International Journal of Industrial Ergonomics 44 (2014) 777–792

Contents lists available at ScienceDirect

International Journal of Industrial Ergonomics

journal homepage: www.elsevier.com/locate/ergon

All for one and one for all: Representing teams as a collection of individuals and an individual collective using a network perceptual cycle approach

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ARTICLE INFO

Article history:
Received 21 February 2013
Received in revised form
12 May 2014
Accepted 17 May 2014
Available online 30 September 2014

Keywords:
Perceptual cycle model
Teams
Networks
Decision making
Distributed cognition

ABSTRACT

The Perceptual Cycle Model (PCM) has been successfully applied to explain individual decision making, however distributed decision making in teams is the focus of much research as it is more relevant in understanding complex sociotechnical systems. This paper explores team perceptual cycle processes. Four crew members from a helicopter search-and-rescue team were interviewed about an engine oil temperature incident using the critical decision method. Thematic analysis was employed to analyse the transcripts. It was demonstrated that the traditional perceptual cycle representation could not model the interconnectivity of teamwork effectively. As such, a network-based approach was employed to demonstrate the contributions of the different components of the PCM to the overall team process. Information processing patterns that are not modelled in the original PCM were found. Implications for this work in relation to modelling distributed cognition and application in the naturalistic decision making literature are discussed.

Relevance to industry: The Perceptual Cycle Model underpins much research with industrial relevance, including decision making and situation awareness. Teams are a feature in all industrial applications; however the perceptual cycle model has yet to be applied to teams. A case study investigating a team representation of the perceptual cycle is presented and the implications discussed.

1. Introduction

The purpose of this paper is to apply Neisser (1976) Perceptual Cycle Model (PCM) to a team activity and explore ways of representing this data in a network analysis-based approach. The PCM has traditionally been concerned with the individual level of analysis; however this is not as relevant in the study of modern, complex socio-technical systems that are characterised by teamwork. By way of a case study method the paper investigates decision making processes of a Search and Rescue (SAR) helicopter team when dealing with a critical incident. Traditional perceptual cycle representations and novel network-based representations are compared and contrasted for different phases of the critical incident. A distributed cognition perspective of the PCM applied to SAR team decision making requires a shift from the traditional notion of the PCM that focuses on the individual to one that focuses on the team. The network approach has been successfully applied to investigate distributed cognition in a variety of domains including, energy distribution (Salmon et al., 2008), air traffic control (Walker et al., 2010), and submariner decision making (Stanton, 2013). However, traditional network analysis does not explicitly consider the interaction between person and world and how this impacts decision making. The impetus for this paper is to explore the scope of a team PCM in order to assess whether there is theoretical potential for the model to account for team processes.

1.1. Decision making and the perceptual cycle model

Naturalistic Decision Making (NDM) refers to the process of how people use their experience to make decisions in the real world as opposed to laboratory settings (Klein, 1998). NDM is a way of understanding how people handle confusions and pressures in their environment which is usually characterised by limited time, goal conflicts and dynamic conditions (Klein et al., 1989). The focus of study in this domain is described by Stanton et al. (2009) as "purposeful behaviour, i.e. teams working together on tasks towards some end goal in highly dynamic collaborative environments" (p. 482). Klein (1998) highlighted dynamic conditions, i.e. the

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http://dx.doi.org/10.1016/j.ergon.2014.05.005
0169-8141/

changing situation, as one of the key features of NDM. As new information is received or old information becomes invalid the situation and goals can be radically transformed.

The most popular model in the NDM domain is Klein (1998) Recognition Primed Decision (RPD) model. In summary, this captures how experts make decisions based on recognition of past experiences that are similar to the current situation. These experiences are used to generate a workable option in a process known as satisficing (Klein, 1998). In complex cases evaluation of the option reveals flaws that require modification or the option is rejected in favour of the next most typical reaction. The RPD model considers mental simulation the mechanism for the cyclical nature of decision making, but this is only internal to the decision maker. As such, the cyclical nature of a changing external environment is not fully captured in the RPD model. Similarly, the implementation of the model does not connect the internal process of the decision maker to the external environment in which decisions are made. Therefore, the explanation provided by the RPD model is primarily one of the decision making processes occurring in the head of the decision maker.

Klein (1998) discussion of team decision making follows a similar vein and focuses very much on the 'team mind', stating that team cognition can be inferred from three sources: the team's behaviours, the contents of the team's collective consciousness and the team's precociousness. The role of the environment, such as artefacts available or the influence of other team members on their colleagues is not acknowledged. Whereas decision making of any kind, especially in the dynamic conditions that characterise the NDM environment, is a product of the interaction of the processes going on in the head of the decision maker and the conditions in the external environment. As Dekker (2006) argued, in order to truly understand decision making it is essential to account for why the actions and assessments undertaken by a decision maker made sense to them at the time. This will be based on internal information in the head *and* external information in the environment. As such, we propose that Neisser (1976) PCM is a more suitable framework to model decision making processes because it accounts for the cyclical interaction that occurs between an operator and their environment in a way that is not fully captured by the RPD model.

As illustrated in Fig. 1, Neisser presented the view that human thought is closely coupled with a person's interaction in the world, both informing each other in a reciprocal, cyclical relationship. World knowledge (schemata) leads to the anticipation of certain types of information (top-down processing, TD in Fig. 1); this then directs behaviour (action) to seek out certain types of information and provides a way of interpreting that information (bottom-up processing, BU in Fig. 1). The environmental experience (world) results in the modification and updating of cognitive schemata and this in turn influences further interaction with the environment.

Carvalho et al. (2005) have argued that feedback and feed-forward loops are one of the defining characteristics of NDM, where dynamic situations are characterised by a series of events taking place overtime. Schemata held by individuals guide perceptual exploration in the world as they prime a perceiver in terms of what to expect from the environment based on past experiences, this is the feed-forward element of the PCM, where early actions are taken using anticipatory strategies (Carvalho et al., 2005). Furthermore, individuals possess both genotype and phenotype schemata. The former are held in the mind of the individual and are developed by the influence of wider systemic factors, whereas the latter refers to the activated schema utilised in task performance by an individual (Neisser, 1976; Stanton et al., 2009). Interaction in the world results in schemata being modified by information attended to in the environment, which in turn modifies further environmental interaction (feedback is derived from the environment).

Klein (1998) attempted to incorporate the role of schemata into the RPD model via the use of expectancies. However, Lipshitz and Shaul (1997) argued that the original RPD model was too simplistic in its representation of schemata. As such, they proposed a schema-driven RPD model which is similar to the PCM in so far as schemata are viewed as the drivers of situational information available to the decision maker. Unlike the PCM, however, the schema-driven RPD model does not include feedback loops and as such, like the original RPD model, overlooks the modifying effect

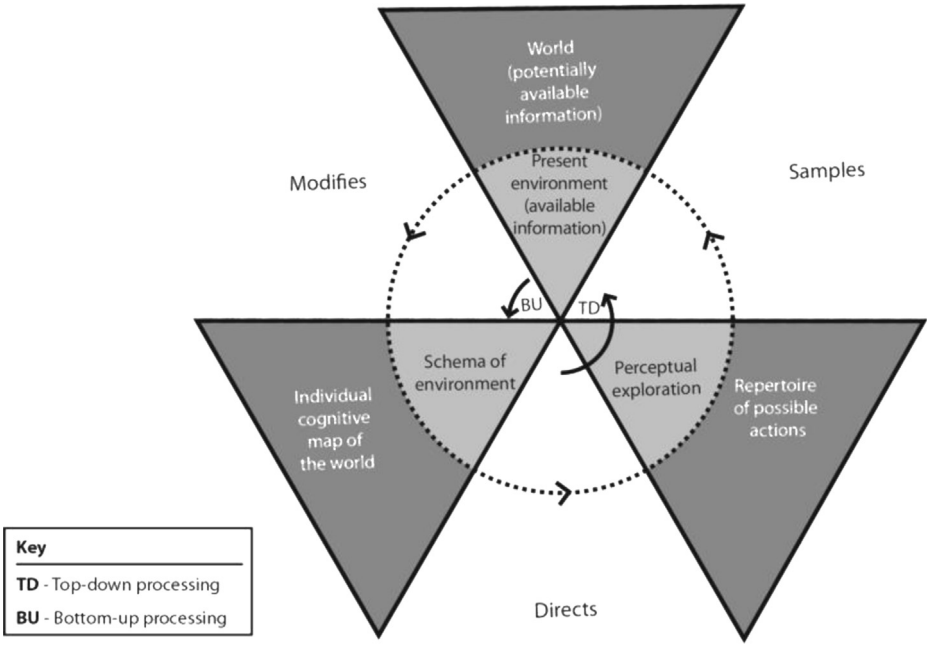

Fig. 1. The perceptual cycle model (adapted from Neisser, 1976).