Article

Effectiveness of Leadership Decision-Making in Complex Systems

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Abstract: This paper traverses the domains of leadership and decision-making within various types of systems with different levels of complexity. The article presents some background about both leadership and decision-making, and then explores the concept of leadership decision-making and some of the factors involved. The paper then reviews complex systems and provides examples to differentiate complex systems from other systems. Finally, these strands are brought together with a consideration of leadership decision-making in complex systems and presentation of a framework to assist managers faced with decision-making in complexity, based on data collected in a survey. The aim and practical contribution of this paper is to improve the outcomes of leadership decision-making within complex systems, based upon the findings and on a decision aid model derived from them. The paper, therefore, should help people in real life and leaders within organizational settings to improve their decision-making effectiveness within the ever-increasing range of complex situations which are now widely encountered.

Keywords: decision-making; leadership; complex systems

1. Introduction

Today's business environment is complex and fast-moving. Current levels of ambiguity and uncertainty make decision-making very challenging. Systems today contain properties of volatility, uncertainty, complexity and ambiguity—the so-called VUCA environment [1]. As management guru Tom Peters said: "If you're not confused, you're not paying attention." In an uncertain environment, followers are looking to their leaders to make sense of the uncertainty and produce high-quality decisions. There is pressure for leaders to make decisions very quickly and there can be expensive failures if the wrong option is pursued. We live in a so-called "stakeholder society", with conflicting values and perspectives [2]. On the one hand, we have an overload of information, which can be confusing. On the other hand, leaders are looking for the right information to help them to keep their focus on important issues and come up with a suitable strategic decision to bring a competitive advantage. A small mistake in decision-making can lead to organizational "sink or swim" in a very public way. Making no decision is not an option.

Given these pressures, many leaders are unsure about how to make decisions which can maximize organizational outcomes. Some leaders succumb to the pressure and fall back on what they did in the past, which is certainly not a blueprint for current success. Approaches of the past are no longer appropriate for today's complex problems. We need a major paradigm shift in leadership decision-making approaches, which fits with our complex world. What is now needed is an approach

that can take account of available information and analyze it quickly to come up with tailor-made solutions which are fit for purpose.

The main purpose of this study is to capture key issues that arise in decision-making in complexity, and to investigate the main factors that affect management decision-making in complex scenarios by analyzing data collected through a questionnaire completed by senior managers. This information can provide insights into how senior leaders combine their knowledge and experience in a holistic way to produce wise decisions that lead to effective solutions to complex problems. It also reveals areas for improvement. As part of this study, the authors also introduce an approach to help managers improve the probability of making effective decisions in a complex situation.

2. Background

2.1. Leadership

There is now much literature concerning the best approaches to leadership. A literature search [3] reveals over four million entries on the topic of leadership. There are also differences regarding the definition of leadership, but in general leadership is viewed as the ability to influence people and motivate them to contribute to organizational outcomes.

Despite the plethora of research outputs concerning leadership, there is not yet a definitive answer to the question: what is the best way to lead? Many different approaches have been taken to understand what makes a good leader. Early research concerned leaders' traits [4–6]. This research often studied people who are called "heroic leaders" [7,8]. Acceptance of the trait approach has varied throughout the last century, and it is still viewed by some writers as a promising path to developing leadership capability [9]. Researchers have also focused upon behavioral approaches to leadership: what leaders should actually do [10,11]. Leadership contingency theories [12,13] explored the need for different behaviors under different circumstances.

Recent theories regarding leadership have moved beyond the realm of behavior and are focused upon transformational leadership (versus transactional leadership) and the importance of developing a vision for the future and bringing followers along with that vision [14]. Transformational leadership is often treated as being interchangeable with charismatic leadership, in which followers perceive their leader to have exceptional powers and abilities. Other recent leadership approaches include authentic leadership, spiritual leadership, servant leadership, adaptive leadership and responsible leadership. Western [7] posited that there were at least 46 different types of leadership theory altogether, ranging from action-centered through to values-based leadership. Another study by Dinh, et al. [15] recognized 66 different leadership styles. Clearly, there is no shortage of different ways to approach the work of leadership within an organization.

Leadership has also been investigated as a process rather than as something associated with the individual leader, moving away from the leader-centric approach to a greater appreciation of the role of followers and context. Distributed or participative leadership, in which power is shared with followers, has been widely investigated [16,17]. This approach is especially relevant to knowledge-based organizations, where the tasks are complex. Clearly, collective leadership requires collaboration. There has also been extensive study of followership. The concept of "power to the edge", for instance, the initial work of Alberts and Hayes [18], and further exploration by other writers, for example, Piersol [19], recognizes the advantages of empowering followers and seeking their input into decisions. Advances in technology and globalization now have a significant impact upon organizational life [7], requiring a more collaborative climate. This is not always welcomed by traditional leaders.

Individual differences as a moderator of leadership effectiveness have been investigated in various ways. The Big Five personality test is a commonly used, easily understood and contemporary assessment technique which is often employed in research. This self-assessment provides scores on five factors—openness to experience; conscientiousness; extraversion; agreeableness; and neuroticism—and these measures have been related to leadership effectiveness. For example, Judge, et al. [20], found

that extroversion and conscientiousness were most strongly correlated with leadership emergence and effectiveness, while agreeableness showed the lowest correlation. This assessment has also been related to the potential for transformational leadership [21].

Confidence has been found to be associated with leadership emergence and perceptions of effectiveness by followers [22–24]. Parr, et al. [25] discriminated six different personality profiles within executive leaders in a study which further explored the Big Five personality dimensions in the context of the assessment center, and concluded that the profile they called Power-Players, who were high on all big five dimensions of extraversion, emotional stability, agreeableness, conscientiousness, and openness to new ideas, were the most prevalent managers who attended at an assessment center for testing. This finding backs up earlier beliefs that extroversion, in particular, is a strong correlate of perceived leadership effectiveness. Such people, these authors say, will be attractive as leaders to a great number of followers.

Another area of research which links individual differences with leadership behaviors and expectations within the context of culture is the vast GLOBE (Global Leadership and Organizational Behavior Effectiveness) study [26]. Mackenbach, et al. [27] reported ratings of managerial competency in mid to large organizations located around the world and found that there were significant differences between 22 countries regarding desired characteristics. Clark, et al. [28] explored the differences in the importance ratings of various managerial competencies with the aim of developing managers for specific locations. They developed a profile containing 135 items across 24 different competency areas and compared nearly 10,000 managers across 40 countries. They reported that two skill dimensions, "drive results" and "analyze issues", were rated very highly across all cultures. Yukl [29] reported that "decisive" was one of the leader attributes rated as being effective in most cultures.

Inefficient leadership has also been studied. As Pyc, et al. commented; "Unintentional ineffective leadership been shown to lead to negative impacts on followers" [30]. The literature generally supports the notion of empowering leadership as being far superior to laissez-faire or authoritarian styles [31], which are now considered insufficient.

2.2. Decision-Making

Similarly, there is a great amount of literature regarding the process of decision-making. Decision-making has been explored across a range of domains, including business, health and education, and there has also been discussion of individual versus group decision-making. Decision-making means generating alternatives and selecting one of those alternatives in order to prepare a suitable action. The decision-making process is a cognitive process which results in a choice. Such processes can be rational or less rational, and may be driven by explicit knowledge, implicit knowledge or by one's own belief systems. Decision-making within an organization was an early theme within managerial studies [32]. A literature search [33] reveals almost two million articles on the broad topic of decision-making. Researchers have explored, among other things, ethical decision-making, rational decision-making, strategic decision-making, decision-making biases and decision-making under uncertainty. Various researchers have investigated personality differences and decision-making ability, and several decision-making assessment scales have been developed; for example, that of Appelt, et al. [34].

There are various theoretical approaches and understandings regarding how people make decisions under different situations. Much of the work is experimental and based upon laboratory research. Some have questioned the generalizability of such findings [35]. Several themes have emerged in studies of general decision-making. Klein [36] introduced the idea that some decisions are based on outcomes experienced in similar situations in the past (recognition-primed decisions, or RPD). This model depends on people having suitable experience and recognition of past effective choices. Kahneman [37], in his famous book *Thinking, Fast and Slow*, suggested that people employ two different types of decision processes. System 1 is the intuition-based decision-making system that helps us to make decisions quickly. This approach generally has priority. System 2 is the slower,

controlled cognitive process and can inhibit System 1 thinking. System 2 can lead to a different decision. Systems 1 and 2 thinking have been shown to be associated with emotional state. Thus, sadness and depression have been found to be associated with the careful, deliberative thinking of System 2 [37], while impulsiveness is associated with System 1 [38]. Kahneman and Klein [39], writing together, concluded that the quality of our decisions will be influenced by the environment's predictability. There is no straight-forward answer to the question as to whether making judgements using intuition is more likely to be reliable or biased and flawed.

The use of various heuristics to assist with decision-making, especially in complex situations, has been studied extensively [40]. Heuristics are shortcuts to decision-making, such as trial and error, using a "rule of thumb", or making an "educated guess". Simon [41–43] famously introduced the concept of "bounded rationality", which recognizes that people often need to make decisions with limited resources, limited time, and a limited ability to deal cognitively with complexity. The belief that optimizing decisions is feasible under truly complex circumstances is clearly erroneous. Rational choice theory assumes that we can make decisions in a rational fashion by considering all the relevant factors, weighing up probabilities and selecting the best possible alternative. When this is not possible, for example in complex conditions in the real world, satisficing will be necessary. Satisficing means searching through available alternatives until an acceptable option is met.

The use of intuition, or gut decision-making, is one type of heuristic [44]. Dijkstra, et al. [45] examined the comparative effectiveness of intuition and deliberation and the role of experience in that comparison. Hayashi [46] talked about intuition as " . . . one of the X factors separating the men from the boys." It has been noted that intuition can be impaired under conditions of anxiety, which is accompanied by various cognitive impairments and reduced decision-making ability [47].

Several writers have stated that emotion and intuition have a positive role in decision-making, including rational decision-making [48]. Peters, et al. [49] discuss the differences between "hot" emotional processes, and "cold" reason-based and deliberative processes. While these authors conclude that affect or emotion have a nuanced role in decision-making, they accept that they can have negative effects, such as in decisions to undertake risky behavior. However, there can be positive effects as well; and emotion can help people to separate important information and make sense of the complex world that they face. They present a very interesting summary: "Without affect, our minds would be overwhelmed by what the world offers; our hearts may be able to guide us through this complexity"—that is, we need heart as well as head in order to make decisions within a complex environment. The work of Lerner [50,51] is highly relevant to understanding the pervasive and often positive role that emotion plays in decision-making.

The difference between intuition and emotion is not always understood. Simon [52] discussed what he called two relatively neglected areas of decision-making: "intuitive" decision making on the one hand, versus decision making that involves interpersonal interaction and the influence of emotions on that behavior. He comments that intuition should not be viewed as being necessarily irrational. The experienced person or expert acquires a huge number of "if-then" premises over time and uses these to take intuitive steps in reasoning at a fast pace. Managers use both types of thinking, intuitive and analytical, in combination, depending upon the task. People are also often inclined to postpone difficult decisions, especially when all the options have undesirable consequences. On the other hand, non-productive actions often occur under circumstances where there are time constraints and where the decision-maker is stressed for various reasons. Simon differentiates the type of intuition which is driven by expertise versus intuition which is driven by emotion. The former could be called expert nonrational decision-making, while the latter can be viewed as irrational counter-productive decision-making caused by stress. Simon concludes that it is a fallacy to differentiate between analytic styles of management and intuitive styles of management. Intuition and judgement are just types of analysis which expert managers are quickly able to call upon. Others have noted the complicated interplay between intuition and rationality. For example, Calabretta, et al. [53] write about the need for managers to accept and work with the inevitable tension between intuition and rationality.

There is considerable literature specifically on the topic of financial decision-making; for example, Frydman and Camerer [54], who state; "Financial decisions are among the most important life-shaping decisions that people make." Yet even highly educated people can make basic mistakes in this domain. In fact, financial illiteracy is widespread. Anthes [55] noted that financial illiteracy was rampant in the United States at that time. More recently, Fairfax [56] noted that even American investors are financially illiterate, and therefore there is a need for far greater financial disclosure and other measures to protect consumers.

2.3. Typology of Systems in Terms of Complexity and Leadership Implications

There is a current tendency to view our world as being particularly unstable, complex, and fast changing—full of "unknown unknowns". The nature and consequences of this instability have been abbreviated as VUCA: volatile, uncertain, complex and ambiguous. This term highlights the lack of predictability and the need for risk management in a world of hyper-connectivity and an accelerating pace of change.

While early systems research focused on scheduling optimization, based on the view that system components and their interrelationships are fixed and measurable, clearly times have now changed and there is a growing body of evidence indicating that systems are becoming more and more complex and that different systems contain different degrees of complexity [57]. The initial concept of the system was presented by Bertalanffy [58] and, originally, the focus of researchers and practitioners was on stand-alone systems. Currently, however, the concept of systems of systems has become well recognized [59,60]. Systems of systems contain multiple integrated complex systems working together to achieve a common goal. Complex systems are now part of our everyday experience.

Systems have been characterized according to complexity level [61]. In their typology, these authors differentiate between four levels of system complexity—simple, complicated, complex and chaotic—and present differing approaches necessary for managers operating within these various contexts. Snowden and Boone [61] suggest that, in the world of the simple or obvious, the leader's job is to sense, categorize and respond. At this level, there are clear cause-and-effect relationships and the right answer is evident. In complicated contexts, leaders should sense, analyze and respond. Expertise may be required here, and there may be a need to consider several options, which may all be good. The complex context is the realm of unknown unknowns, and this is where much of the contemporary business world now lies. Leaders need to probe, sense and then respond. This is the field of emerging solutions and patterns. In chaotic contexts, typified by crises, it is not possible to see relationships between cause-and-effect because there are no patterns. The leader needs to move between several domains, separating out simple, complicated and complex problems and dealing with them all appropriately. Several other authors have picked up this categorization across a range of dimensions, including health, IT and education [62–65]. Figure 1 presents the characteristics of various degrees of system complexity and appropriate leadership styles.

2.4. Leadership Decision-Making Effectiveness in Complexity and Some Barriers

Personal decision-making is one thing: making decisions on the behalf of many others with whom one is in a power relationship is something else. This is much more challenging when decisions are being made by a leader in a complex system environment. Decision-making is a big part of leadership behavior, and never more so than in complexity. Management innovation has been called for, given our turbulent times and high levels of uncertainty [66]. Many decisions made by leaders are biased and this leads to errors. Barriers to effective decision-making have been investigated [67]. Thus, coming to an early conclusion before considering all the information, overconfidence in our judgements, and failing to use a systematic approach can all result in faulty decisions. The literature rarely talks about the effectiveness of leadership decision-making. Yet, as noted by Hammond, et al. [68], "Making decisions is the most important job of any executive. It's also the toughest and the riskiest." In this article, the authors talk about well-known traps based upon biases related to one's beliefs, including the anchoring

trap (where the mind gives too much weight to the first information received), confirmation bias (the tendency to seek or recall information in a way which supports one's previously held beliefs), the status quo trap (a tendency to leave things as they are), and the sunk cost trap (making choices which justify past decisions). These authors stress the importance of the correct framing of the question about the decision that is to be made. As they say, "A frame can establish the status quo or introduce an anchor. It can highlight sunk costs or lead you toward confirming evidence."
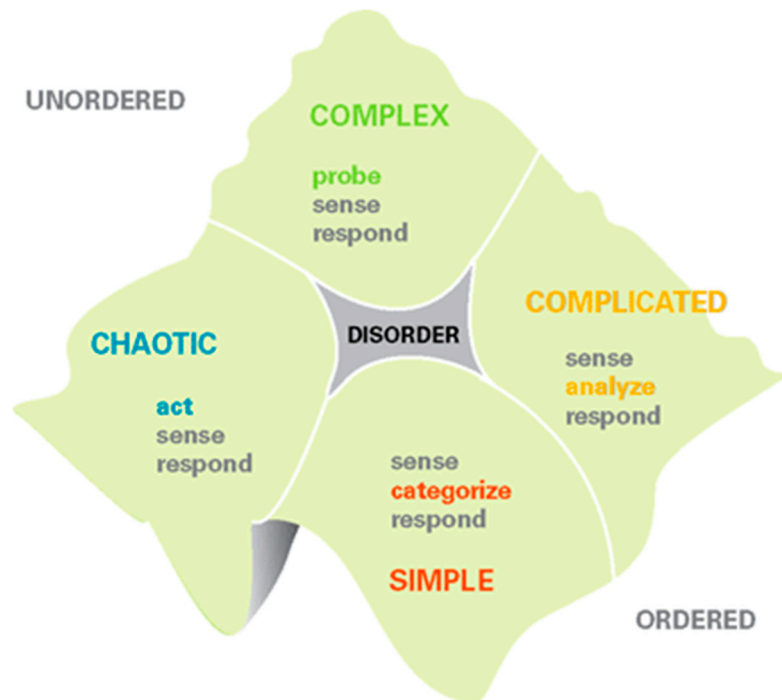

Figure 1. The Cynefin model. Adapted from Snowden and Boone [61].

Another issue which concerns leaders in complex organizational environments is the need to make decisions at a high speed. Some writers, for example Eisenhardt [69] and Bartkus, et al. [70], have argued that, in order to make quick decisions, one needs to use fewer sources of information. Luan, et al. [71] reprised the well-recognized concept of fast-and-frugal heuristics, first popularized by Gigerenzer, for example [40,72], which indicate that, contrary to what might be expected, using less information can actually result in a better outcome. Having power centralized in one person could also enable more rapid decision-making [73]. Low levels of interpersonal conflict and lower levels of participation have been suggested as precursors to rapid decision-making [74]. However, an early study by Eisenhardt [75] did not support these ideas.

The work of Baum and Wally [76] also indicated that making decisions at speed did not necessarily negatively impact on their effectiveness; in fact, fast strategic decision-making was related to higher outcomes and profit. Conventional wisdom on this topic does not seem to have been supported in the literature. As famous writer Robert Greenleaf commented [77], "On an important decision one rarely has 100% of the information needed for a good decision no matter how much one spends or how long one waits. And, if one waits too long, he has a different problem and has to start all over. This is the terrible dilemma of the hesitant decision maker." Hesitancy will be even more deadly in the complex environment, where changes happen much more rapidly. The proverb: "He who hesitates is lost" was never more apt.

There is no doubt that systems are becoming more complex due to a range of uncertainties: rapid globalization, technological progress and growing interconnectedness [78,79]. As PMI noted in 2013: "Complexity is not going away and will only increase." It is by now generally accepted that managing complex systems requires a different type of approach from that used within a simple

context. Within a complex context, leadership is an emergent event, emerging from the interactions among the group, and not as a result of the qualities of the individual leader [80]. The influential work of Uhl-Bien [81,82] stresses the need for adaptive leadership. in which leaders support innovative and creative decision-making and encourage a culture of trial and error without judgement, thus enabling organizational adaptability [83]. Within complex adaptive systems, problems can be solved in a creative way as new solutions emerge from the collaborative environment. This view of leadership as emergent behavior is quite different from the traditional view, in which the focus is on the attributes or the behaviors of the person designated as leader and their impact on followers. Adaptive leadership will be a challenging stance for a leader to take.

3. Research Method

The purpose of this research is to understand the behavior of managers in making important decisions in complex situations. As complex situations often fall into the "unknown-unknowns" domain (e.g., sudden time events, a range of stakeholder involvement, chaotic information), qualitative research methods are appropriate to provide explanations and insights, rather than quantitative methods for functionalizing factors affecting the managers' decision outcome.

The questionnaire survey is a well-known and widely-used research technique for gathering and analyzing data from a population under study [61]. Questionnaire surveys have been used in many contexts, e.g., health, industrial relations, construction, transport planning, rural development, politics [84]. In this study, a questionnaire survey was used to investigate the subjective factors which lead to poor managers' judgements in complex situations. Burgess [85] offers a basic structure to be considered when developing a survey.

1.　Define the research aims;
2.　Identify the population and sample;
3.　Decide how to collect replies;
4.　Design the questionnaire;
5.　Run a pilot survey;
6.　Carry out the main survey;
7.　Analyze the data;
8.　Critical evaluation.

A survey questionnaire containing 13 items was constructed based upon a literature search as well as a recent study conducted by the authors [86]. The questionnaire was piloted with contacts to ensure comprehensibility. The survey proper, entitled "Complexity Leadership Survey", was carried out at the 2017 IEEE System Conference in Vancouver, Canada, with the participation of 44 senior managers who were attendees at the conference and self-described as system managers. NVivo software was used to code the main themes for analysis. Appendix A contains a copy of the interview questions.

Following three questions about demographics, question 4 asked people to self-categorize according to an established and well-known personality typing system, resulting in four basic types of person [87–89]. Next, there are two questions about the relative difficulty of three generic types of decisions (technical, financial and human) and where people seek information from when making difficult decisions (friends and colleagues, family and relatives, the internet, and experts). Question 7 deals with perceptions of the importance of emotions in decision-making effectiveness. Questions 8, 9 and 10 investigate the use of subjective opinion and intuition, confidence level and acceptable level of riskiness. Next there are three questions about the effectiveness of decisions within different domains: technical, financial and human.

4. Research Findings and Discussion

4.1. Research Findings

Table 1 presents the background of participants. The majority of participants (48%) are older than 50 years and have had either less than five years' experience (36%) or between 5 and 20 years of experience (54%) in managing people within complex systems. A total of 25% of people said that they had over 20 years of experience in the field. In terms of self-assessed personality, the majority characterize themselves as being "friendly" and the next most frequent personal description was "logical". Only 7% of participants said they were "decisive". The majority of participants (68%) were men.

Table 1. Participants" background.

Gender	Age Range	Complex Management Experience	Personality
68% of 44 participants are male	48% of participants are older than 50 years	36% of participants have less than 5 years of experience	45% of participants describe themselves as "friendly"
	20% of participants are 40–49 years old	27% of participants have from 5 to 10 years of experience	34% of participants describe themselves as "logical"
32% of 44 participants are female	16% of participants are 30–39 years old	27% of participants have from 10 to 20 years of experience	14% of participants describe themselves as "optimistic"
	16% of participants are under 30 years	25% of participants have more than 20 years of experience	7% of participants describe themselves as "decisive"

Figure 2 shows that it was the human aspects of decision-making that respondents reported finding the most difficult; perhaps not surprising results. This choice is closely followed by the "other" category (30%). When seeking information regarding decision-making in complexity, most people (41%) seek help from their friends and colleagues (41%), followed by family and relatives (32%) and then from experts (32%). Use of the internet under these circumstances is relatively rare amongst this group of respondents (9%).
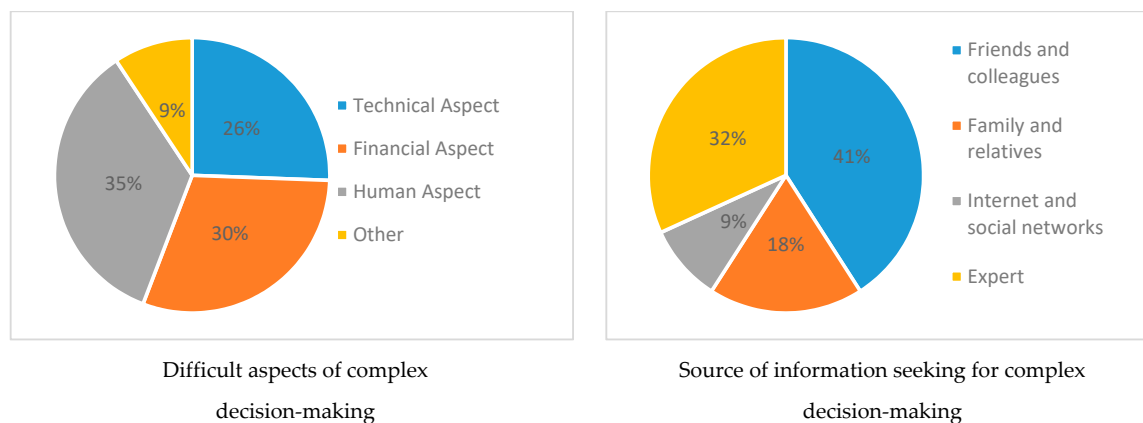

Difficult aspects of complex

decision-making

Source of information seeking for complex

decision-making

Figure 2. Difficult aspects of decision-making and relevant information used.

As shown by Figure 3 above, when asked which emotional state has the most impact on their decision-making, being tired (46%) followed by feeling tense (41%) are the most frequent responses. Being happy has the least impact; only 5% participants chose this response. Regarding whether subjective opinion affects their complex decision-making, most respondents (41%) said sometimes, followed by often (36%), indicating that intuition still plays a role in their decision-making.
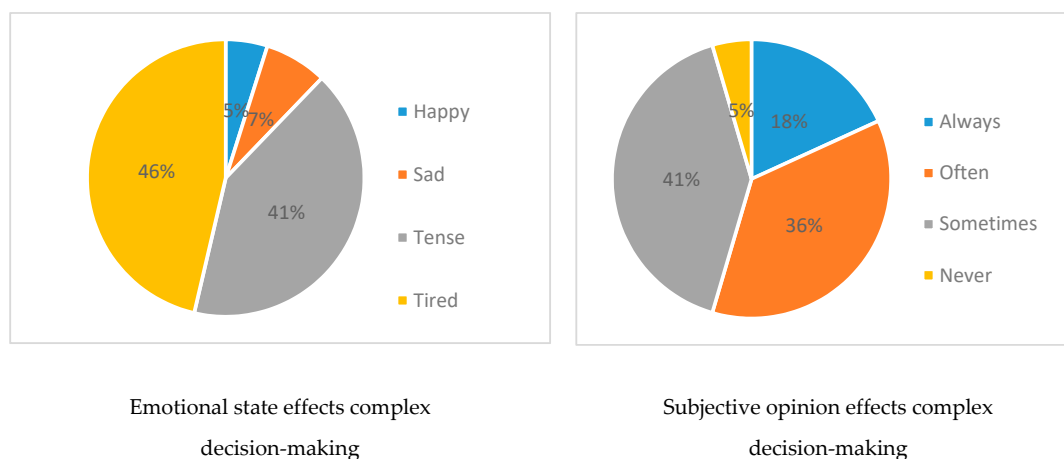
Emotional state effects complex
decision-making

Subjective opinion effects complex
decision-making

Figure 3. Emotional state and subjective opinion in complex decision-making.

Figure 4 shows that when asked how confident they were in making complex decisions, most respondents said highly confident (61%), followed by very highly confident (23%). No participants selected low confidence. These results indicate an overall very high confidence in decision-making in this group of respondents. Regarding accepting risk in making important decisions which affect other people, the majority said they would accept medium risk (43%), followed by high risk (32%). Only 5% of respondents said they would take a very high risk in this circumstance.
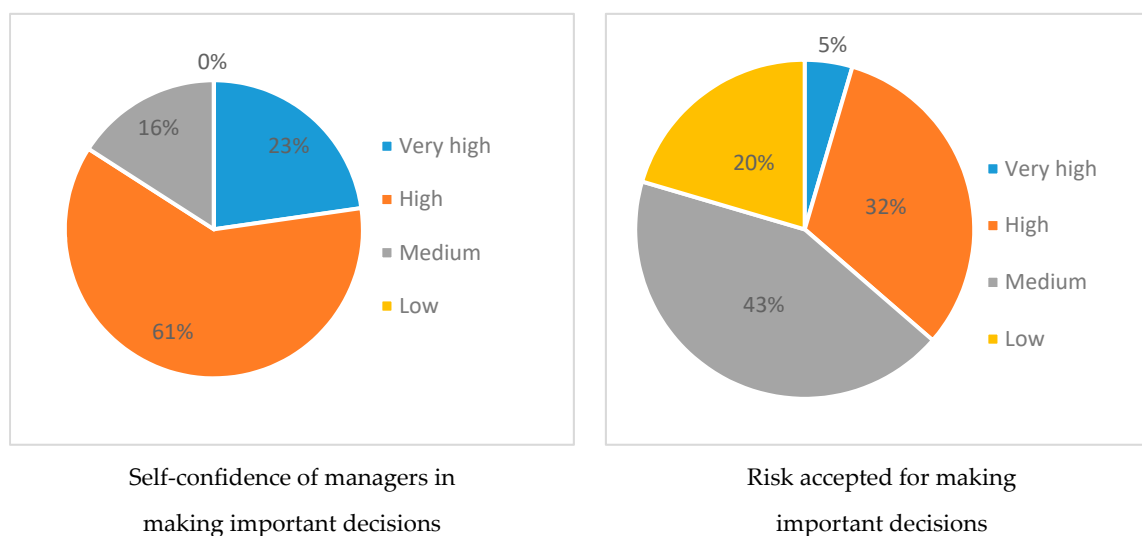

Self-confidence of managers in
making important decisions

Risk accepted for making
important decisions

Figure 4. Self-confidence and risk accepted in complex decision-making.

Figures 5–7 below present gender breakdowns of the three different types of complex decisions covered in the survey: technical, financial and human.

Figure 5 shows that men are more confident regarding their decisions made on the technical aspects of a complex situation. In total, 83% of male respondents in the survey rated themselves as either very highly or highly effective in this domain. Women respondents were more likely to rate themselves as being effective only at a medium level.
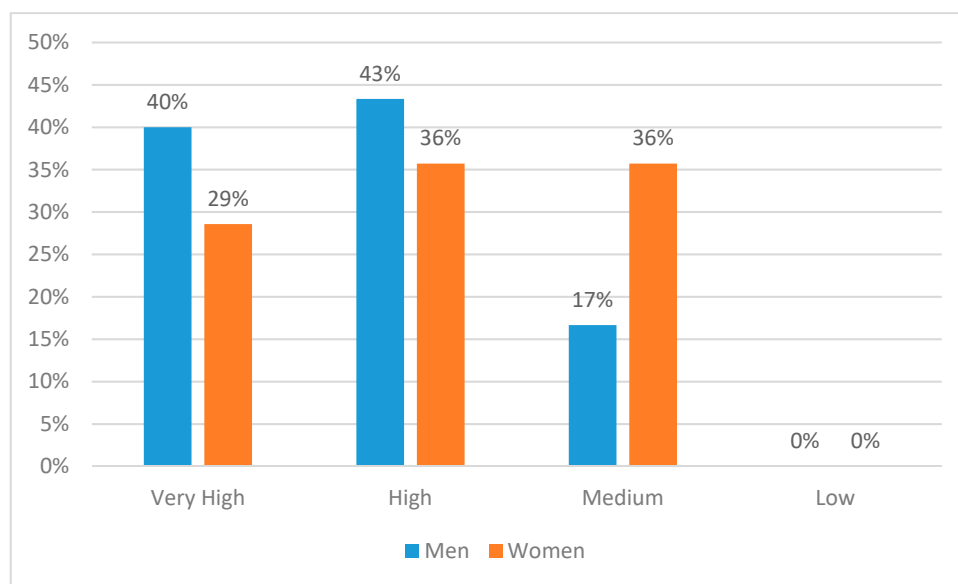
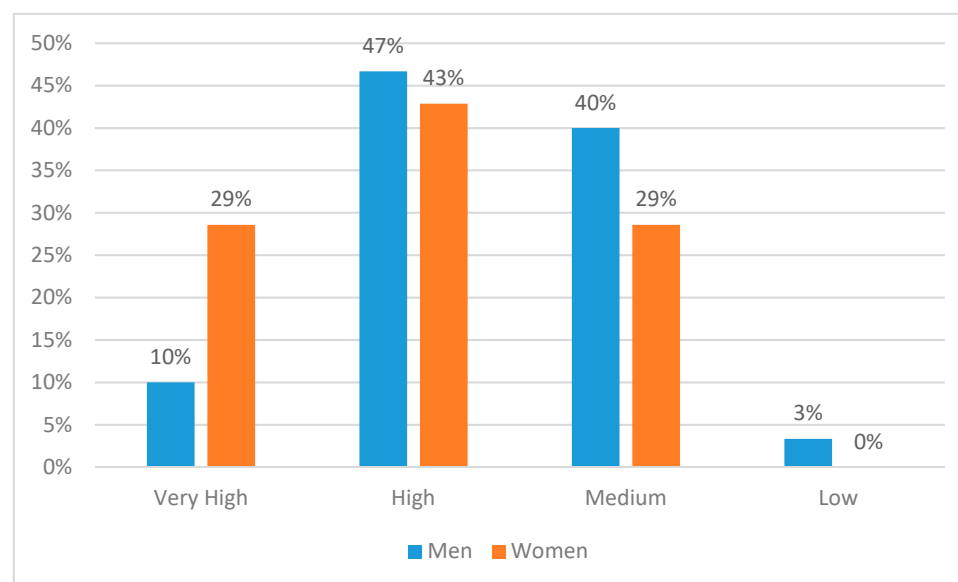**Figure 5.** Self-effectiveness rating on technical aspects of complex situations.

Figure 6. Self-effectiveness rating on financial aspects of complex situations.

Figure 6 shows that women respondents in this survey rate themselves as "very highly effective" when making financial decisions. A total of 29% of women, compared with only 10% of men, chose this response. The male respondents in this survey view themselves as being less competent than women in making financial decisions—a somewhat surprising result.

Figure 7 presents the differences between men and women respondents in terms of decision-making on the human aspects of a complex situation. There is a clear difference here, in that women are more confident and 86% of women rate their effectiveness as very high or high. Only 67% of men thought that their effectiveness was very high or high. Men were more likely to say that they were effective only at the medium level in this domain.
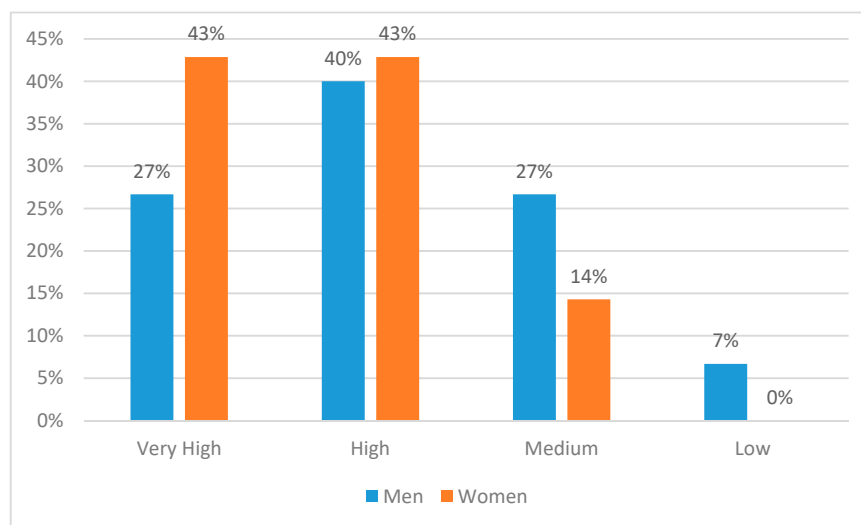
Figure 7. Self-effectiveness rating on human aspects of complex situations.

In summary, four main points were drawn from this survey, including:

- Participants reported that the human aspects of decision-making are the most challenging for them;
- Managers tend to seek assistance from those around them, particularly in getting advice from their friends and family members;
- Feeling tired or tense are emotions which respondents say have the most impact on their decision-making efficiency;
- There were some significant differences between genders in self-rated effectiveness in the technical, financial and human aspects of complex situations.

4.2. Research Discussion

These findings have clear applications for leadership decision-making within complexity. Firstly, while leaders are confident about their decisions and are prepared to take risks, they do report finding the human aspect of decision-making to be the most challenging. Complex problem-solving has been part of psychological research for several decades [90]. Complex or ill-defined problems have no clear problem definition or end goal. Whether the problem is at the individual level or at the political level, this kind of problem will be more challenging for most people. Respondents also report that they ask their family and friends for advice about important decisions. This latter finding is somewhat unexpected. The literature reports that many people say they rely on the internet and the huge amount of information available on social media to help them to understand and respond to complex problems. For example, the results of Sanders and Crozier [91] regarding women's decision-making when choosing birthing options in a mega study across four different countries reported that many studies show that, while women faced with this important decision used formally available and personally shared information, they also relied heavily upon information from a variety of media and from the internet in their decision-making. The internet was a powerful and immediate benefit for them in their search for information. Similar findings have been reported regarding patients with cancer who need to make important and complex decisions about treatment options; for example, Eng, et al. [92], who even suggested that the internet was so useful for cancer patients needing to make decisions regarding their treatment that those who needed it should be given computer training.

It is important for people to be mindful when seeking out the optimal source of information. Perhaps, when dealing with complex scenarios, family and friends are not the best option. While these people may be both helpful and supportive, and perhaps these are the people who know us best, it is worth considering taking expert opinion, or at least seeking a wide range of information such as that available on the internet and through social networks. This applies to high-level managers as much as

it does to anybody else. The use of the popular Delphi technique across a range of domains [93,94] is an example of the usefulness of taking expert opinion, as is the increasing reliance upon expert evidence in legal matters [13].

In a complex decision-making situation, the decision-maker needs to be aware of their emotional state. As noted by Dörner and Funke [90], the ability to stay calm in the face of a challenging situation is critical in solving complex problems. Respondents in the survey reported that being tense or tired presented the greatest impediment to them making good leadership decisions. There is no surprise in this finding. Once again, even highly trained and experienced people need to realize that their decision-making ability can be impaired under these circumstances and it would be just as well to take a break, or do something different—even something simple like deep breathing or taking a short walk. While it is commonly understood that making decisions while anxious or tired is not a good idea, people need to be aware of this knowledge and act upon it. The literature has often asserted the powerful role of emotion within decision-making. Lerner, et al. [51] commented upon the revolution in the science of emotion and the fact that emotions are "potent, pervasive, predictable, sometimes harmful and sometimes beneficial drivers of decision-making". Many authors have commented that emotions are the main drivers of most important life decisions [95]. Emotions guide our efforts to avoid negative feelings and enhance our positive feelings, even if we are not aware of this. However, high levels of anxiety have not been shown to be helpful in decision-making effectiveness.

Respondents also commented that they often or sometimes make complex decisions based upon subjective opinion. Subjectivity in decision-making may be viewed by some as being somehow illegitimate, or at least inappropriate [96]. Some writers believe that subjective opinion and intuition are similar and that both are restricted ways of making decisions which can lead to poor results [97]. However, it has also been suggested that intuition contains a valuable way of accessing tacit knowledge. Jankowicz [96], in line with the earlier view of Simon (1987), states that, in fact, intuitive decision-making by people with experience can be accurate and effective. This finding does not necessarily disagree with the earlier findings regarding the seeking of advice. Making decisions subjectively can occur following the seeking of a range of alternative views.

Another important finding regards self-confidence. A total of 84% of these respondents reported very high or high self confidence in making important decisions. Most respondents also reported that they were highly effective in their decision-making, whether their decisions concerned technical, human or financial matters. Perhaps this is not surprising, given that most respondents were over 40 years of age. Regarding confidence in decision-making, as noted by Fu, et al. [98], overly confident people can have a larger impact on group decisions, even when not more competent than the other people present. This would certainly be the case when considering more powerful individuals making decisions on behalf of others in a group setting. Confidence and competence are separate issues and need to be recognized as such.

Interestingly, for the respondents in the survey, making decisions about financial matters indicated a relatively high level of self-rated effectiveness. The financial domain is an area where people often make errors. It is certainly possible for people to be overconfident when making complex decisions here. As commented by Frydman and Camerer [54], financial illiteracy is quite widespread, even among highly educated people. Van Raaij [99] noted that financial decisions are complex and people need to avoid complacency. Lusardi [100] suggested that consumers are confronted now with more and more complex financial instruments and many people are not well-equipped to make complex financial decisions. Making informed decisions requires that people understand financial concepts, and financial literacy may need to be added to school curricula, according to this author.

The self-assessed superiority of women respondents regarding effective decision-making on human aspects is worth noting. This is not a new finding and is in keeping with the concept of gender stereotypes but also supported by findings from the leadership and gender differences literature. While women are not demonstrated by meta-analyses of research to lead in a more interpersonally oriented and less task-oriented manner than men [11], they do tend to make more use of democratic and

participative leadership styles and use more transformational leadership behaviors, which contributes to the success of decision-making in the human aspect of complex systems [101].

5. Research Implications

In this paper, the respondents are well-established individuals working in organizations and in charge of many people, yet their decision-making may not always be optimal. People in authority positions need to carefully manage their decision-making when facing complex problems. Figure 8, below, presents a decision model for managers needing to address complex problems. In this figure, it can be seen that, when faced with the need for a decision, the decision-maker first must be aware of their emotional state to ensure that they are in the right headspace to make a wise decision. The figure highlights the importance of people not making decisions while they feel tense or tired. Next, decision-makers must be cognizant of the fact that there is a range of information sources which may be helpful, and they should be sure to access as many appropriate information sources as needed. There are arrows between emotional state and information sources because it is likely that choosing information sources may be affected by one's emotion state, and that taking information from a range of sources may, in turn, affect one's emotion. Having then adequately consulted suitable sources of information, the decision-maker now decides to accept a certain level of risk, before moving to making a decision. There is a feedback loop from the point of having made the decision to the starting point of a new decision being required. This enables reflection on the suitability of a decision and the role of experience in enhancing decision-making capability.
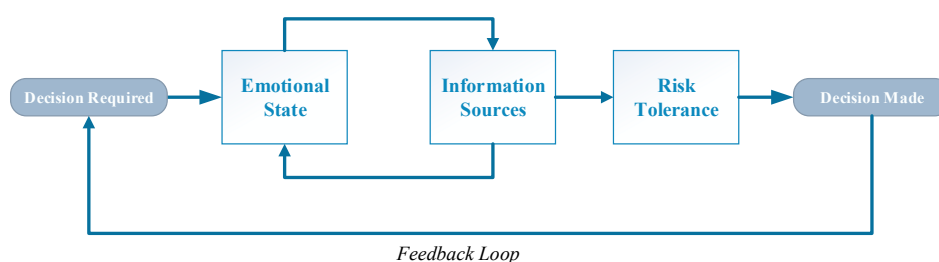

Feedback Loop

Figure 8. Systematic decision-making process in a complex situation.

Next, Figure 9 presents one way in which decision makers can assess risk according to its likelihood and probability, prior to finalizing their decision. The risk matrix is a useful technique for highlighting where there will be high risk and the need for great caution. It is included here for the purpose of illustrating one way in which risk can be assessed. Clearly, a risk which has a very high likelihood and a very severe impact will require that the decision-maker has a greater degree of confidence [102].

RISK	Negligible	Minor	Moderate	Significant	Severe
Very Likely	Low Med	Medium	Med Hi	High	High
Likely	Low	Low Med	Medium	Med Hi	High
Possible	Low	Low Med	Medium	Med Hi	Med Hi
Unlikely	Low	Low Med	Low Med	Medium	Med Hi
Very Unlikely	Low	Low	Low Med	Medium	Medium

Figure 9. Risk matrix assessment for complex decision-making. Adopted from ISO 31000: 2009 [103].

Calculations of risk are, of course, related to confidence levels, and an individual's confidence level in any given situation will affect how much risk they are willing to take. The highly competent and experienced leader may be prepared to accept more risk because they have a greater bank of intuitive experience to call upon. Levels of confidence also appear to be related to personality. Self-confidence has been widely investigated within psychology. While accuracy of judgement may vary, confidence in decisions appears to be a consistent individual difference within people. Several studies have looked at individual levels of confidence in context. There is also a significant literature on unrealistic optimism [104]. Taylor and Brown [105] propose that, in fact, overconfidence is associated with subjective well-being and higher productivity and motivation. The illusion of being unrealistically optimistic is associated with positive outcomes, high levels of social skill and high levels of intellectual functioning. It has also been found that confidence ratings show a consistent pattern within individuals. Confidence is a personality trait, a stable individual difference and a predictor of behavior [106]. Overconfidence is highly related to good adjustment and may even be necessary to maintain good mental health. However, when making decisions concerning the well-being of other people, perhaps it is worthwhile countering this tendency to be overly optimistic and considering a more realistic assessment [107].

There are, of course, many other contextual factors which may impact upon managers' decision-making beyond those represented in the current model. This is indeed a complex scenario and beyond the knowledge, competence and experience of the manager and their behavior and values, external and contextual factors such as the firm ownership structure, the firm's legal and organizational structure, connections with key stakeholders, organizational goals, the type and size of business, competition, conditions specific to the industry, as well as cultural values and norms, are all factors which are part of this decision-making context. These factors have non-linear relationships, which may be different according to the particular business context, so this study focuses on the main factors that are the major concerns of senior system managers.

6. Research Limitations

This survey used a small sample of attendees at an engineering conference in North America. The questionnaire was quite brief and did not ask about the respondents' organizational type or size, the industry setting, or the organizational culture. Future research could also explore in greater detail issues around individual managers' personality type and emotional states and their impact on leadership decision-making within particular complex scenarios.

7. Conclusions

This study has investigated leadership decision-making in complex systems and the role of confidence and emotion. The study shows that in this group of respondents there is some room for improvement in decision-making strategies, even though they expressed high levels of confidence. The study found that it was the human aspects of decision-making which are the most challenging, and therefore such decisions need to be treated with particular care and attention. Another noteworthy finding from the survey concerns the sources of information used in making such decisions. Somewhat unexpectedly, most respondents said that they asked family and relatives and friends and colleagues to help them when facing difficult decisions. Only a minority of people report that they use the internet or expert sources. Managers should be mindful of the shortcomings of asking people close by, rather than seeking information more broadly, when making complex decisions. While no doubt it could be easier and quicker to ask family or friends, there may well be shortcomings in the information they provide. Thirdly, respondents to this survey understood that feeling anxious or tired were barriers to effective decision-making. While it may be common knowledge that this is so, it is worth keeping at the front of one's mind that optimal decisions are not made under these circumstances. Emotions can be helpful in decision making but they are not always helpful, and stress and tiredness will not generally provide suitable circumstances for complex decision-making. Finally, there were differences

between men and women in terms of the three types of decisions considered. Women rated themselves as being very highly effective in decisions concerning financial matters and human aspects. It was only in terms of technical matters that men rated themselves as more effective. The findings from the survey give some indications of areas where managers may need to show caution in their decision-making.

This study has investigated the factors which were considered significant by respondents to a questionnaire seeking their opinion about their experiences in making complex decisions. These findings were used to create an easily understood procedure, which should be helpful in guiding managers through some fundamental steps and in increasing their competence and confidence in making important decisions in complex situations.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A Research Questionnaire

This research has received ethics approval from the University of Adelaide.
Ethics Approval Number: H-2018-106.

(1)　What is your gender?

    a.　Male
    b.　Female

(2)　What is your age?

    a.　Under 30 years old
    b.　30–39 years old
    c.　40–49 years old
    d.　Over 50 years old

(3)　How many years have you been working in the industry as a senior manager where you are responsible for the work of other people?

    a.　Less than 5 years
    b.　5–10 years
    c.　10–20 years
    d.　More than 20 years

(4)　How would you describe your personality? Please choose the option which is most like you.

    a.　friendly
    b.　logical
    c.　optimistic
    d.　decisive

(5)　In what aspect of your work is it difficult for you to make important decisions?

    a.　Technical aspect
    b.　Financial aspect
    c.　Human aspect
    d.　Other

(6) When you suffer difficulties in making decisions, what source do you use most to help you with problem-solving?

    a.   Friends and colleagues
    b.   Family and relatives
    c.   Internet and social networks
    d.   Experts

(7) Which of the below emotional states do you think would affect your leadership decisions most?

    a.   Happy
    b.   Sad
    c.   Tense
    d.   Tired

(8) Do you often make decisions based on your subjective opinion?

    a.   Always (>80%)
    b.   Often (50–80%)
    c.   Sometimes (<50%)
    d.   Never (0%)

(9) How confident are you with yourself when making important decisions?

    a.   Very high confidence (>75%)
    b.   High confidence (60–75%)
    c.   Medium confidence (40–60%)
    d.   Low confidence (<40%)

(10) How risky are you prepared to be when you make important decisions which will have an impact on other people?

    a.   Very High (>75%)
    b.   High (60–75%)
    c.   Medium (40–60%)
    d.   Low (<40%)

(11) Overall, how would you rate the effectiveness of your decision-making on the technical aspect in complex situations?

    a.   Very High (>75%)
    b.   High (60–75%)
    c.   Medium (40–60%)
    d.   Low (<40%)

(12) Overall, how would you rate the effectiveness of your decision-making on the financial aspect in complex situations?

    a.   Very High (>75%)
    b.   High (60–75%)
    c.   Medium (40–60%)
    d.   Low (<40%)

(13)　Overall, how would you rate the effectiveness of your decision-making on the human aspect in complex situations?

　　a.　　Very High (>75%)
　　b.　　High (60–75%)
　　c.　　Medium (40–60%)
　　d.　　Low (<40%)

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