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Impromaps: Applying Rasmussen's Risk Management Framework to improvisation incidents

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ABSTRACT

Effective, appropriate improvisation has the potential to enhance system resilience, yet the phenomenon is currently not well understood. This research tests the notion that improvisation is a systems phenomenon and examines the appropriateness of Rasmussen's (1997) Risk Management Framework and Accimap methodology for examining the factors influencing improvisation in safety critical situations. Impromaps (improvisation Accimaps) were used to determine whether the factors identified as influencing improvisation in two case studies met the predictions made by Rasmussen's Risk Management Framework. The findings indicate improvisation is a systems phenomenon and support the use the Framework and Impromaps as an analysis methodology for the examination of improvisation incidents. The methodology allowed the identification of factors across all levels of both systems, and was able to describe the relationships between factors both within and across the system levels. It is concluded that Impromaps are applicable to improvisations occurring in different domains and resulting in positive as well as negative outcomes.

1. Introduction

Resilience, or the ability of a system to anticipate, respond to, and recover from unexpected, unprepared for disturbances, has been the focus of increasing levels of research over the last decade (Hollnagel, 2006; Reason, 2008). Performance variability provides the means by which organisations can adapt to these disturbances in order to maintain system stability (Woods and Hollnagel, 2006; Westrum, 2006) and one form of performance variability that can provide this adaptation is improvisation (Grøtan et al., 2008). Improvisation is the spontaneous, real-time conception and execution of a novel response to a situation that is beyond the boundaries for which a system has prepared (Trotter et al., 2013). Adaptation through improvisation can occur during the performance of standard work procedures (Moorman and Miner, 1998) and can also occur in response to safety critical situations. It is in the latter situations where the concept remains ambiguous. While there is a long history of incidents in which improvisation has prevented or mitigated catastrophic systems failure, such as the ditching of US Airways flight 1549 in the Hudson River (National Transportation Safety Board, 2010) and the restoration of critical infrastructure after the World Trade Centre attack (Mendonça, 2007), there are also instances in which improvisation has produced less favourable outcomes, for example, the Mangatepopo Gorge incident (Brookes et al., 2009) and the Chernobyl disaster (International Nuclear Safety Advisory Group, 1992). Whether improvisation results in positive or negative outcomes is likely to be determined by multiple factors.

Improvisation that is appropriate and effective, or in other words "legitimate" in that it "...fits with extant organisational goals and is not likely to cause harm to the improviser or anyone else" (Bigley and Roberts, 2001, p. 1289) has the potential to impact positively on organisational resilience in safety in critical situations. Despite this, exactly why positive outcomes were achieved in situations where improvisation has mitigated systems failure is typically not investigated. In fact, there is a paucity of Human Factors research into the concept of improvisation in general (Trotter et al., 2013).

Within the discipline of Human Factors, researchers have argued for the adoption of a systems approach when attempting to understand and enhance performance in complex sociotechnical systems (e.g. Larsson et al., 2010; Leveson, 2011; Rasmussen, 1997); however, despite improvisation being an emergent property of complex sociotechnical systems, no research had yet examined improvisation from a systems perspective (Trotter et al., 2013). As a result, practical applications intended to support/enhance appropriate, effective improvisation are unlikely to succeed, given that the conditions across the system that may influence improvisation are not well understood. This represents a significant research gap which currently prevents the concept from being realised within safety critical systems.

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To address this, Trotter et al. (2013) proposed Rasmussen's Risk Management Framework (1997) as a suitable framework through which to examine improvisation from a systems perspective; however, the appropriateness of this framework has yet to be investigated. The aim of this article is to test this approach when used in the improvisation context through a systems analysis of two high profile incidents in which improvisation played a key role in the outcomes. Specifically, Accimap analyses (Rasmussen, 1997) of the two improvisation incidents are presented. The aim of these analyses was first, to determine whether the concept of improvisation can be considered a systems phenomenon as described by Rasmussen's (1997) Risk Management Framework, and second, to determine whether the framework can be used to identify systems factors influencing appropriate, effective improvisation as well those influencing inappropriate, ineffective improvisation. The analyses from two different domains, with opposite outcomes in terms of safety, are evaluated against a series of predictions made by Rasmussen's Risk Management Framework regarding performance and safety in complex socio-technical systems.

1.1. Rasmussen's Risk Management Framework

Rasmussen's (1997) Risk Management Framework (Fig. 1) is underpinned by the notion that safety is an emergent property of complex sociotechnical systems that is impacted by the decisions of all actors, not just by those of front line operators alone (Cassano-Piche et al., 2009). According to the framework, factors impacting safety reside across a hierarchy of systems levels but it is the interaction (vertical integration) between these levels that controls the system's safety and performance. While the number of levels and their labels can differ according to the system being examined, in the interests of consistency with previous research, the framework and Accimap level labels adopted here reflect those used by Rasmussen (1997) and Svedung and Rasmussen (2002). In this study the framework includes six organisational levels: government; regulatory bodies and associations; company management; technical and operational management; staff; and work. According to Rasmussen (1997), normal variation in behaviour releases accidents that are 'waiting' within routine work practices

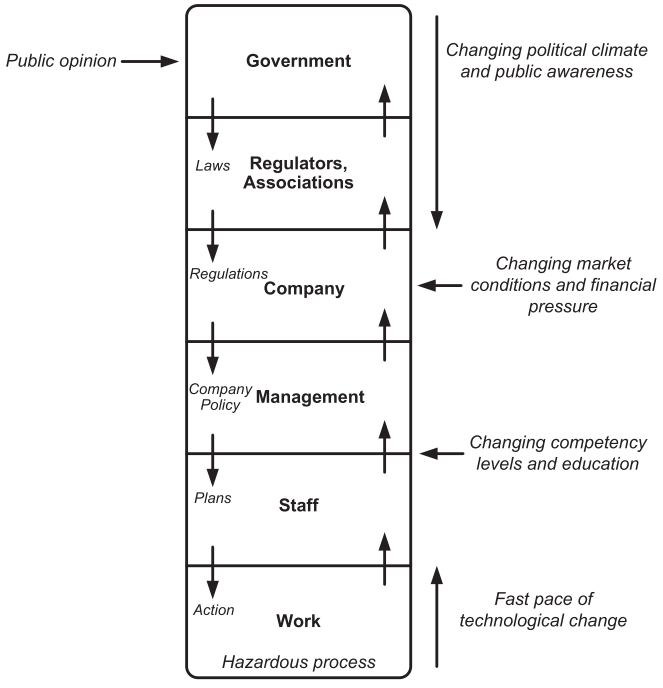

Fig. 1. Risk Management Framework (adapted from Rasmussen, 1997).

across system levels. As improvisation is an emergent property of systems, it is argued here that factors at these systems levels will also release or restrict improvisation.

Rasmussen's Risk Management Framework makes a series of predictions in relation to performance and safety in complex sociotechnical systems (Table 1). These predictions have been used to evaluate the applicability of the framework in new areas of application (e.g. Cassano-Piche et al., 2009; Salmon et al., 2010). In the present study Rasmussen's predictions are used to test the assertion that improvisation is a systems phenomenon.

In conjunction with the Risk Management Framework, Rasmussen developed the Accimap method as a means of graphically representing factors from different systems levels that contribute to accidents (Rasmussen, 1997; Svedung and Rasmussen, 2002). Specifically Accimaps describe the failures, decisions and actions at the six systems levels considered in the framework and the interactions between these. In describing the interactions between factors both within and across the different systems levels, Accimaps have particular utility in the development of interventions to improve system safety and performance. Accimaps have been applied to the analysis of incidents within many domains including led outdoor activities (Salmon et al., 2010), space travel (Johnson and Muniz de Almeida, 2008), and public health (Vicente and Christoffersen, 2006).

2. From Accimap to Impromap

2.1. Selection of cases

Meeting the aims of this study required the selection of two cases that met the following criteria: the cases came from widely different domains; the cases differed in terms of the appropriateness and effectiveness of the improvisation, and hence in terms of the safety outcomes the improvisation achieved; and sufficient information was available to establish the nature of the improvised response and to allow identification of factors influencing improvisation. Incidents meeting these criteria are relatively rare. The Mangatepopo Gorge incident (Brookes et al., 2009) is a recent and pertinent example of improvisation that was inappropriate and ineffective and resulted in negative safety outcomes. While other, higher profile instances of improvisation resulting in negative safety outcome exist (e.g. the Chernobyl incident), details around the nature of the improvisations (particularly the conception of the improvised response) can be scarce. In this case the survival of the instructor means sufficient detail can be found in the coroner's report and independent inquiry report to pin-point the instances of improvisation and to allow the identification of influencing factors and their interactions across different systems levels. Finding well documented cases where improvisation has had a positive effect on safety outcomes proved even more difficult; however, the response to the LM Consumables issue aboard Apollo 13 (National Aeronautics and Space Administration (NASA), 1970) is a well-known example of appropriate, effective improvisation around which substantial documentation exists, including detailed description of various improvisations, making this case an ideal candidate for this study.

2.2. Case study one: Mangatepopo Gorge incident

The Mangatepopo tragedy occurred on the 15th April 2008 when a group of 10 high school students and their teacher, led by an instructor from an Outdoor Pursuit Centre (OPC), were completing a gorge walking activity in the Mangatepopo Gorge in the Tongariro National Park, New Zealand. Due to heavy rain in the river catchment area, a flash flood occurred which led to increased river level and flow in the gorge (Brookes et al., 2009), trapping the