Naturalistic Decision-Making in Natural Disasters: An Overview

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Abstract

Decision-making can take place in many settings: daily life problems, financial issues, health care matters or in emergencies and situations that require quick and high-risk decisions to be made. In natural or man-made disasters, the immediate decisions are crucial for effective mitigation and management. Thus, the Decision-makers during such situations must process a large amount of unreliable and incomplete information under sharp time restrictions and critical judgments are frequently made under pressure and high stake. The purpose of this paper is to present the decision-making process in real-life settings focusing on the recognition-primed model (RPD) in an attempt to understand how decisions are made in emergencies and natural disasters. Literature review was conducted and it was found that the dynamic behaviour of disasters requests the decision-makers to allocate resources and attention to collaboration and coordination. Decision-making, therefore, is a sensitive task of all management actors especially emergencies and disasters managers and the effective response to such calamities depends on how effective and timely are the decisions that have been made.

Keywords: Disasters; Emergency; Disaster management; Decision-making; NDM; RPD

Introduction

In the 21st century, a variety of natural disasters such as volcanic eruptions, earthquakes, fires; floods, typhoons, and recently tsunamis have claimed thousands of lives and caused large economic and asset losses each year as a result of the arising concentration of people in vulnerable areas due to the augmentation in the world's population which has significantly increased the risk (i.e. probability and/or severity) of natural disasters. Earthquakes, landslides, floods and typhoons are the main disasters which aggressively struck large areas and societies throughout the world [1].

During natural or man-made disasters, the decisions made at the first time are crucial to achieve effective mitigation, loss control, and the whole disaster management [2,3]. Disaster management agencies are required to make critical decisions, including moving equipment and manpower, evacuation, and providing sheltering and food for the affecting communities [4]. Therefore, high risk decisions are frequently made under stress and uncertain conditions; this is what we call the naturalistic decision-making. This paper reviews the concept of naturalistic decision-making in natural disaster management focusing on recognition-primed decision-making model (RPD) as a decision-making model for emergencies and natural disasters.

Methodology

This paper presents the decision-making process in real-world settings and describes deeply the naturalistic decision-making in natural disasters through recognition-primed decision-making (RPD) model which is also deeply discussed. Therefore, in order to fulfil its objectives, the paper is divided into five parts as follows: 1) disaster management, 2) decision-making, 3) naturalistic decision-making, 4) recognition-primed model, and 5) naturalistic decision-making in disaster management.

Paper Design

Disaster management

Disasters may come suddenly and without previous warning. Some disasters happen due to an interaction of human and technology,

while other disasters would be generated by the environment itself [5]. Natural disasters have causes from natural hazards such as floods and earthquakes which cannot be avoided, but their impacts can be reduced through sound preparedness and response from both governments and local communities.

Disaster management is an option for decision-makers to enhance the community resilience and minimize the damages due to natural disasters. Disaster management can be defined as an "on-going process composed of a set of activities before, during, and after an event". It is the continuous process of supervising and controlling the disaster management activities separated into four phases: preparedness, mitigation, response, and recovery. Hence, in all these phases, information used by the agencies involved in disaster management is of great importance to ensure effective decision-making. Thus, it is critical to be reliable, timely, and complete about the situation of the environment variables, and forecast the upcoming changes and their potential consequences.

Disasters and other complex issues have clearly showed the need to collaborative efforts to deploy the available resources to solve them such as poverty, diseases, and natural disasters. These issues go beyond the ability of one agency to cope with. It requires many agencies from different sectors to be involved and interacted for comprehensive decision-making strategy and implementing solutions [6].

Decision-making

Decision-making is a major task of all mangers. Mintzberg [7]

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stated that among the ten roles of management, we can consider four as "decision roles": entrepreneur, monitor, resource provider, and negotiator. Managers play a crucial role in the decision-making group regarding to their positions and authority; they can orient the agency to new actions and have the sufficient information to make the agency's strategic decisions [8].

Decision researches have been conducted in various areas ranging from mathematics to psychology. However, it was surprising that most of these learning's cannot be easily applied on decision tasks in the real-world events [9]. There are severe restrictions to generalize the results obtained from laboratory studies to real-world settings. In this regard, Orasanu and Connolly cite:" the basic cause of the mismatch is that traditional decision research has invested most of its energy in only one part of decision making, which we shall refer to the decision event. Research on decision events tends to focus on the ways in which decision makers pull together all available information into their choice of a best alternative".

Decision-making is often developed and implemented based on the information available. However, in many settings, studies have demonstrated that decisions are made with incomplete information. Hammond said that different events require different types of cognitive activity; some situations for example, require making decisions based on 'analysis' of the plausible alternatives and select the best choice to implement (i.e. Analytical Decision-Making), where other situations require quick and intuitive decisions (i.e. Naturalistic Decision-Making). Both situation at hands and the peoples' reaction are crucial in generating and implementing the decisions. Hence, in real-world settings, making a decision is a part of a larger task which is usually achieving a broader goal (i.e. action). Decisions are incorporated in task processes that include determining the nature of the problem; developing an action plan; generating the action to achieve this goal; and assessing the impacts of that action.

Naturalistic decision making (NDM)

In his study, Klein [10] argues that the decision event process does not explain what fire ground commanders say that they really do, their focus is on the nature of fire they face, and based on experience with similar pre-experienced events (i.e. previous fires); they select the action which is likely to be correct to achieve their goals, given the limitations of the situation at hand. The plan is assessed by simulating its likely effects; if none is found, the plan will be implemented. This new model which attempts to understand the decision-making process in real-world settings has been developed over the last twenty years, this model is called: the Naturalistic decision-making (NDM).

The historians of NDM development highlight a sequence of conferences, beginning in 1989, the first conference was held in Dayton, Ohio, and sponsored by the army research institute, at which scientists from different domains shared many common themes [11,12]. Then, a second conference held in 1994, in Dayton at which 100 participants were present. The period (1989-1994) was for developing and testing models. Following, the third conference was held in 1996 in Aberdeen, Scotland, where the scope of NDM is extended to cover larger related areas such as expertise, problem solving, and process control with special focus on situation awareness as a key-performance of decision-making. Next, the fourth conference was held in Warrenton, Virginia in 1998 and focusing on the efforts to enhance the methodologies for conducting a field research. Later, the fifth conference took place in Stockholm, Sweden, in 2000 focusing on finding implementations for NDM findings [12,13].

This new outcome of cognitive sciences and classical decision-making is the concept commonly known as NDM or the Naturalistic Decision-Making [14] attempts to understand how people in real-world settings such as Navy commanders, crisis managers, nuclear power plant operators, army small unit leaders, aviation cockpits, healthcare workers, fire fighters, and highway engineers make decisions in complex, high-stakes, time pressure, uncertain, conflicting, and dynamic environments using their experience. Therefore, understanding the decision-making process in such situations requires the researchers to "apply innovative solutions to real-world problems and situations" [15].

NDM is defined by Orasanu and Martin [16] as "decision-making by individuals with some level of domain expertise in real world contexts". It explores the methods used by the people involving in decision-making whether individuals or within a team to "identify and assess their situations, make decisions, and take actions whose consequences are meaningful to them and to the larger organization in which they operate" [17]. Moreover, NDM is the commitment to develop a plan of action and implement it while other options exist and even if the expert does not weigh up or compare these different options and alternatives [18].

Klein has discussed some issues concerning the application of NDM framework. He states that it appears that NDM studies are less applied than normative decision studies. To Klein it is because NDM attempts to explain what experts really do, while normative decision-making studies seek to "discover deviations from optimal strategies in order to prescribe better strategies". The normative frameworks cannot match many natural settings because, as Klein cites: "the boundary conditions in terms of data quality and time available to perform the analyses are not met". In contrast, the naturalistic approach will seek to build on the already-used strategies rather than attempting to replace these strategies. One final advantage of the NDM frame-work is that it tends to ground the applications within a context. Whereas the normative, analytical approach had the strength of being generic, it had the weakness of not being grounded within the context of a specific domain.

One of main factors to distinguish NDM from laboratory decision models (i.e. classical) is the much effort devoted identify and clarify the situation at hands including objectives and assumptions (i.e. Situation Assessment) rather than the moment of choice. The decision-making process was extended to cover a prior phase of recognition and situation assessment as described in the model of the NDM framework in addition to developing appropriate courses of action not only selecting among alternatives [19]. Therefore, Naturalistic Decision-Making process involves situational awareness, recognition, and assessment in order to determine the nature of the issue and its relevant factors. A solution suggested by a candidate would be considered, assessed, and implemented if it is adequate.

NDM is typically used in the events that characterized by time pressure; fast change; goal conflicts; and multiple sources of information. In such events, decision-makers whether they operate as individuals or within a team would cooperate to support their decision-making. However, the reasons of using NDM in complex environments are cited by Klein as follows:

i.	Classical (i.e. analytical) frameworks cannot address many real-world settings (e.g. disaster response).

ii.	Experts can be deployed as benchmarks of individual or team

performance (i.e. from which the performance ability is built in junior decision-makers).

iii. NDM attempts to describe the strategies that decision-makers really use; and

iv. Experts generate appropriate courses of action especially when high stake, complex, and time constraints exist in the dynamic environment.

Naturalistic decision-making features: Lipshitz surveys eight factors that shape the decision-making during emergencies, but researchers often pay no attention to some of them. Though, we cannot find all the factors in their extreme levels in one system – setting – but some of these factors are present in any decision process.

Overall, these factors include: ill-structured problems; uncertain dynamic settings; Shifting and competing goals; action/feedback loops; time pressure; high stakes; multiple decision makers; and organizational goals and norms; and experienced decision-makers [20-22]. The worst cases for decision makers are the ones with maximum values on the eight features mentioned above.

Following Lipshitz, Orasanu and Connolly confirm through many opening scenarios that is easy to find examples where natural settings that symbolize extreme values of many features. These features are required to be understood even though it is difficult to be reproduced in the laboratory. Thus, conducting laboratory studies to test the hypothesis brought from mathematical models of best strategies to make a decision and understand how managers make decisions in real life settings is inappropriate even by using experienced participants.

Naturalistic decision-making models: Various models of decision-making have been emerged from the NDM body of the research.

Lipchitz reviews nine individual decision-making models in real-settings which grow out of classical decision theory where there is an uncertainty about its reliability and applicability in real-world events; Lipshitz highlights a set of the common trends, in which they are focusing on the importance of situational awareness, using mental simulation in many of them, trying to describe real-world event, and shifts between naturalistic and analytical strategies, and trying to support people's decision-making strategies.

According to Lipchitz these models are: a) Noble's situational assessment model, b) Klein's recognition-primed model, c) Pennington and Hastie's explanation-based decisions model; d) Montgomery's model of dominance search; e) Image theory of Beach and Mitchell's; f) Rasmussen's cognitive control model; g) Hammond's theory of cognitive continuum; h) Connolly's decision cycles model; and i) Lipchitz's argument-driven action. Hence, Decision-making models suppose that all the alternatives, options, results and choices are pre-known and able to be evaluated.

Lipchitz et al. mention that Klein's Recognition-primed model RPD can be considered as "prototypical NDM model". Klein however, does not mention that RDP model is the only suitable model of human decision-making. RPD, as mentioned by Klein; can be considered as one of the frameworks used by experts in complex environment under time pressure and uncertainty [23].

Recognition-primed model (RPD): Scholars are increasingly assuming that human understanding of decision-making and the importance of experience-based judgement under uncertainty has been significantly improved by the implementation of NDM.

Recognition-Primed Decision-making model (RPD) was developed by Klein to explain how experienced decision-makers can rapidly make decisions in their operational settings [24]. It stresses on Situation Assessment and how decision-makers are able to draw upon their experience to generate the appropriate course of action in high stake settings based on that assessment.

Klein et al. conduct observations on five research areas in different fields (e.g. fire fighters, tank manoeuvres etc.); the findings show that usually commanders can quickly categorize the situation, develop a course of action to cope with it, and modify the plan if necessary to fit the changes in the situation. Thus, RPD lies within the field of NDM and is specifically appropriate when undertaking emergency management decisions [25].

The Recognition-Primed Decision-making model developed by Klein includes three phases as follows:

i. Situation Recognition: conversely to pre-experienced situation which brings typical solutions, new events would be challenging because of the unpredictability.

ii. Serial option evaluation: using mental simulation, the commanders will evaluate action alternative (i.e. only one alternative is evaluated at a time) and,

iii. Mental Simulation: when decision-makers find appropriate alternatives; they will implement it regardless it is the optimal solution.

A simple model of RPD happens when the decision-makers categorize (recognize) the situation at hands, they would know the appropriate response as well, and the series of actions that would take place. If the recognition is delayed, there will be an included phase of situation appraisal (i.e. Situation Assessment).

The RPD model (Figure 1) postulates that decision makers can intuitively make good decisions without comparing the available options. They would identify and evaluate an appropriate course of action as the first one they analyse by conducting mental simulations rather than having to weigh up the different plausible alternatives [26].
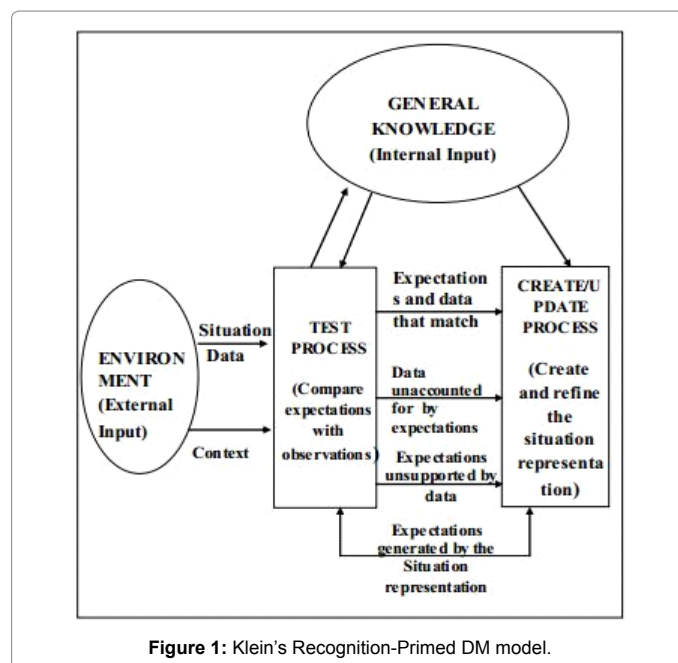

Figure 1: Klein's Recognition-Primed DM model.

They can generate such courses of action and implement them by using their experience which they have already come across and from which they know the solutions.

RPD therefore, stresses on successive evaluation of alternatives (i.e. only one option is evaluated at a time) which avoids the need for simultaneous deliberation between options that highlight the 'moment of choice'. This strategy allows them to quickly make difficult decisions by saving the time which they otherwise have used to decompose the situation into basic elements and perform analysis and calculations based on those elements. Thus, RDP model focuses only on finding an appropriate solution rather than optimizing the solution (i.e. finding the first option that works not necessarily the best option).

However, RDP model combines intuition and analysis together. The intuitive part is the pattern matching, and the analytical part is the mental simulation. This combination matches two systems: system 1 (quick and unconscious), and system 2 (slow and analytic). A completely intuitive approach will depend on pattern matching and would be quite risky since the pattern matching generates defect options. Whereas, an entirely deliberative "analytic" approach would be quite tardy; the emergency will go beyond control when the managers finish deliberating.

NDM in disaster management

Disasters and large scale accidents response studies have revealed some common issues with decision-making processes. These findings would significantly have implications on the individuals and teams involved in incident management as well their agencies and the organizations in which they have responsibility for emergency response. Those individuals and teams must have a comprehensive understanding of the naturalistic decision-making strategy and the factors present during large scale events that would affect the decision-making performance.

Various types of decision-making are used in disaster management including analytical, naturalistic, procedurally based, creative, and distributive decision-making. The most important are two; the analytical and the naturalistic decision-making. The former, is based on seizing up the plausible alternatives and select the best options is used when time and reliable information are available where the last is made quickly and intuitively based on the decision-makers' experience and used when the disaster environment requires high stake and timely limited decisions to be made [27]. Sinclair et al. describe the contribution of decision-making types in disaster management; the analytical strategy is used during preparedness and recovery phases, and the NDM strategy is used in response phase of a disaster where the analytical would be a 'hindrance'.

During response phase, the disaster scene is dynamic, fast changing, uncertain, and ambiguous. The analytical frameworks in this case is likely to be impossible because the information available are varying in reliability or does not exist with a limited and usually not enough time to treat all the available alternatives [28].

A number of issues in disaster response management have been identified. Boin and Hart, find that organizational chaos, poor command and control on scene, media pressure, stress, and unreliable data are among the major affecting factors of Naturalistic Decision-Making performance. Thus, the need arises to effective strategies to respond to such accidents and skilful disaster personnel to make effective decision-making during an incident. Moreover, as mention by Boin and Hart; emergencies decision-makers shift from routine procedure in making-decision to quick and intuitive decision-making in dynamic and complex situations in which the decision-maker must stay flexible [29].

The crucial role of the Naturalistic Decision-Making (NDM) in complex environments has been studied in different settings and domains including military, fire fighting, emergency services, policing, offshore oil production, public health, and aviation sector etc. In these environments, the decisions are always made under stress, complexity, and time-pressure. The dynamic behaviour of disasters increasingly requests the decision-makers to allocate resources and attention to inter-organization and inter-sector collaboration and coordination. Therefore, Decision-making in emergencies and disasters needs innovative methodologies and instruments that would be more non-hierarchical and flexible [30].

Sinclair et al. stresses on the need to study, learn, develop, and implement effective decision-making in emergencies and disaster management because poor decisions lead to poor emergency and disaster management. In this regard, Brehmer cites: "The study of decision making in a dynamic, real time context, relocates the study of decision making and makes it part of the study of action, rather than the study of choice [31-33]. The problem of decision making, as seen in this framework, is a matter of directing and maintaining the continuous flow of behaviour towards some set of goals rather than as a set of discrete episodes involving choice dilemmas". Hence, improving decision-making performance needs information and decision-making management skills and procedures to be developed [34-36].

Conclusion

Decision-making is a sensitive task of all management actors especially emergency and disaster managers who are often required to make decisions in limited time and based on inadequate information. Therefore, effective response depends on how effective and timely are the decisions that have been made.

In natural or man-made disasters and emergencies, the immediate decisions are crucial for effective mitigation; life and assets loss control; prevention, control of financial costs; and consequently, the whole disaster management. Thus, Decision-makers during such situations must process large amount of unreliable and incomplete information and commonly under sharp time restrictions. Also, critical judgments are frequently made under time pressure and high stake since all human beings are unable to cope with unlimited numbers of problems at a time, only few issues can be treated.

Cosgrave recommends the decision-makers to consider Drucker's advice to part and limit the amount of the considered decisions at any time which allows them to pay more attention to the quality of decisions. Therefore, it is worthy to visualize all the issues that decision-makers are aware of but they did not decide yet whether to shortlist a decision as a "decision queue". Moreover, one way to optimize the decision queue is to examine the decisions that present available time and data (i.e. non-urgent) as necessary decisions (i.e. urgent) and omit them from the queue as well. Delegating or even ignoring the unimportant issues until a decision will be made by someone can also be considered as a way to reduce the decision queue. Hence, decision load would be one of the sustainable features of emergency management.

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