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Adaptive Shared Mental Models for Medical Teams

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ABSTRACT

This paper describes how second-order adaptive network models for mental processes can be used to model and support (shared) mental models for team performance and organizational learning. The paper illustrates on the one hand the value of adequate shared mental models for safe and efficient team and organizational performance. On the other hand it illustrates cases of imperfections of such shared team models in practice and how this complicates the team and organisational performance. To this end, the controlled adaptive network models can cover use, adaptation and control of a shared mental model and its learning. It is illustrated for an application context of a medical team and organization performance. Simulations illustrate how such adaptive network models are able to address the type of complications that can occur in realistic scenarios and also how better shared mental models can be learnt by organisational learning through aggregation of the best individual mental models. The paper discusses implications for healthcare safety and future research.

Keywords: Shared mental models, Medical decision making, Team learning, Organisational learning, Network oriented Modeling, AI Coach

INTRODUCTION

The concept of a shared mental model has recently received increased attention in medical team performance literature as well as in other domains. Shared mental models are often brought in relation to the quality of team performance and safety (Burtscher, Kolbe, Wacker, 2011; Burtscher, M., Manser, T., 2012; Higgs, A., et al, 2018; Seo et al, 2021; Todd, 2018; Wilsom 2019). A team has a shared mental model when relevant knowledge structures concerning how reality works or should work are held by all team members and when there is sufficient alignment in the internal representations of these knowledge structures (Fisschoff & Johnson, 1997; Jones & Roelofsma, 2000; Mathieu, Hefner, Goodwin, Salas, Cannon-Bowers, 2000). The extent to which a team and organization have adequate shared mental models has important consequences among others for safety.

Safety, both in work and daily life has evolved more and more from being the responsibility of individuals to a shared responsibility of organisations.

Terminology has evolved from a focus on errors (Leape, 1994) to 'patient safety' (Donaldson, 2002; Institute of Medicine, 1999; to 'psychological safety' and adopting a 'safety culture' with adequate 'shared mental models' (Lee, et al., 2019;Sammer et al., 2010; Halligan, 2011; Van Ments et al, 2021). Scholars advocate to share incidents, analyse them across teams, and create an organisational culture that is amenable to sharing and learning from mistakes together (Khatri et al, 2009; Dekker, 2018; Groeneweg et al, 2018; Harvey, Sotardi, 2017). This evolution has required a delicate balance of removing blame while holding people and organisations to account when necessary. Scholars have advocated moving from a so-called 'blame culture' to a 'psychologically safe' and 'just culture'. This means that organisations confidently share incidents and analyse them across teams. An example of such an organisational domain is the hospital.

USING A SHARED MENTAL MODEL

Like mental models in general, shared mental models are used in mental processes for internal mental simulation and decision making based on their outcomes; e.g., (Craik, 1943). Moreover, they often are adaptive in the sense that they can be learnt or forgotten, and for such adaptation usually a form of control is applied. These aspects of shared mental models are all addressed in the current paper. More specifically it makes use of the modeling work of Treur (2020) who has shown how an adaptive network-oriented modeling approach and a three-level cognitive architecture for mental models described in detail in (Treur and van Ments, 2022) can be used to model second-order adaptive mental processes involving individual and shared mental models. Van Ments, et al (2021a,b,c) demonstrate how in particular for the mental processes of members of a medical team, second-order adaptive network models can accurately describe and predict optimal and suboptimal decision making in medical teams, see Figure 1. More specifically, the successful simulations in Van Ments et al (2021, a,b,c) cover both the errors and other imperfections that are daily practice in medical teams and they illustrate the way in which such teams can handle these.

ORGANISATIONAL LEARNING TO OBTAIN A SHARED MENTAL MODEL

Building on the work described above, Canbaloğlu et al (2021a,b) have successfully addressed organizational learning to form a shared mental model (feed forward learning) for medical teams and to learn from it by individuals (feedback learning). This was also done by applying and adaptive second-order adaptive network modeling approach; see Figure 2. Simulations illustrate how such adaptive network models are able to address the type of complications that can occur in realistic scenarios and also how better shared mental models can be learnt by organizational learning through aggregation of the best individual mental models.

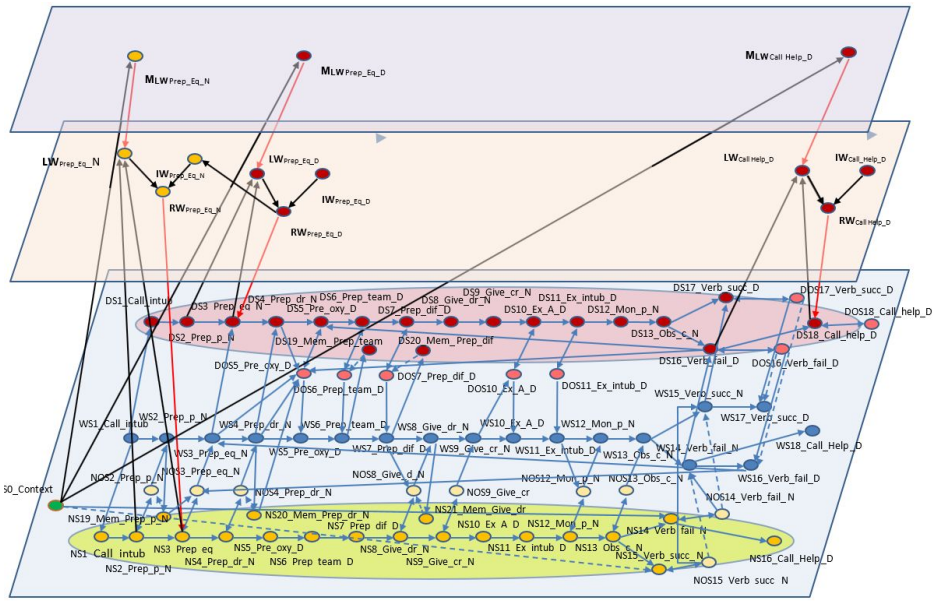

Figure 1: Connectivity of the designed adaptive network model for the use of a shared mental model. It includes the two mental models of the nurse (long yellow oval) and of the doctor (long red oval). The adaptation is modeled by the self-model for the first-order (the pink plane) and the control of it by the second-order self-model (the purple plane). Dashed connections indicate connections with negative weights.

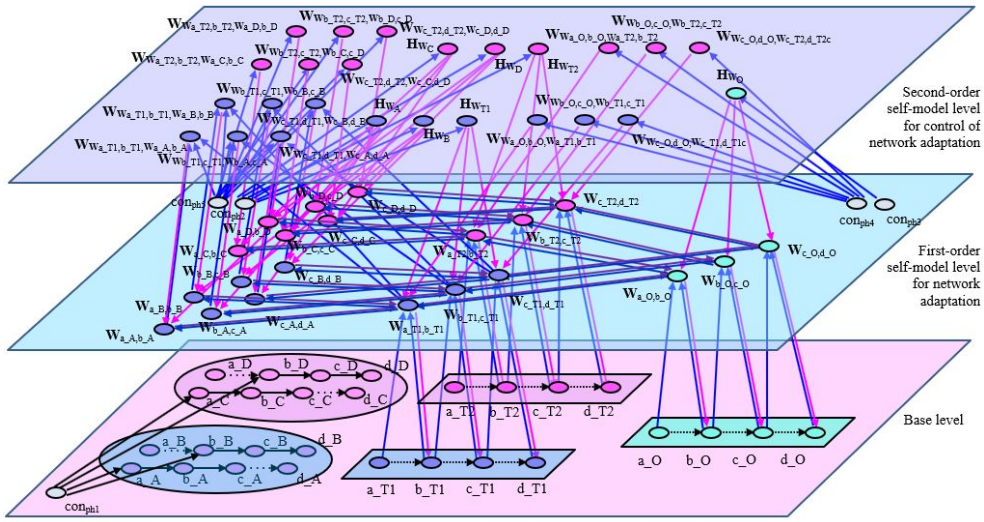

Figure 2: Modeling multilevel organisational learning: the connectivity of the second-order adaptive network model for formation and learning from shared mental models within an organisation.

DISCUSSION

The work of Van Ments et al (2021, a, b, c) and Canbaloğlu et al (2021a,b) has several important implications. One is the that it opens the way for proposing an Artificially Intelligent (AI) coach for medical teams and organisations.

Such an AI coach can collect and combine situational, behavioural and verbal information, e.g through sensors and microphones and/or an interactive dashboard, and process this, thereby using the modelling algorithms described above. The AI-coach can ask relevant questions to verify that all members have a shared mental model and intervene if necessary, e.g. using mediated communication through the interactive dashboard and artificial speech. Such a system would have superior capabilities and no concerns e.g. about speaking up behavior in case problems arise.

The overarching aim of such an implication can then be to explore: *How can this AI coach contribute in the hospital in improving patient safety by creating an adaptive shared mental model for team based on organisational learning?* The underlying models and algorithms of an AI-coach can be further developed to enable this. The vision can be further elaborated in that the AI coach will interact with users (patients and clinical and non-clinical hospital staff) in a personalised and motivating way and guide the organisation towards improvement of patient safety. This aims to optimise the utilisation of all available knowledge and the professional, personal and social skills of all team members facilitated by the AI-coach. The AI coach can stimulate hospital staff by giving suggestions for initiatives and opportunities to improve patient safety. This will be done by stimulating and implementing, e.g., behavioural change within the organisation, elements of safety, and a shared mental model.

Such an AI coach can provide a new approaches for safety and quality of care, e.g. through introducing a concept of co-designed clinical pathways supported by the AI coach. The AI coach can be an intervention for both improving hospital-wide safety and two exemplary clinical pathways in exceptional vulnerable patients. It can empower users by supporting and facilitating the development of a shared mental model for team and organisational learning. The AI coach can function as an information, communication, cooperation and decision support system.

Several hospitals across Europe are willing to participate in forming such an AI coach in a co-creation process, e.g., by a connected Living Labs, which forms a 'learners' community' in which hospitals learn and develop shared mental models for organisational and team learning. The AI coach can be developed, validated and disseminated in such a way. This AI coach can then be applicable in all hospitals where comparable patients are treated.

Such an AI coach implication is urgent since the available knowledge and current recommendations exceed the cognitive bandwidth of the average healthcare provider, especially in pathways where multidisciplinary care is provided. AI provides important solutions for challenges such as contradictory recommendations and innovations in this area. The impact of the implication can be such that within several years after the start of the project, hospitals using the AI coach will have better adherence to appropriate medical guideline and protocols, improved psychology safety in teams of healthcare providers and a higher level of patient safety.

In sum, the core implications are that the adaptive second order network modeling approach described in this paper will lead to:

- a new framework for patient safety
- inclusive and user-centered design of clinical pathways and total hospital quality
- an AI platform with an interactive AI coach who reaches out and empowers its users with policy recommendations
- improvements in team and organisational learning and training.

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