Library and Information Resources

2000; Randall et al. 2013). Recently, data governance has gained traction with many organizations as a means to develop this trust (Al-Ruithe et al. 2019; Brous et al. 2016). However, it remains unclear how data governance contributes to the development and maintenance of trust in data science for decision-making, leading to calls for more research in this area (Al-Ruithe et al. 2019; Brous et al. 2020).

The goal of data science is to improve decision-making. According to Dhar (2013), the term data science refers to knowledge gained through systematic study and presented in the form of testable explanations and predictions. As such, data science differs from traditional science in a number of ways (Dhar 2013; Provost and Fawcett 2013). Traditionally, scientists study a specific subject and gather data about that subject. This data is then analyzed to gain in-depth knowledge about that subject. Data scientists tend to approach this process differently, namely by gathering a wide variety of existing data and identifying correlations within the data which provide previously unknown or unexpected practical insights. However, research has shown that favoring analytical techniques over domain knowledge can lead to risks related to incorrect interpretation of the data (Provost and Fawcett 2013). Due to the automation of the decision-making process, it may be tempting to regard data science decision-making outcomes as being purely rational. However, as with all decision-making, the quality of the outcomes are subjected to the constraints of bounded rationality (Simon 1947; Newell and Simon 1972), in that decision-making is constrained by the quality of the data available at the time. Data science models make decisions based on the information available to them at the time and also in the time given (Gama 2013). According to Gama (2013), bounded rationality can also appear in data science in the tradeoff between time and space required to solve a query and the accuracy of the answer. As such, it is not surprising that many organizations are implementing data governance in order to gain control over these factors (Alofaysan et al. 2014; Brous et al. 2020; van den Broek and van Veenstra 2018). Although recognized as being a powerful decision-making tool, data science is limited by the quality of the data inputs and the quality of the model itself.

Data governance can be defined as "the exercise of authority and control (planning, monitoring, and enforcement) over the management of data assets" (DAMA International 2017, p. 67), and can provide direct and indirect benefits (Ladley 2012). For example, Paskaleva et al. (2017) show that adoption of data governance can change how data is created, collected, and used in organizations. Data governance can greatly improve the awareness of data science outcomes for the management of infrastructure in, for example, a smart city environment (Paskaleva et al. 2017). However, information technology (IT)-driven data governance initiatives have failed in the past (Al-Ruithe et al. 2019), often being affected by technical feasibility aspects carried out on system by system basis.

In this paper, a different starting point is used, and the focus is put on the investigation of data governance as a boundary condition for data science, which needs to be satisfied in order to be able to trust data science outcomes as suggested by Brous et al. (2020) and Janssen et al. (2020). In this research, boundary conditions for data science are defined as socio-technical constraints that need to be satisfied in order to be able to trust data science outcomes. These conditions refer to the "who, where, when" aspects (Busse et al. 2017) of data science before data science outcomes can be used. Previous research (Brous et al. 2020; Janssen et al. 2020) has suggested that data governance can be viewed as a boundary condition for data science. As such, our main research question asks, how is data governance a boundary condition for data science decision-making outcomes?

In order to answer this question, two explanatory data science case studies in the asset management domain were analyzed with specific regard for the role of data governance as a boundary condition for trustworthy predictive decision-making through the creation of trust in data science decision-making outcomes. The first case under study is a data science project designed to improve the efficiency of road maintenance through predictive maintenance. The project was performed under the auspices of a large European government organization using a multitude of datasets which were sourced both within the organization and externally. Open data (Zuiderwijk and Janssen 2014) were also employed within this case study. The second case study is a data science project which analyzes transformer data to identify the fraudulent use of electricity within medium and low tension electrical grids without infringing

privacy regulations. This project was performed under the auspices of a European distribution grid operator (DGO) which is responsible for the distribution of electricity over medium and low tension grids in a highly industrialized region of Europe.

Duality of technology theory (Orlikowski 1992) is used to guide the analysis of the case studies in understanding trust in data science outcomes as a boundary value problem and specifically the role of data governance as a boundary condition for trusting data science outcomes. Duality of technology (Orlikowski 1992) describes technology as assuming structural properties while being the product of human action. From a technology standpoint, data science outcomes are created by data scientists in a social context, and are socially constructed by users who attach different meanings to them and provide feedback to the data scientists. In this way, data science outcomes are the result of the ongoing interaction of human choices and organizational contexts, as suggested by duality of technology (Orlikowski 1992). This approach differs from previous research into data science success factors, which have focused on the view that data science is either an objective, external force which has a deterministic impact on organizational properties (Madera and Laurent 2016), or that trust in data science outcomes is purely a result of strategic choice and social action (Gao et al. 2015). Duality of technology theory suggests that either model would be incomplete and suggests that both perspectives should be taken into account when analyzing boundary conditions of data science. The results of the case studies suggest that data science outcomes are more likely to be accepted if the organization has an established data governance capability, and we conclude that data governance is a boundary condition for data science as it enables organizational conditions and consequences of data science to be met and ensures that outcomes may be trusted.

The paper reads as follows. Section 2 presents the background of literature regarding the relationship between data governance and data science. In Section 3 the methodology of the research is described. Section 4 describes the findings of the case study. Section 5 discusses the findings of the case study and Section 6 presents the conclusions.

2. Literature Background

The literature review method proposed by Webster and Watson (2002) was followed to methodologically analyze and synthesize quality literature. The goal of the literature review is to gain an understanding of the current knowledge base with regards to the role of data governance for creating trust in data science decision-making outcomes. In order to understand the duality of data governance, we discuss literature which helps us understand how data governance structures organizations, taking into account research into the adoption and impact of technology on organizations as suggested by research on other disrupting technologies such as artificial intelligence (AI) and the internet of things (IoT). This paper utilizes the duality of technology theory (Orlikowski 1992) as a practice lens for studying the role of data governance for the creation of trust in data science and follows the case study methodology to investigate this phenomena. The propositions that are investigated in the case studies are synthesized from the literature following the logic of duality of technology.

Based on Giddens' (1976) theory of structuration, duality of technology (Orlikowski 1992) describes technology as assuming structural properties while being the product of human action. Giddens (1976) recognizes that "human actions are both enabled and constrained by structures, yet that these structures are the results of previous actions" (Orlikowski 1992, p. 404). In her structuration model of technology, Orlikowski (1992) identifies four main relationships, namely: (1) technology as a product of human agency, (2) technology as a medium of human agency, (3) organizational conditions of interaction with technology and, (4) organizational consequences of interaction with technology. The technology referred to in this article is data science. Data governance is about the coordination and control of the use and management of data (Janssen et al. 2020; Khatri and Brown 2010). The objective of this article is to understand the role of data governance as a boundary condition for data science. As such, this article looks at the role of data governance in data science using the duality of technology as

a guiding logic. Figure 1 below shows how the synthesized propositions and their elements are linked following the logic of the duality of technology.
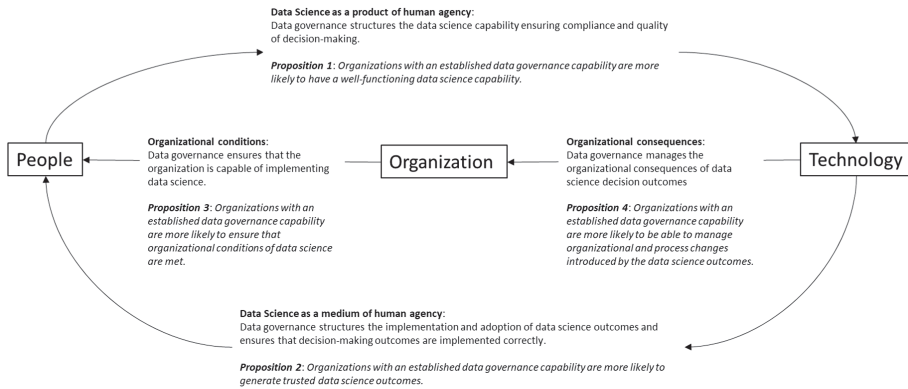

Data Science as a product of human agency:
Data governance structures the data science capability ensuring compliance and quality of decision-making.

Proposition 1: Organizations with an established data governance capability are more likely to have a well-functioning data science capability.

People → Organization → Technology

Organizational conditions:
Data governance ensures that the organization is capable of implementing data science.

Proposition 3: Organizations with an established data governance capability are more likely to ensure that organizational conditions of data science are met.

Organizational consequences:
Data governance manages the organizational consequences of data science decision outcomes

Proposition 4: Organizations with an established data governance capability are more likely to be able to manage organizational and process changes introduced by the data science outcomes.

Data Science as a medium of human agency:
Data governance structures the implementation and adoption of data science outcomes and ensures that decision-making outcomes are implemented correctly.

Proposition 2: Organizations with an established data governance capability are more likely to generate trusted data science outcomes.

Figure 1. The relationship of the propositions with duality of technology. According to Orlikowski (1992), technology is created as a result of human agency. In order for the process of technology creation to be successful, certain organizational boundary conditions need to be met. The resulting technology also has consequences for the organization, which need to be coordinated and controlled. For example, in order to develop a data science capability for an organization, it is necessary to have the required information technology (IT) infrastructure in place, available data, and sufficient data scientists with the necessary knowledge, requiring large investments (Adrian et al. 2017).

2.1. The Role of Data Governance with Regards to Data Science as a Product of Human Agency

According to Gao et al. (2015), data scientists develop domain expertise over time, and apply this knowledge in big data analysis to gain the best results. However, the intellectual limitations of the data scientists themselves as well as the computational limitations of the available technology (Gigerenzer and Selten 2002) mean that although data scientists often seek to compensate limited resources by exploiting known regularity, bias and variance can create errors in the decision outcomes which can be exacerbated by large data sets (Brain and Webb 2002). Following the logic of bounded rationality (Simon 1947), data scientists develop models based on their own limited knowledge, and therefore, the models are themselves constrained by the intellectual limitations of their makers as well as the quality of the data from which they learn and the technical infrastructure in which they operate.

Big data can provide organizations with complex challenges in the management of data quality. According to Saha and Srivastava (2014), the massive volumes, high velocity, and large variety of automatically generated data can lead to serious data quality management issues, which can be difficult to manage in a timely manner (Hazen et al. 2014). For example, IoT sensors calibrated to measure the salinity of water may, over time, begin to provide incorrect values due to biofouling. Data science information products often rely on near real-time data to provide timely alerts, and, as such, problems may arise if these data quality issues are not timely detected and corrected (Gao et al. 2015; Passi and Jackson 2018).

Often, modern data processing systems which are required to allow large amounts of varied big data (Dwivedi et al. 2017) to be ingested without compromising the data structure are generally immediately accessible, allowing users to utilize dynamic analytical applications (Miloslavskaya and Tolstoy 2016; Ullah et al. 2018). This immediate accessibility, as well as the retaining of data in its original format presents a number of challenges regarding the governance of the data, including data security and access control (Madera and Laurent 2016), as well as in maintaining compliance with regards to privacy (Morabito 2015). As such, data governance has increasingly gained popularity as a means of ensuring and maintaining compliance, and Madera and Laurent (2016) have gone so far as

to posit that data governance principles should be key components of data science technologies for managing risk related to privacy and security. According to Kroll (2018), a responsible data governance strategy should include strategies and programs in both information security and privacy.

Proposition 1. *Organizations with an established data governance capability are more likely to have a well-functioning data science capability.*

Proposition 1 considers the interaction of data science with human agency from a product perspective. In other words, data governance is believed to play an essential role in coordinating and controlling the development of data science as a capability of the organization.

2.2. The Role of Data Governance with Regards to Data Science as a Medium of Human Agency

Data science differs from traditional science in a number of ways (Dhar 2013; Provost and Fawcett 2013). Traditionally, scientists study a specific subject and gather data about that subject. This data is then analyzed to gain in-depth knowledge about that subject. Data scientists tend to approach this process by gathering a wide variety of existing data and identifying correlations within the data which provide previously unknown or unexpected practical insights. Data scientists gain domain expertise and apply this knowledge in big data analysis to gain the best results (Gao et al. 2015). However, the trustworthiness of data science outcomes in practice is often affected by tensions arising through ongoing forms of work (Passi and Jackson 2018). According to Passi and Jackson (2018), data science is a socio-material practice in which human agency and technology are mutually intertwined. de de Medeiros et al. (2020) therefore stress the importance of developing a "data-driven culture."

Data governance is important for creating value and moderating risk in data science initiatives (Foster et al. 2018; Jones et al. 2019), as it can help organizations make use of data as a competitive asset (Morabito 2015). Data governance aims at maximizing the value of data assets in enterprises (Otto 2011; Provost and Fawcett 2013). For example, capturing electric and gas usage data every few minutes benefits the consumer as well as the provider of energy. With active governance of big data, isolation of faults and quick fixing of issues can prevent systemic energy grid collapse (Malik 2013).

Proposition 2. *Organizations with established data governance capability are more likely to generate trusted data science outcomes.*

Proposition 2 looks at the interaction of data science with human agency from a medium perspective. In other words, data governance is expected to play an important role in coordinating and controlling the use of data science in organizations.

2.3. The Role of Data Governance with Regards to Organizational Conditions of Interaction with Data Science

A common challenge in data science is aligning the data science inputs and outcomes with the structure of an organization (Janssen et al. 2020). This mismatch can result in unclear responsibilities and a lack of coordination mechanisms which give organizations control of the data over its entire life-cycle. This is particularly the case for data science projects which require data inputs from multiple departments. There is often a lack of established mechanisms for data governance leading to the ad hoc handling of data (Janssen et al. 2020). According to Wang et al. (2019) it is necessary to develop data governance mechanisms beginning with policy development to define governance goals and strategies, followed by the establishment of organizational data governance structures. Top management support (Gao et al. 2015), well-defined roles and responsibilities (Saltz and Shamshurin 2016), and the choice of the data governance approach (Koltay 2016) are considered critical. According to Janssen et al. (2020), data governance contains mechanisms to encourage preferred behavior. Incentives such as monetary rewards or public recognition should be complemented by mechanisms such as audits. Creating sound

data governance requires a balance between complete control, which does not allow for flexibility, and lack of control (Janssen et al. 2020).

Research has shown that favoring analytical techniques over domain knowledge can lead to risks related to the incorrect interpretation of the data (Provost and Fawcett 2013). Waller and Fawcett (2013) therefore believe that a data scientist should have a good understanding of the subject matter as well as having strong analytical skills. For example, recent years have seen a surge of interest in predictive maintenance and anomaly detection in the asset management domain (Raza and Ulansky 2017), however, when implementing data science for predictive maintenance or anomaly detection, data scientists also need to have a strong understanding of how assets deteriorate over time. Furthermore, according to Kezunovic et al. (2013), much of the data may not be correlated in time and space, or not have a common data model, making it difficult to understand without in-depth knowledge of how or why the data has been generated. As the number of people with data science skills as well in-depth domain knowledge is limited (Waller and Fawcett 2013), these insights suggest that data science initiatives should be governed by people with in-depth domain knowledge. According to Wang et al. (2019), organizations should develop comprehensive data governance mechanisms, beginning with policy development to define governance goals and strategies, followed by the establishment of organizational data governance structures.

Proposition 3. *Organizations with an established data governance capability are more likely to ensure that organizational conditions of data science are met.*

Proposition 3 considers the role of data governance as being important for coordinating and controlling the organizational requirements of the data science capability.

2.4. The Role of Data Governance with Regards to the Organizational Consequences of Data Science

As well as establishing data management processes that manage data quality, data governance should also ensure that the organization's data management processes are compliant with laws, directives, policies, and procedures (Wilbanks and Lehman 2012). According to Cato et al. (2015), policies and principles should be aligned with business strategies in an enterprise data strategy. Panian (2010) states that establishing and enforcing policies and processes around the management of data should be the foundation of effective data governance practice as using big data for data science often raises ethical concerns. For example, automatic data collection may cause privacy infringements (Cecere et al. 2015; van den Broek and van Veenstra 2018), such as in the case of cameras used to track traffic on highways, which often record personally identifiable data such as number plates or faces of persons in the vehicles.

Data governance processes should ensure that personally identifiable features are removed before data is shared or used for purposes other than legally allowed (Narayanan et al. 2016). Data governance should, therefore, establish what specific policies are appropriate (Khatri and Brown 2010) and applicable across the organization (Malik 2013). For example, Tallon (2013) states that organizations have a social and legal responsibility to safeguard personal data, whilst Power and Trope (2006) suggest that risks and threats to data and privacy require diligent attention from organizations.

Proposition 4. *Organizations with an established data governance capability are more likely to be able to manage organizational and process changes introduced by the data science outcomes.*

Proposition 4 considers the role of data governance as being important for coordinating and controlling the organizational consequences of data science outcomes.

3. Methodology

This paper describes two exploratory case studies using a multi-method approach to investigate the role of data governance as a boundary condition for data science. Case study is a widely adopted method for examining contemporary phenomena, such as the adoption of data governance (Choudrie and Dwivedi 2005; Eisenhardt 1989). In this research, we follow the design of an explanatory case study research proposed by Yin (2009), including the research question, the propositions for research, the unit of analysis, and the logic linking the data to the propositions. As suggested by Eisenhardt (1989), the research was contextualized by a review of background literature.

The literature background reveals that the results of data science initiatives are often not accepted by asset management organizations (Brous et al. 2017). Data science initiatives often face a number of acceptance challenges in asset management organizations due, in part, to a lack of trust in the data science outcomes (Cao et al. 2016; Yoon 2017). Facing these challenges has led many asset management organizations to adopt data governance as a means of coordinating and controlling the impact of data science on organizations. However, data governance remains a poorly understood concept and its contribution to the success of data science has not been widely researched. As discussed above, our main research question therefore asks, how is data governance a boundary condition for data science?

Following Ketokivi and Choi (2014), deduction type reasoning provided the basic logic for the propositions to be tested in a particular context, namely data science in an asset management domain. According to Ketokivi and Choi (2014), this general logic is augmented by contextual considerations. The data analysis in this research utilizes a combination of within-case analysis (Miles and Huberman 1994) and cross-case analysis, which enabled the delineation of the combination of factors that may have contributed to the outcomes of the case (Khan and Van Wynsberghe 2008). In this research, the unit of analysis was a data science project in the asset management domain.

Two case studies were selected. The first case study, "Project A", was a data science project for the purpose of predictive, "just-in-time" maintenance of asphalted roads. The project was conducted under the auspices of a large European public organization tasked with the maintenance of national highways. The second case study, "Project B", was a data science project for the purpose of discovering fraudulent use of electricity in medium and low tension electrical grids without impacting individual privacy rights. Table 1 below shows the properties of the two cases according to the subject, domain, organization size, organization type, number of datasets used, and the length (in time) of the project.

Table 1. Case selection.

Property	Project A	Project B
Case subject	Asphalt life expectancy	Fraud detection in electrical grids
Subject domain	Road management	Electrical Grid Management
Organization size	±4000 staff	±4000 staff
Organization Type	Government	Semi-government
Number of data sets	40+	10
Project length	3 months	18 months

The case studies were conducted using a multi-method approach. In order to prepare the respective organizations for the case studies, both organizations were provided with information material outlining the objectives of the research. Following the suggestions of Yin (2009), the case study research followed a research protocol. The research design was multi-method, and multiple data sources were used.

Primary data sources included the use of individual interviews. The interviews were conducted by the researchers over a period of two weeks. The interviews took place six months after the completion of the projects. The interviews were limited to one hour and followed a set line of questioning, although space was given during the interviews for follow-up questions in order to clarify descriptions or

subjective statements. In both cases, two data scientists (interviewee 1 and 2), one enterprise data architect (interviewee 3), and two data governance officers (interviewee 4 and 5) were interviewed.

Secondary data sources included relevant market research and policy documents as well as websites. Internal policy documents were provided to the research team by the interviewees and the researchers were also given access to the organizations' intranet and internet websites. All documents reviewed were documents that are available in the public domain.

Triangulation of factors relating to the role of data governance as a boundary condition for data science case was made by listing aspects of data governance found in internal documentation and comparing these to the aspects of data governance exposed in the interviews, and matching these with the responses of the interviewees as to the contribution of these aspects towards the success of the project. Interviewees were also requested to provide feedback with regards to possible improvements.

4. Findings

The results of the case studies were analyzed using a combination of within-case and cross-case analysis. In Sections 4.1 and 4.2 the within-case analysis is reported using the theory of the duality of technology as a guiding logic. The cases have been anonymized. Section 4.3 reports the cross-case analysis.

4.1. Project A: Asphalt Life Expectancy

The organization under whose auspices project A is managed is a public organization in Europe tasked with the management and maintenance of public infrastructure, including the construction and maintenance of roads. The organization has a budget of approximately €200 million per annum on asphalt maintenance, with operational parameters traditionally focused on traffic safety. According to interviewee 4, "this has led to increasing overspend due either to premature maintenance, or too expensive emergency repairs in the past." Interviewee 5 stated that the prediction of asphalt lifetime based on traditional parameters has been shown to be correct "one-third of the time."

According to staff members, the organization has implemented data governance for their big data in order to remain "future-proof, agile, and to improve digital interaction with citizens and partners." According to an interviewee 3, "(*the organization*) wants to be careful, open, and transparent about the way in which it handles big and open data and how it organizes itself."

4.1.1. Data Science as Product of Human Agency

The data science model utilized more than 40 different datasets which were fed into a data lake from the various source systems using data pipelines. These datasets included data related to traditional inspections, historical data generated during the laying of the asphalt, road attribute data, and planning data, as well as automatically generated streaming data, such as weather data, traffic data, and IoT sensor data. The current model takes about 400 parameters into consideration. According to an interviewee 2, "this number will only grow, as the (*project partners*) continue to supply new data." The ultimate goal of the project is a model that can accurately predict the lifespan of a highway. In the model, higher-order relationships between the datasets were discovered using machine learning techniques such as decision trees, random forests, and naïve Bayes algorithms. Neural networks were used to reduce overfitting and improve generalization error, and gradient boosting was used to efficiently minimize the selected loss function.

The organization has implemented a policy of providing knowledge, tools, and a government-wide contact network in which best practices are shared with other government organizations. These best practices refer to organization of data management, data exchange with third parties, data processing methods, and individual training. Furthermore, the organization has introduced the policy of assessing and publishing the monetary cost of data assets in order to raise awareness of the importance of data quality management. According to interviewee 2, "managers are required to know the cost of producing their data." This means that every process and every organizational unit is encouraged to

be aware of its data needs and the incurred costs. The data is then considered a strategic asset and considered to be a production input.

4.1.2. Data Science as Medium of Human Agency

The goal of project A is to reduce spending by extending the lifespan of asphalt where possible while reducing the number of emergency repairs made through predictive, "just-in-time" maintenance. Using available big data in a more detailed manner, such as raveling data combined with vehicle overloading data, has doubled the prediction consistency. According to interviewee 1, improving the accuracy of asphalt lifetime prediction "has enabled better maintenance planning, which has significantly reduced premature maintenance, improving road safety and cost savings, and reducing the environmental impact due to reduced traffic congestion and a reduction in CO^2 emissions."

4.1.3. Organizational Conditions of Data Science

The organization has translated their policy and principles into a data strategy in which the opportunities, risks, and dilemmas of their policies and ambitions are identified in advance and are made measurable and practicable. Interviewee 3 reported that the organization has also asked the data managers in the organization to appoint a sponsor or data owner. By means of the above control and design measures, the organization ensures that the data ambitions are operationalized.

The organization has invested heavily in the fields of big data, open data, business intelligence and analytics. Interviewee 5 believed that "the return (of the investment) stands or falls with the quality of data and information." As such, according to the interviewee 5, "the underlying quality of the data and information is very important to work in an information-driven way and as much as 70% of production time has been lost in almost every department due to inadequate data quality." The organization has, therefore, implemented a data quality framework to improve its control of data quality. The data quality management process follows an eight-step process, which begins by identifying: 1. the data to be produced, 2. the value of the data for the primary processes, and 3. a data owner. The data owner is the business sponsor.

4.1.4. Organizational Consequences of Data Science

Once ownership had been established, the current and desired future situations were assessed in terms of production and delivery. Interviewee 2 reported that a roadmap was then established, which was translated into concrete actions. According to the interviewee, "the final step in the process was the actual production and delivery of data in accordance with the agreement." The organization has developed their own automatic auditing tool in combination with a manual auditing tool to monitor the quality of the data as a product in order to further improve its grip on data quality. According to interviewee 3, these tools "ensure that quality measurements were mutually comparable," and " . . . cause changes in the conscious use of data as a strategic asset." Data quality measuring is centralized; the goal is to ensure a standardized working method. However, the organization maintains the policy that every data owner is responsible for improvements to the data management process and the data itself. The data quality framework is based on fitness for use, and data quality measurement is maintained according to 8 main dimensions and 47 subdimensions. Terms and definitions are coordinated with legal frameworks related to the environment to ensure compliance. Responsibilities relating to compliance with privacy laws are centralized, and privacy officers are assigned to this role. The CIO has the final responsibility for ensuring that privacy and security are managed and maintained, however, data owners are responsible for ensuring compliance to dataset-specific policy and regulations.

4.2. Project B: Fraud Detection in Electrical Grids

Project B is a data science project designed to detect the fraudulent use of electricity within medium and low voltage grids without infringing on personal privacy rights. The project is managed

under the auspices of a large European distribution grid operator (DGO). The role of the DGO is to transport the electricity from the high voltage grid to the end-user. The project was developed to improve the discovery rates of traditional methods utilized by the expensive commercial, off-the-shelf (COTS) system, which was in place at the time.

According to interviewee 5, the organization has implemented data governance as "an integral part of their digital transformation strategy." Interviewee 4 reported that "the data governance team, the data science team, and the data engineering teams are managed within the same department and report directly to the Chief Data Officer."

4.2.1. Data Science as Product of Human Interaction

Project B was one of the first data science projects undertaken in the organization. Developing the data science capability within the organization required the development of a managed data lake and data pipelines to ensure connectivity from the data sources. Initially, the data science model was developed in an external data lake. According to interviewee 1, this meant that "no automatic data pipelines between the internal data systems and the data science model could be established, so we were forced to improvise." This meant that the data science model needed to be initially fed with batch uploads of data. This situation was eventually rectified with the development of an internal data lake which allowed connectivity with the original data source systems.

According an interviewee 2, the data science model initially utilized two sets of data originating from smart grid terminals, "but was eventually expanded to include ten data sets after we had spent quite some time on discovery and after many hours of discussion and investigation." Two years of training data were made available to the data scientists. According to the data scientists involved in the case, understanding the data was exceptionally difficult in this case. For example, during the project, it was discovered that the values in certain columns had been incorrectly labeled and needed to be corrected to attain the correct value, which corresponded to the required units. The data were not supplied with metadata, and finding subject matter experts with in-depth knowledge about the data was very difficult. For example, the data scientists discovered during the project that the OBIS codes did not follow the standardized values. The OBIS code is a unique identification of the registers in the smart meter's memory, according to IEC 62056-61.

Data were supplied by a subsidiary of the organization. The subsidiary was eventually sold to a third party during the project. This led to a situation whereby data owners were not available, and no single person could be found with a definitive knowledge of how the data were collected and collated. Data were collated and managed by two data engineers assigned to the project. Interviewee 4 reported that collaboration between the data engineers and the data scientists was not optimal as code was sometimes changed without sufficient documentation or collaboration. According to a data scientist 1 "the engineer changed quite a lot of code without checking with us (the data scientists) first."

4.2.2. Data Science as Medium of Human Interaction

Reducing fraudulent usage of electricity on the middle and low voltage electrical grids without infringing on personal privacy rights is of importance for a number of reasons, although few of the reasons are directly related to the DGO itself. Fraudulent usage of electricity is essentially theft, as electricity is being used without paying the provider for the service. According to interviewee 4, "in middle and low tension grids it is especially hard to decide from whom the fraudster is stealing electricity, because there are multiple electricity providers who sell their electricity directly to the end-user but use the common grid to transport the electricity." The fraudster is essentially taking electricity out of a shared service, so it is impossible to know from whom electricity is being stolen. Furthermore, fraudsters that are caught generally only have to pay the net stolen kWh, although damage is also suffered by the network operator. This amount, the so-called "grid loss", is 70% lower than the price that consumers pay.

It is important to know how much energy is being used on the grid in advance in order to be able to balance the use of energy with the supply so that the grid is not overloaded. However, balancing of the entire electricity supply is generally performed by the transmission system operator (TSO), which manages the high voltage grid.

Catching fraudsters also requires collaboration with a number of parties, including the police. Moreover, European privacy laws dictate that the end-user is the owner of the data collected by the electricity meters, which means that DGOs are not able to read the values without permission from the end-users, which fraudsters are unlikely to give. According to interviewee 5 it is often difficult to coordinate a response to combating fraud, whilst the rewards for fraudulent usage remain high—"we are always behind fraudsters as catching them is expensive, whilst there is almost no risk for them." From a data governance perspective, this makes it especially difficult to coordinate and control the proper collection and collation of the required data.

4.2.3. Organizational Conditions of Data Science

The data science projects in the organization are decided upon and prioritized by managers of the primary business processes. The data scientists work according to sprints of two weeks, according to directions suggested by the product owner. The disruption to the project caused by the sale of the subsidiary mean that a new product owner as well as new data owners need to be found within the organization. According to one of the data scientists, the data owners are necessary "to be able to coordinate and control the proper collection, collation, and management of the data, provide input to the data scientists regarding the content of the data (metadata) and accept and control the quality of the data science outcomes." This means that data governance officers and privacy officers attached to the department were required to develop a roles and responsibilities matrix for the management of the data and the use of the data, in concurrence with privacy regulations.

4.2.4. Organizational Consequences of Data Science

Despite the technological and social challenges faced during the project, the data science team reported that after an extended period of 18 months, they were able to present a workable model that greatly outperformed traditional methods of fraud detection. The model was presented to the energy management team which had been identified as the client and the main data owner. The data science team reported that the presentation was not well-received and that the model was eventually not adopted, despite the proven improvements. The data science team believed that the reason for this was that "they didn't want to believe the results. (The organization) has spent millions on the COTS system, and they are reluctant to accept that they've made a procurement error. Their argument was that the data was unreliable, but technically it's the same data being used by the COTS system." This reaction suggests that end-users as well as data owners should be an integral part of the data science project and that not only results but also intentions should be tested throughout the project.

4.3. Cross-Case Analysis

In the cross-case analysis, the results of the case studies were analyzed in comparison to the relative maturity of the data science capability as reported by the interviewees, the perceived success of the data science outcomes from the perspective of the project team, and whether or not the outcomes were accepted and adopted within the primary business processes. Table 2 below compares the two case studies based on data governance maturity, data science outcomes, and the adoption status of the data governance outcomes.

Table 2. Comparison of the case studies.

Project	Data Science Maturity	Data Science Outcomes	Business Acceptance of Data Science Outcomes
Project A	Established	Demonstrated improvement on traditional methods	Data science outcomes integrated within business processes in combination with traditional methods
Project B	Initial	Demonstrated improvement on traditional methods	Data science outcomes not accepted by business

Table 2 above shows that Project A has an established data governance capability and that the outcomes of the project were accepted by the business. In Project B, the organization does not have an established data governance capability, and the data science outcomes were not adopted by the business.

4.3.1. The Role of Data Governance with Regards to Data Science as a Product of Human Agency

In Table 3 below, the role of data governance with regards to the successful implementation of data science as an organizational capability is compared between the cases.

Table 3. Comparison of the cases with regards to the role of data governance in data science as a product of human agency.

Role of Data Governance	Project A	Project B
Coordinate and control data science capabilities e.g., coordination and control of: • Data access and availability • Compliance (privacy and security) • Data quality • Data engineering, and predictive analytics skills • Algorithm management	Although much of the infrastructure and required staff capacity was available, the coordination and control provided by business leaders provided good, previously unknown insight into the available data and improved the analytical skills of the data scientists. Much of the data used in project A were open data, which were readily available. This allowed the project to progress according to schedule, even with large amounts of data.	During the project, the entire IT and data infrastructure needed to be developed. The disruption caused by the sale of the subsidiary demonstrated the importance of business leadership in coordinating and controlling the quality and trust in the data science outcomes. Data access was a major issue throughout the project, technically and ethically. The lack of data connectivity created long delays and privacy regulations needed to be checked and adhered to. This was exacerbated by the lack of business leadership to monitor and control data access.

In Table 3 above, we notice that although Project A required more data sets than Project B, data access was not considered an issue, and the project was able to be completed with a minimum of extra effort. In contrast, project B team members were required to set up the data infrastructure, find the data, and manage access and data quality themselves.

4.3.2. The Role of Data Governance with Regards to Data Science as a Medium of Human Agency

In Table 4 below, the role of data governance with regards to the acceptance, coordination, and control of data science outcomes is compared between the cases.

Table 4. Comparison of the cases with regards to the role of data governance in data science as a medium of human agency.

Role of Data Governance	Project A	Project B
Increase the business value of data assets—e.g., oversee data usage with regards to: - Acceptance of data science outcomes for risk management - Acceptance of data science outcomes for improved efficiency of primary processes - Acceptance of data science outcomes for improved effectiveness of primary processes	Project A data science outcomes showed an improved result in contrast to traditional methods. The outcomes were accepted and adopted by the business. Data owners were able to monitor the development of the data science outcomes throughout the process and had ownership of the results.	Although project B demonstrated a marked improvement in traditional methods, the business did not choose to adopt the data science outcomes. Business leaders were not a part of the data science project, and results were presented only at the end of the project.

From Table 4 it becomes clear that in project A, data owners were involved from the start of the project until delivery. In addition, data owners were accorded ownership of the outcomes. As a result, the outcomes were accepted by the data owners. This is in contrast to Project B, in which data owners were not available, and business owners did not accept the data science results.

4.3.3. The Role of Data Governance with Regards to Organizational Conditions of Data Science

In Table 5 below, the role of data governance with regards to the coordination and control of organizational conditions of data science is compared between the cases.

Table 5. Comparison of the cases with regards to the role of data governance in coordinating and controlling the organizational conditions of data science.

Role of Data Governance	Project A	Project B
Ensure that relevant coordination and control mechanisms are in place	Principles and policies have been adopted in a data strategy that follows an annual cycle of planning and control.	Project B did not benefit from a strict regime of planning and control, and the data science team were required to be self-managing. Resources were limited to the initial project team, although there were no time pressures for delivery. As a result, the project duration was much longer than initially expected.
Ensure sufficient resources (budget and staffing) are available	Budget and staffing is monitored and tested according to the data agenda.	
Ensure roles and responsibilities are sufficiently filled	Each business unit is required to appoint a data owner for every data set it manages.	Business leaders were difficult to find, and no owners were available.

From Table 5 we can conclude that Project A has a strict regime of coordination and control following a yearly review as well as well-defined roles and responsibilities. In contrast, team members of Project B were given little direction and no ownership was displayed by business leaders.

4.3.4. The Role of Data Governance with Regards to Organizational Consequences of Data Science

In Table 6 below, the role of data governance with regards to the coordination and control of organizational consequences of data science is compared between the cases.

Table 6. Comparison of the cases with regards to the role of data governance in coordinating and controlling organizational consequences of data science.

Role of Data Governance	Project A	Project B
Coordinate and control new costs related to data science: e.g., • IT infra costs • HR costs	IT infra costs and staffing costs are managed centrally according to demand.	The project team was assigned by the department manager. The project team was a part of the data office team, the costs of which were managed centrally. The acquisition of an expensive commercial, off-the-shelf (COTS) application that provided similar functionality conflicted with the data science outcomes.
Coordinate and control organizational changes as a result of data science: e.g., • new departments • new business processes • new roles and responsibilities	The management of organizational change is handled by the project manager, who oversees the data science project from initiation to adoption. Business units are required to name data owners.	The management of the new data office team fell under the control of the chief data officer who reports to the chief strategy officer. The primary business was not involved in time management. Data ownership was not defined.
Coordinate and control new risks related to data science: e.g., • non-compliance • incorrect decisions due to incorrect data • need for increased security • lack of trust in data science outcomes	Privacy and security issues are managed by means of privacy impact assessments and baseline information security testing.	Compliance was monitored by data privacy officers through privacy impact assessments, and assistance was given to the data science team by data governance officers.

From Table 6 it can be derived that in Project A, the implementation of the data science outcomes was managed by a dedicated project manager in conjunction with the data owners. This was in contrast to Project B, in which no data owners were involved and a rival COTS application which had previously been acquired by business leaders created an insurmountable conflict for the project team.

5. Discussion

Case study methodology was used in this research to identify the role that data governance plays as a success factor for data science. The choice for an in-depth case study was based on the contemporary nature of both data science and data governance. The study was conducted on the basis of two case studies in different organizations, and the results should be regarded in this light. The study was conducted in the asset management domain as asset management organizations by nature are often data-rich due to the need to monitor the state of the infrastructure assets. This may limit the applicability of the study for domains which are less data intensive, however the essence of generating value from data is likely to be the same in other domains.

5.1. Proposition 1. Organizations with an Established Data Governance Capability Are More Likely to Have a Well-Functioning Data Science Capability

With regards to Proposition 1, which proposes that organizations with an established data governance capability have better functioning data science capabilities, the results of the case studies suggest that when data governance has been actively implemented before the start of a data science project, the complexity of issues such as access to data and the understanding of the data is greatly reduced. The use of big data in data science projects often leads to serious data quality (Saha and Srivastava 2014) and compliance (Narayanan et al. 2016) issues which can be difficult to manage in a timely manner (Hazen et al. 2014). Data governance policies and principles (Madera and Laurent

2016) and a responsible data governance strategy (Kroll 2018) should therefore be key components of data science technologies. This suggests that data governance plays an important role in ensuring the effectiveness and efficiency of the data science capability in an organization.

5.2. Proposition 2. Organizations with Established Data Governance Capability Are More Likely to Generate Trusted Data Science Outcomes

Proposition 2 suggests that organizations with an established data governance capability are better positioned to produce trusted data science decision outcomes. The results of the case studies confirm that data science projects in which data owners have a direct influence on the project from start to finish are more likely to generate trusted outcomes. Data governance is important for creating value and moderating risk in data science initiatives (Foster et al. 2018), as the trustworthiness of data science outcomes in practice is often affected by tensions arising through ongoing forms of work (Passi and Jackson 2018). This suggests that data governance plays an important role in creating trust in data science outcomes and positively influencing the use and acceptance of data science outcomes in the organization.

5.3. Proposition 3. Organizations with an Established Data Governance Capability Are More Likely to Ensure that Organizational Conditions of Data Science are Met

Successful data science outcomes require data governance mechanisms beginning with policy development to define governance goals and strategies (Wang et al. 2019), followed by the establishment of organizational data governance structures. Top management support (Gao et al. 2015), well-defined roles and responsibilities (Saltz and Shamshurin 2016), and the choice of the data governance approach (Koltay 2016) are considered critical. Proposition 3 proposes that organizations having an established data governance capability are more likely to be in a position to meet organizational conditions. In this regard, the case studies suggest that a regime of coordination and control of data management processes, following a regular cycle, as well as well-defined roles and responsibilities, play important roles in developing ecosystems in which data science projects are more likely to be successful.

5.4. Proposition 4. Organizations with an Established Data Governance Capability Are More Likely to Be Able to Manage Organizational and Process Changes Introduced by Data Science Outcomes

Data governance establishes data management processes which manage data quality (Passi and Jackson 2018) and compliance with relevant laws, directives, and policies (Cato et al. 2015). Data governance aligns policies and principles with business strategies in an enterprise data strategy (Cato et al. 2015). Proposition 4 proposes that organizations with mature data governance are more likely to be able to manage changes introduced by data science decision outcomes. In this regard, the results of the case studies suggest that organizations which have a well-developed data governance capability are more likely to be able to manage new costs arising from changes in staff and technology, manage changing risks arising from changes in primary processes, and manage organizational and process changes introduced by the acceptance of data science outcomes within the business.

6. Conclusions

In this paper we analyzed two data science case studies in the asset management domain in order to understand the role of data governance as a boundary condition for creating trust in data science decision outcomes. The first case under study was a data science project which predicts the maintenance requirements of asphalt on national highways over time. The second case study was a data science project which discovers the fraudulent use of electricity in a middle- and low-level voltage grid. The results of the case studies suggest that data science decision outcomes are more likely to be accepted if the organization has an established data governance capability. Furthermore, the results suggest that organizations with an established data governance capability are more likely to have a well-functioning data science capability, are more likely to generate trusted data science

outcomes, are more likely to ensure that organizational conditions of data science are met, and are more likely to be able to manage organizational and process changes introduced by the data science decision outcomes. These results confirm the propositions of the research and we conclude that data governance is a boundary condition for managing the organizational consequences of data science outcomes. Viewing the acceptance of data science decision outcomes for decision-making in organizations as a socio-material challenge in which trust plays a central role implies that the analysis and interpretation of data is tightly coupled with the governance and proper management of that data. Simply "throwing data" at a problem without regard for the quality or bias of the data or the algorithm itself does not necessarily lead to acceptance of the decision outcomes. Rather, it is necessary to look at the development of trustworthy data science decision outcomes not as a purely technical problem, requiring a technical solution, but as one in which human agency and organizational forces play a significant role. This approach also has practical implications, as managers responsible for data science should ensure that the data governance capability of the organization is well established before the focus is placed on the development of the data science capability. The research was limited to two data science projects in (semi)-government organizations within the asset management domain. Further investigation with regards to data science projects with different scopes, domains, and organizations is recommended.

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References

Adrian, Cecilia, Rusli Abdullah, Rodziah Atan, and Yusmadi Yah Jusoh. 2017. Factors influencing to the implementation success of big data analytics: A systematic literature review. Paper presented at 2017 International Conference on Research and Innovation in Information Systems (ICRIIS), Langkawi, Malaysia, July 16–17; pp. 1–6. [CrossRef]

Alofaysan, Sarah, Bandar Alhaqbani, Rana Alseghayyir, and Maryam Omar. 2014. The significance of data governance in healthcare: A case study in a tertiary care hospital. In *Proceedings of the International Joint Conference on Biomedical Engineering Systems and Technologies-Volume 5*. Eseo: SCITEPRESS-Science and Technology Publications, pp. 178–87.

Al-Ruithe, Majid, Elhadj Benkhelifa, and Khawar Hameed. 2019. A systematic literature review of data governance and cloud data governance. *Personal and Ubiquitous Computing* 23: 839–59. [CrossRef]

Brain, Damien, and Geoffrey I. Webb. 2002. The Need for Low Bias Algorithms in Classification Learning from Large Data Sets. In *Proceedings of the Principles of Data Mining and Knowledge Discovery*. Edited by T. Elomaa, H. Mannila and H. Toivonen. Berlin and Heidelberg: Springer, pp. 62–73.

Brous, Paul, Paulien Herder, and Marijn Janssen. 2016. Governing Asset Management Data Infrastructures. *Procedia Computer Science* 95: 303–10. [CrossRef]

Brous, Paul, Marijn Janssen, and Rutger Krans. 2020. Data Governance as Success Factor for Data Science. In *Responsible Design, Implementation and Use of Information and Communication Technology*. Edited by Marié Hattingh, Machdel Matthee, Hanlie Smuts, Ilias Pappas, Yogesh K. Dwivedi and Matti Mäntymäki. Skukuza: Springer International Publishing, pp. 431–42. [CrossRef]

Brous, Paul, Marijn Janssen, Daan Schraven, Jasper Spiegeler, and Baris Can Duzgun. 2017. Factors Influencing Adoption of IoT for Data-driven Decision Making in Asset Management Organizations. In *IoTBDS*. Porto: Scitepress, pp. 70–79. Available online: http://www.scitepress.org/DigitalLibrary/Link.aspx?doi=10.5220/0006296300700079 (accessed on 1 June 2020).

Busse, Christian, Andrew P. Kach, and Stephan M. Wagner. 2017. Boundary Conditions: What They Are, How to Explore Them, Why We Need Them, and When to Consider Them. *Organizational Research Methods* 20: 574–609. [CrossRef]

Cao, Quyet H., Imran Khan, Reza Farahbakhsh, Giyyarpuram Madhusudan, Gyu Myoung Lee, and Noel Crespi. 2016. A Trust Model for Data Sharing in Smart Cities. In *IEEE International Conference on Communications 2016 (ICC 2016)*. Kuala Lumpur: IEEE.

Cato, Patrick, Philipp Gölzer, and Walter Demmelhuber. 2015. An investigation into the implementation factors affecting the success of big data systems. In *2015 11th International Conference on Innovations in Information Technology (IIT)*. Dubai: IEEE, pp. 134–39. [CrossRef]

Cecere, Grazia, Fabrice Le Guel, and Nicolas Soulié. 2015. Perceived Internet privacy concerns on social networks in Europe. *Technological Forecasting and Social Change* 96: 277–87. [CrossRef]

Choudrie, Jyoti, and Yogesh Kumar Dwivedi. 2005. Investigating the research approaches for examining technology adoption issues. *Journal of Research Practice* 1: D1.

Council on Library and Information Resources, ed. 2000. *Authenticity in A Digital Environment*. Washington: Council on Library and Information Resources.

DAMA International. 2017. *DAMA-DMBOK: Data Management Body of Knowledge*. Basking Ridge: Technics Publications.

de Medeiros, Mauricius Munhoz, Norberto Hoppen, and Antonio Carlos Gastaud Maçada. 2020. Data science for business: Benefits, challenges and opportunities. *The Bottom Line* 33: 149–63. [CrossRef]

Dhar, Vasant. 2013. Data science and prediction. *Communications of the ACM* 56: 64–73. [CrossRef]

Dwivedi, Yogesh K., Marijn Janssen, Emma L. Slade, Nripendra P. Rana, Vishanth Weerakkody, Jeremy Millard, Jan Hidders, and Dhoya Snijders. 2017. Driving innovation through big open linked data (BOLD): Exploring antecedents using interpretive structural modelling. *Information Systems Frontiers* 19: 197–212. [CrossRef]

Eisenhardt, Kathleen M. 1989. Building Theories from Case Study Research. *The Academy of Management Review* 14: 532–50. [CrossRef]

Foster, Jonathan, Julie McLeod, Jan Nolin, and Elke Greifeneder. 2018. Data work in context: Value, risks, and governance: Data Work in Context: Value, Risks, and Governance. *Journal of the Association for Information Science and Technology* 69: 1414–27. [CrossRef]

Gama, João. 2013. Data Stream Mining: The Bounded Rationality. *Informatica* 37: 6.

Gao, Jing, Andy Koronios, and Sven Selle. 2015. Towards A Process View on Critical Success Factors in Big Data Analytics Projects. Available online: https://aisel.aisnet.org/amcis2015/BizAnalytics/GeneralPresentations/16/ (accessed on 10 June 2020).

Giddens, Anthony. 1976. *New Rules of Sociological Method: A Positive Critique of Interpretative Sociology*. Stanford: Stanford University Press.

Gigerenzer, Gerd, and Reinhard Selten. 2002. *Bounded Rationality: The Adaptive Toolbox*. Cambridge: MIT Press.

Hazen, Benjamin T., Christopher A. Boone, Jeremy D. Ezell, and L. Allison Jones-Farmer. 2014. Data quality for data science, predictive analytics, and big data in supply chain management: An introduction to the problem and suggestions for research and applications. *International Journal of Production Economics* 154: 72–80. [CrossRef]

Janssen, Marijn, Paul Brous, Elsa Estevez, Luis S. Barbosa, and Tomasz Janowski. 2020. Data governance: Organizing data for trustworthy Artificial Intelligence. *Government Information Quarterly* 37: 101493. [CrossRef]

Jones, Kerina, Elizabeth Ford, Nathan Lea, Lucy Griffiths, Sharon Heys, and Emma Squires. 2019. Developing data governance standards for using free-text data in research (TexGov). *International Journal of Population Data Science* 4. [CrossRef]

Ketokivi, Mikko, and Thomas Choi. 2014. Renaissance of case research as a scientific method. *Journal of Operations Management* 32: 232–40. [CrossRef]

Kezunovic, Mladen, Le Xie, and Santiago Grijalva. 2013. The role of big data in improving power system operation and protection. Paper presented at 2013 IREP Symposium Bulk Power System Dynamics and Control—IX Optimization, Security and Control of the Emerging Power Grid (IREP), Rethymno, Greece, August 25–30. [CrossRef]

Khan, Samia, and Robert Van Wynsberghe. 2008. Cultivating the under-mined: Cross-case analysis as knowledge mobilization. *Forum qualitative Sozialforschung/Forum: Qualitative Social Research* 9. [CrossRef]

Khatri, Vijay, and Carol V. Brown. 2010. Designing data governance. *Commun. ACM* 53: 148–52. [CrossRef]

Koltay, Tibor. 2016. Data governance, data literacy and the management of data quality. *IFLA Journal* 42: 303–12. [CrossRef]

Kroll, Joshua A. 2018. Data Science Data Governance [AI Ethics]. *IEEE Security Privacy* 16: 61–70. [CrossRef]

Ladley, John. 2012. *Data Governance: How to Design, Deploy and Sustain an Effective Data Governance Program*. London: Academic Press.

Lin, Shien, Jing Gao, and Andy Koronios. 2006. The Need for A Data Quality Framework in Asset Management. Available online: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.84.1469andrep=rep1andtype=pdf (accessed on 1 June 2020).

Madera, Cedrine, and Anne Laurent. 2016. The Next Information Architecture Evolution: The Data Lake Wave. In *Proceedings of the 8th International Conference on Management of Digital EcoSystems*. New York: Association for Computing Machinery, pp. 174–80. [CrossRef]

Malik, Piyush. 2013. Governing Big Data: Principles and practices. *Ibm Journal of Research and Development* 57: 1. [CrossRef]

Miles, Matthew B., and A. Michael Huberman. 1994. *Qualitative Data Analysis: An Expanded Sourcebook*. London: SAGE.

Miloslavskaya, Natalia, and Alexander Tolstoy. 2016. Big Data, Fast Data and Data Lake Concepts. *Procedia Computer Science* 88: 300–5. [CrossRef]

Morabito, Vincenzo. 2015. Big Data Governance. In *Big Data and Analytics*. Cham: Springer, pp. 83–104. [CrossRef]

Narayanan, Arvind, Joanna Huey, and Edward W. Felten. 2016. A Precautionary Approach to Big Data Privacy. In *Data Protection on the Move*. Edited by Serge Gutwirth, Ronald Leenes and Paul De Hert. Cham: Springer, vol. 24, pp. 357–85. [CrossRef]

Newell, Allen, and Herbert Alexander Simon. 1972. *Human Problem Solving*. Englewood Cliffs: Prentice-Hall, vol. 104.

Nunn, Sandra L. 2009. Driving Compliance through Data Governance. *Journal of AHIMA* 80: 50–51.

Orlikowski, Wanda J. 1992. The Duality of Technology: Rethinking the Concept of Technology in Organizations. *Organization Science* 3: 398–427. [CrossRef]

Otto, Boris. 2011. Data Governance. *Business and Information Systems Engineering* 3: 241–44. [CrossRef]

Panian, Zeljko. 2010. Some practical experiences in data governance. *World Academy of Science, Engineering and Technology* 38: 150–57.

Paskaleva, Krassimira, James Evans, Christopher Martin, Trond Linjordet, Dujuan Yang, and Andrew Karvonen. 2017. Data Governance in the Sustainable Smart City. *Informatics* 4: 41. [CrossRef]

Passi, Samir, and Steven J. Jackson. 2018. Trust in Data Science: Collaboration, Translation, and Accountability in Corporate Data Science Projects. *Proceedings of the ACM on Human-Computer Interaction* 2: 1–28. [CrossRef]

Power, E. Michael, and Roland L. Trope. 2006. The 2006 survey of legal developments in data management, privacy, and information security: The continuing evolution of data governance. *Business Lawyer* 62: 251–94.

Provost, Foster, and Tom Fawcett. 2013. Data Science and its Relationship to Big Data and Data-Driven Decision Making. *Big Data* 1: 51–59. [CrossRef] [PubMed]

Randall, Robert, Don Peppers, and Martha Rogers. 2013. Extreme trust: The new competitive advantage. *Strategy and Leadership* 41: 31–34. [CrossRef]

Raza, Ahmed, and Vladimir Ulansky. 2017. Modelling of predictive maintenance for a periodically inspected system. *Procedia CIRP* 59: 95–101. [CrossRef]

Saha, Barna, and Divesh Srivastava. 2014. Data quality: The other face of big data. In *2014 IEEE 30th International Conference on Data Engineering*. Chicago: IEEE, pp. 1294–97.

Saltz, Jeffrey S., and Ivan Shamshurin. 2016. Big data team process methodologies: A literature review and the identification of key factors for a project's success. In *2016 IEEE International Conference on Big Data (Big Data)*. Washington: IEEE, pp. 2872–79. [CrossRef]

Simon, Herbert A. 1947. *Administrative Behavior: A Study of Decision-Making Processes in Administrative Organization*. New York: Macmillan.

Tallon, Paul P. 2013. Corporate Governance of Big Data: Perspectives on Value, Risk, and Cost. *Computer* 46: 32–38. [CrossRef]

Ullah, Saeed, M. Daud Awan, and M. Sikander Hayat Khiyal. 2018. Big Data in Cloud Computing: A Resource Management Perspective. *Scientific Programming*. [CrossRef]

van den Broek, Tijs, and Anne Fleur van Veenstra. 2018. Governance of big data collaborations: How to balance regulatory compliance and disruptive innovation. *Technological Forecasting and Social Change* 129: 330–38. [CrossRef]

Waller, Matthew A., and Stanley E. Fawcett. 2013. Data science, predictive analytics, and big data: A revolution that will transform supply chain design and management. *Journal of Business Logistics* 34: 77–84. [CrossRef]

Wang, Chen-Shu, Shiang-Lin Lin, Tung-Hsiang Chou, and Bo-Yi Li. 2019. An integrated data analytics process to optimize data governance of non-profit organization. *Computers in Human Behavior* 101: 495–505. [CrossRef]

Webster, Jane, and Richard T. Watson. 2002. Analyzing the Past to Prepare for the Future: Writing a Literature Review. *MIS Quarterly* 26: 13–23.

Wilbanks, Debra, and Karen Lehman. 2012. Data governance for SoS. *International Journal of System of Systems Engineering* 3: 337–46. [CrossRef]

Yin, Robert K. 2009. *Case Study Research: Design and Methods*. Thousand Oaks: SAGE.

Yoon, Ayoung. 2017. Data reusers' trust development. *Journal of the Association for Information Science and Technology* 68: 946–56. [CrossRef]

Zuiderwijk, Anneke, and Marijn Janssen. 2014. The Negative Effects of Open Government Data—Investigating the Dark Side of Open Data. In *Proceedings of the 15th Annual International Conference on Digital Government Research*. New York: Association for Computing Machinery, pp. 147–52. [CrossRef]