A literature review on effects of time pressure on decision making in a cyber security context

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Abstract. Shortages of time has become a natural characteristic of the professional environment. Individuals are often pressed to make fast decisions and complete tasks in a timely manner. This element of time pressure is particularly prevalent in the Information Technology (IT) sector due to fast-paced changes in demand, competition, and technology. Reviewing a wide range of journal articles, this paper aims to contribute to a broader discussion on the effects of time pressure on decisions. This paper explores the theoretical and practical considerations of decision-making, considering key decision-making models and the effect of technology on the decision-making process. Subsequently, this paper explores time pressure in a general sense, and then reviews the stress it causes individuals and its presence in technological environments, in particular a cyber-security context. After reviewing both decision-making and time pressure individually, the paper explores the relationship between the two, considering the influence time pressure on decision-making in technological settings. Concluding that time pressure can have an adverse effect on decision-making and hence possibly impacting cyber security services.

Index Terms—cyber security, technological environments, time pressure, decision making

1. Introduction
With increasingly complex environments at the hand of emerging technologies and competition, individuals and firms are often forced to make faster decisions (Salanova et al., 2002). Decisions are becoming more variegated, yet still require timely responses (Clark & Collins, 2002). Consequently, these external time pressures cause stress and fatigue to individuals (Bourne & Yarouch, 2003). This can affect their decision-making process and subsequently affects the output of their decisions. Despite the largely hegemonic acceptance that time pressure effects decision making, the impact in technological environments has been noticeably absent from the research agenda. Therefore, this paper aims to contribute to a broader discussion on the effects of time pressure on decisions by considering its presence and impact in technological environments.
Reviewing a wide range of journal articles from the fields of Engineering, Psychology, Management, Economics and Information and Communication Technology (ICT), this review will consider the theoretical and practical considerations of decision-making and time pressure. Subsequently, the relationship between the two concepts are considered, reviewing the influence of time pressure on decision making in technological environments. Specifically, in the context of cyber security, and the effect time pressured decisions might have on quality of service and support. Of most technological environments, cyber security is deemed the most critical real time service and subject to high pressure and need for quick decisions during crisis situations. For example, this might include the rapid spreading of a new virus in an Enterprise network, a Denial of Service (DoS) attack, or the detection of Trojan horses or real time data hacking activities.

2. Decision making in technological environments

Decision-making is typically defined as a mental process, which involves judging multiple options or alternatives (Bohanec, 2009). Making decisions usually requires evaluating at least two alternatives that differ on a number of attributes (LePine et al., 2005). Throughout the literature, there are many different decision-making processes, however there are two that have been widely accepted: rational decision-making and cognitive decision-making. Both theories follow three main steps: first, problem definition, secondly, identification, evaluation and selection of alternatives, and thirdly, implementation (Fredrickson, 1984; Mitchell & Beach, 1990; Clark & Collins, 2002; Baum & Wally, 2003). This review will consider the application of this process in both rational decision-making and cognitive decision-making.

2.1. Decision-making models

Whilst the existing literature concurs in the three steps of decision-making, the process of evaluating and selecting alternatives differs. Originating from the field of economics, the rational decision-making model is referred to as normative or prescriptive, where the decision problem is defined in terms of identifying the optimum decision, assuming an ideal decision maker who is fully informed (French, 1986; Bohanec, 2009). This method presupposes that complete information is available and that individuals are rational. Simon (1955) was the first to strongly criticize this view of perfect rationality, arguing that humans have a bounded rationality. Simon’s (1995) theory suggests that the limitations of the human cognitive system, as well as limitations in accessing relevant information, do not allow people to make perfectly rational decisions (Campitelli & Gobet, 2010). Rather, it is suggested that people ‘satisfice’, selecting a ‘good enough’ option, not necessarily the best option (Campitelli & Gobet, 2010,p.355). The notion that individuals are typically willing to settle for imperfect accuracy of their decisions in return for a reduction in effort is well supported (Bettman et al. 1990; Haubl & Trifts 2000). Experts in the field, Ariely (2008) and Haubl and Trifts (2000), suggest that individuals tend to use heuristics and take shortcuts to choose among alternatives in the decision-making process. In turn, the cognitive decision-making process has become more frequently acknowledged as the most realistic decision-making.

2.2. The influence of technology in decision-making processes

When dealing with the above mentioned decision-making criticisms, the question frequently posed throughout the literature is how can computers and information technology support people who are faced with difficult decisions, so that they can decide better, faster and more effectively (Bohanec, 2009). This is the main area of interest for computer scientists and information technologists, who try to provide effective methods and tools for supporting human decision makers (Bohanec, 2009). Many writers have suggested that the use of IT should improve strategic decisions and have developed a myriad of propositions about the effects of IT on strategic decision-making. Molloy and Schwenk (1995) examined the relationships between the use of computer-assisted information processing and strategic decision-making process and noticed that the use of information technology does improve
both the efficiency and, more importantly, the effectiveness of the decision-making process. Since then an extensive volume of literature has supported this notion.

Research on decision-making and technology has suggested that advances in computing and telecommunications technology have a positive impact on how people make group decisions. Baker (2002) explored this idea, comparing the performance of sixty-four virtual teams using different technologies. Baker (2002) research presented that the introduction of collaborative video and audio technology significantly aided strategic decision-making within teams. Despite there being thorough research on the impact of technologies on decision-making, few writers have been able to draw on any systematic research into the effect of technology in decision-making in technical environments.

The benefits of technologies such as decision support systems (DSS) and communication technologies in decision-making are frequently discussed in the literature. It is proposed that these technologies support decision makers in a multitude of ways. Gonzalez and Kasper (1999) suggested that the primary goal for computerized decision support systems is to improve decision quality. This effectiveness has been reported in diverse settings. Demikan and Delen (2013) explored the benefits of DSS in a cloud environment. Their research shows DSS in cloud enables scale, scope and speed in organisations. Additionally, Bharati and Chaudhury (2004) investigated web-based decision support systems, finding that quality DSS were directly related to information relevance, accuracy, completeness, and timeliness.

However, this position on DSS is not unanimous in the literature. Some scholars argue that the use of DSS does not improve individual or group decision-making effectiveness. For instance, in a study of task complexity and DSS, Webby and O'Connor (1994) found that the DSS did not affect subjects' performance. Despite the findings about the role of technology in supporting decisions, research shows that technology can also complicate the decision-making process. According to Noorderhaven (1995), four cognitive factors influence the decision-making process. Two of these factors are complexity and uncertainty. In the literature, the presence of these two factors is frequently discussed when considering technology.

Given the growth of information technology and the internet, an individual’s ability to access large amounts of information has increased. Described as information overload, this is increasingly perceived as having an adverse effect on decision making by overwhelming the decision-maker and complicating the process (Bawden & Robinson, 2009). This was confirmed by a series of reports of large-scale surveys conducted on business managers by international news agency Reuter (Bawden & Robinson, 2009). Results showed that nearly half of the surveyed managers believed important decisions were delayed and adversely affected as a result of having too much information (Bawden & Robinson, 2009).

One criticism of these surveys is that it relies heavily on qualitative data. More comprehensive quantitative research is needed to make these studies more valid. Further, theory suggests that technology is the catalyst of uncertainty. It is argued that rapid technological change and turbulence in the marketplace creates uncertainty, and thus normal decision-making processes do not apply to technical environments (Baum & Wally, 2003). However, few studies test this hypothesis, and therefore further research is needed. The differing opinions in the literature suggest that there is still extensive research that should be done on the role of technology in decision-making.

3. Time pressure in technological environments

The shortage of time has now become a natural characteristic of the environment, with individuals often being pressed to complete increasing daily tasks in a short period (Klapproth, 2008). The reduction of time available to complete a task is referred to as time pressure (Klapproth, 2008). In the literature, the term time pressure tends to be used to refer to the psychological stress that results from having to perform duties in lesser time (Bourne & Yaroush, 2003). This is particularly prevalent in the IT sector, where individuals are frequently required to complete tasks and make decisions under significant time constraints. Broadly, the concept of time pressure is lacking in the literature. Rather literature explores the application of time pressure to real world situations - the effects and presence of
time pressure are explored. Therefore, the following part of this section considers in greater detail the effects of time pressure on individuals, and its growing presence in high technology environments.

According to LePine, Podsakoff, and LePine (2005), time pressure can have a beneficial effect on individuals, being associated with high motivation, productivity and improved performance. In one study, Cavanaugh, Boswell, Roehling, and Boudreau (2000) found that demands such as time pressure increase effort in individuals. Labeled as a ‘challenge stressor’ they argue individuals increase intensity in the hope to successfully cope with this demand and experience a sense of personal accomplishment or formal recognition (Cavanaugh et al., 2000). However, while being positively related to motivation and performance, more recent theory suggests time pressure increases strain and stress (Bakker & Demerouti, 2007; Syrek et al., 2013).

There is no single universally agreed definition of stress, however it is consistently reported that environmental conditions such as heavy workload and constant time pressure are major sources of stress and fatigue (Bourne & Yarouch, 2003). This is particularly the case in the IT sector, with IT employees ranking third as experiencing the most time pressure in a study conducted by the Federation of German Trade Unions (Syrek et al., 2013). Expanding on the ‘challenge stressor’ concept, Syrek, Apostel, and Anton (2013) explore the negative effects of time pressure in highly demanding IT jobs.

Time pressure is identified as a serious stressor, exhibiting a strong negative relationship to employee strain and wellbeing (Syrek et al., 2013). Additionally, scholars addressing employees in IT find that the level of exhaustion is particularly high due to the time constraints (Hetland et al., 2007). This stress and fatigue experienced due to time pressure causes individuals to deviate from normal cognitive and physical behaviour, thus affecting the decision-making process. The following sections of this paper will explore a more detailed account of time pressure in technological environments and consider how the stress it can cause individuals to experience subsequently affects their decision-making processes and outcomes.

Time pressure is increasingly prevalent in high-velocity environments, deriving from the need to make fast decisions and complete tasks in a timely manner. Particularly in the IT sector, because of globalization and increasing competition, individuals are under increasing pressure to meet deadlines and reduce response times (Salanova et al., 2002). High-velocity environments are described to involve fast-paced changes in demand, competition, and technology which may result in instability and uncertainty (Eisenhardt, 1989). When considering decision-making in these environments, Kedia, Nordtvedt and Perez (2002) claimed that traditional decision-making theories recommend individuals search for additional relevant information. However, many scholars have challenged this claim on the grounds that this delays the decision-making process and affects performance. Eisenhardt (1989) proposed a model of strategic decision-making speed for eight high-tech firms facing high-velocity environments. It was observed that the faster decision-making the better, with faster decision-makers having the best sales and profitability (Eisenhardt, 1989). Consequently, increasing time pressure on individuals. This theory, while important at the time, has become even more relevant to decision-making in the information age, with the importance of making timely decisions increasing with technology.

Decision-making in these high technology environments require quick decisions, as only timely decisions can lead to a competitive advantage (Audretsch, 2001; Clark & Collins, 2002). Consequently, decision makers in these environments often feel pressured to move quickly in order to be advantageous. Supporting Eisenhardt’s evidence, Baum and Wally (2003) also concluded that faster decision-making has a positive impact on profitability and growth. However, by testing Eisenhardt's model on sixty-six high technology firms, they further concluded that environments with rapid changes in demand and discontinuous results, such as the IT industry, have more time pressures, in turn forcing a faster decision-making speed (Baum & Wally, 2003). This is due to decision speed being identified as a key enabler of technology firms to be able to exploit opportunities before they disappear (Baum & Wally, 2003). With increasing complex environments at the hand of emerging technologies, individuals and firms are often forced to make faster decisions. However, despite this
research widely exploring the idea that technology increases time pressure when making decisions, a more comprehensive study would have included the types of decisions made.

4. How time pressure affects decision-making

Emotion and time pressure are two important factors affecting decision-making (Hu et al., 2015). Individually, the effects of time pressure and stress are frequently discussed in decision making literature. However, despite the literature examining the influence of emotion and time pressure on decision-making, there is limited research considering the interaction of these two elements. Therefore, in the section that follows the effect of time pressure on decision-making, and the effect of time pressure induced stress on decisions will be considered.

Reviews of literature on time pressure have identified a number of ways in which the outcomes and processes of decision-making change when there is limited time available (Maule et al., 2002). The research agenda has been dominated by debates about how time pressure affects the quality of decision-making, with the general finding that individuals perform significantly worse under time pressure. Research into this area has been present in such fields as economics, management science, and psychology. However, there is a void in understanding the impact of time pressure specific to the field of IT.

Vance, Anderson, Kirwan and Eargle (2014) explored the effect of time pressure on critical security decisions. Participants responded to web browser security warnings when doing work under time pressure, thus simulating real-world working conditions. However, this study does not offer an adequate explanation of the effects of time pressure on the subject’s decisions, as no attempt was made to quantify the association between the two. The study would have had higher validity if the author had placed a larger emphasis on the time pressure variable.

There are many computer-driven studies on the effect of time pressure on decision-making. Using computer simulations, many theories conclude that time pressure negatively effects the quality of decision-making. Studies consistently show that under time pressure, the information processing strategy is altered. It is suggested under time pressure, people limit their information choices to that which can be attained quickly and easily (Savolainen & Kari, 2006). Tombros, Ruthven & Jose (2005) conducted a study that compared the information seeking behaviors of online searchers when assessing the relevance of web pages for information-seeking tasks. Participants were given 15 minutes versus those given 30 minutes to complete search tasks (Tombros et al., 2005). They found evidence that the group with less time relied on more ‘obvious’ features such as query terms and link quality versus in-depth examination of content and structure (Tombros et al., 2005, p337). They also found that the 15-minute group reported the tasks as being more stressful, and they were less satisfied with their decisions (Tombros et al., 2005).

Even with the presence of decision supported technologies, time pressure is found to impair decision quality. An experiment was conducted by Smith and Hayne (1997), in which a group makes business decisions under time pressure, where half of the groups enjoyed the benefits of DSS and the other half had no access to a DSS. They found that the presence of time pressure was negatively related to quality of decision-making for both the supported and non-supported subgroups.

Decision strategies are influenced by emotion, which can play a bigger part in decision-making when people are under stress. One of the most obvious ways to put a performer under stress is to impose time limitations (Bourne & Yaroush, 2003). Conte (2015) experimentally explores the effects of time pressure on decision-making. Consistent with the results above, a significant proportion of participant’s decisions were impaired by time limitations. Interestingly, this impairment is not due to the severity of the time pressure, but mainly due to the fact that being exposed to any level time pressure causes stress and panic in individuals (Conte, 2015). In turn, causing the subjects to use time inefficiently thus impairing decision performance. However, this research also exhibited a number of contradictory findings, with a number of subjects not affected by time limitations.

5. Cyber security time pressured decisions
As organizations are becoming more dependent on information technology, the emphasis on information security is getting more significant (Yayla, 2011). Consequently, the effects of time pressure and its related stress have been debated in the field of information and computer security. Whitman (2004, p49) considers the ‘act of human error or failure’ as one of the most severe threats to information security. Literature suggests that some of the underlying reasons behind user errors are due to time pressure and stress. West (2008) summarizes principles of decision-making in computer security.

Consistent with the previously discussed cognitive decision-making theory, he suggests people have limited time and mental resources when making decisions regarding online security. Consequently, West argues that the user is often motivated to get on with the primary task as quickly as possible and, therefore, less likely to make a pro-security decision (West, 2008). For instance, in cases where users are prompted to install software updates, scan a file for viruses before opening, and so forth, users are less likely to comply when in the middle of another task, especially if in a hurry (West, 2008). Further, Yayla (2011) considers the effect of time pressure related stress on individuals in information security. He proposes that user errors and negligence are arguably the two most common unintentional insider threats and that user errors are related to the ‘unintentional threat’ of time pressure (Yayla, 2011, p5). Yayla suggests that reducing work related stress and fatigue levels by adjusting time pressure and workload will reduce unintentional insider threats to information security. However, despite both Yayla (2011) and West (2008) investigating the effect of time and stress related variables on information and computer security decisions, there has been little attempt to quantify these theories.

6. Conclusion and future research

Due to continuous changes in competition and technology, the shortage of time is increasingly prevalent factor in decision-making (Klapproth, 2008). Despite the unanimous understanding that time pressure effects decisions, this literature review argues that the effect of time pressure on decision-making in technological environments has not been exhaustively engaged with in the literature. Upon the review of the literature, various gaps have been identified in existing research. When considering the role of technology in decision-making, there are differing opinions in the literature, suggesting that there is still further research needed. Additionally, the influence of time pressure and emotion on decision making is frequently discussed in the literature, however there is limited research considering the interaction of these two elements. This review suggests there is an adverse effect of time pressure and its related stress on decision making, negatively effecting the quality and process. This has been displayed in computer and web studies, and discussed in the field of cyber security. Both Yayla (2011) and West (2008) investigated the effect of time and stress related variables on online security decisions, however little attempt has been made to substantiate these theories. The authors and research center colleagues future research has a project centered on time pressure effects on Cyber Security decision making.

References

[1] S. Chen, B. Mulgrew, and P. M. Grant, “A clustering technique for digital communications channel equalization using radial basis function networks,” IEEE Trans. on Neural Networks, vol. 4, pp. 570-578, July 1993.
[2] Ariely, D. (2008). Predictably Irrational. New York: HarperCollins Publishers.
[3] Audretsch, D. B. (2001). Research issues relating structure, competition, and performance of small technology-based firms. Small Business Economics, 16(1), 37-51.
[4] Baker, G. (2002). The effects of synchronous collaborative technologies on decision making: A study of virtual teams. Information Resources Management Journal, 15(4), 79.
[5] Bakker, A. B., & Demerouti, E. (2007). The job demands-resources model: State of the art. Journal of managerial psychology, 22(3), 309-328.
[6] Baum, J., & Wally, S. (2003). Strategic decision speed and firm performance. Strategic
[7] Bawden, D., & Robinson, L. (2009). The dark side of information: overload, anxiety and other paradoxes and pathologies. Journal of information science, 35(2), 180-191.

[8] Beach, L. R., & Mitchell, T. R. (1990). Image theory-a behavioral-theory of decision-making in organizations. Research in organizational behavior, 12, 1-41.

[9] Bettman, J. R., Johnson, E. J., & Payne, J. W. (1990). A componential analysis of cognitive effort in choice. Organizational behavior and human decision processes, 45(1), 111-139.

[10] Bharati, P., & Chaudhury, A. (2004). An empirical investigation of decision-making satisfaction in web-based decision support systems. Decision support systems, 37(2), 187-197.

[11] Bohanec, M. (2009). Decision making: A computer-science and information-technology viewpoint. Interdisciplinary description of complex systems, 7(2), 22-37.

[12] Bourne Jr, L. E., & Yarouch, R. A. (2003). Stress and cognition: A cognitive psychological perspective.

[13] Campitelli, G., & Gobet, F. (2010). Herbert Simon's decision-making approach: Investigation of cognitive processes in experts. Review of General Psychology, 14(4), 354.

[14] Cavanaugh, M. A., Boswell, W. R., Roehling, M. V., & Boudreau, J. W. (2000). An empirical examination of self-reported work stress among US managers. Journal of applied psychology, 85(1), 65.

[15] Clark, K., & Collins, C. J. (2002). Strategic decision-making in high velocity environments: A theory revisited and a test.

[16] Conte, A., Scarisini, M., & Sürücü, O. (2015). Does time pressure impair performance? An experiment on queueing behavior.

[17] Demirkan, H., & Delen, D. (2013). Leveraging the capabilities of service-oriented decision support systems: Putting analytics and big data in cloud. Decision Support Systems, 55(1), 412-421.

[18] Eisenhardt, K. M. (1989). Making fast strategic decisions in high-velocity environments. Academy of Management Journal, 32(3), 543-576.

[19] Fredrickson, J. W. (1984). The comprehensiveness of strategic decision processes: Extension, observations, future directions. Academy of Management Journal, 27(3), 445-466.

[20] French, S. (1986). Decision theory: an introduction to the mathematics of rationality. New York: Halsted Press.

[21] Häubl, G., & Trifts, V. (2000). Consumer decision making in online shopping environments: The effects of interactive decision aids. Marketing science, 19(1), 4-21.

[22] Hetland, H., Sandal, G. M., & Johnsen, T. B. (2007). Burnout in the information technology sector: Does leadership matter?. European journal of work and organizational psychology, 16(1), 5875.

[23] Hu, Y., Wang, D., Pang, K., Xu, G., & Guo, J. (2015). The effect of emotion and time pressure on risk decision-making. Journal of Risk Research, 18(5), 637-650.

[24] Kedia, B. L., Nordtvedt, R., & Pérez, L. M. (2002). International business strategies, decision-making theories, and leadership styles: An integrated framework. Competitiveness Review: An International Business Journal, 12(1), 38-52.

[25] Klapproth, F. (2008). Time and decision making in humans. Cognitive, Affective, & Behavioral Neuroscience, 8(4), 509-524.

[26] LePine, J. A., Podsakoff, N. P., & LePine, M. A. (2005). A meta-analytic test of the challenge stressor–hindrance stressor framework: An explanation for inconsistent relationships among stressors and performance. Academy of Management Journal, 48(5), 764-775.

[27] Maule, A. J., Hockey, G. R. J., & Bdzola, L. (2000). Effects of time-pressure on decision-making under uncertainty: changes in affective state and information processing strategy. Acta psychologica, 104(3), 283-301.

[28] Molloy, S., & Schwenk, C. R. (1995). The effects of information technology on strategic decision making. Journal of Management Studies, 32(3), 283-311.
[30] Noorderhaven, N. (1995). Strategic decision making. Wokingham, UK: Addison-Wesley Publication.

[31] Salanova, M., Peiró, J. M., & Schaufeli, W. B. (2002). Self-efficacy specificity and burnout among information technology workers: An extension of the job demand-control model. European Journal of work and organizational psychology, 11(1), 1-25.

[32] Savolainen, R., & Kari, J. (2006). User-defined relevance criteria in web searching. Journal of Documentation, 62(6), 685-707.

[33] Simon, H. A. (1955). A behavioral model of rational choice. The quarterly journal of economics, 69(1), 99-118.

[34] Smith, C. A. P., & Hayne, S. C. (1997). Decision making under time pressure: an investigation of decision speed and decision quality of computer-supported groups. Management Communication Quarterly, 11(1), 97-126.

[35] Syrek, C. J., Apostel, E., & Antoni, C. H. (2013). Stress in highly demanding IT jobs: Transformational leadership moderates the impact of time pressure on exhaustion and work-life balance. Journal of Occupational Health Psychology, 18(3), 252.

[36] Tombros, A., Ruthven, I., & Jose, J. M. (2005). How users assess web pages for information seeking. Journal of the Association for Information Science and Technology, 56(4), 327-344.

[37] Vance, A., Anderson, B. B., Kirwan, C. B., & Eargle, D. (2014). Using measures of risk perception to predict information security behavior: Insights from electroencephalography (EEG). Journal of the Association for Information Systems, 15(10), 679.

[38] Whitman, M. E. (2004). In defense of the realm: understanding the threats to information security. International Journal of Information Management, 24(1), 43-57.

[39] Webby, R., & O’connor, M. (1994). The effectiveness of decision support systems: the implications of task complexity and DSS sophistication. Journal of Information Technology, 9(1), 19.

[40] West, R. (2008). The psychology of security. Communications of the ACM, 51(4), 34-40.

[41] Yayla, A. A. (2011, October). Controlling insider threats with information security policies. In ECIS (p. 242).

[42] J. U. Duncombe, “Infrared navigation—Part I: An assessment of feasibility,” IEEE Trans. Electron Devices, vol. ED-11, pp. 34-39, Jan. 1959.

[43] C. Y. Lin, M. Wu, J. A. Bloom, I. J. Cox, and M. Miller, “Rotation, scale, and translation resilient public watermarking for images,” IEEE Trans. Image Process., vol. 10, no. 5, pp. 767-782, May 2001.