



## Keeping it together: The role of transactional situation awareness in team performance



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### ABSTRACT

It has been argued that communications in teams are a means of transmitting Situation Awareness to improve performance. This study explored the frequency and types of situation awareness transactions in two groups of teams. Twelve teams were grouped into either more effective or less effective teams, based on performance measures. Distributed Situation Awareness theory predicts that Situation Awareness transactions are a medium for co-ordinating teamwork, and that more of these transactions will lead to improved performance. Differences in the frequency and type of transactions were observed between the more effective teams and the less effective teams with the former having a higher frequency of overall communications and, more importantly, a higher number of relevant situation awareness transaction types compared to less effective teams. Situation awareness transactions supported the team in making sense of the situation they found themselves in as it unfolded and enabled team members to perform their discrete tasks and therefore contribute to overall team success.

Relevance to industry: Teams are a major feature of most industrial applications of work and communication play an important role in coordinating team work. Communication has been found to be linked to both team performance and situation awareness. Situation awareness is distributed in teams through transactions of information. A study was devised to explore the differences between more effective and less effective teams on a number of situation awareness transactional factors. Analysing the team as a functional unit of situation awareness is presented for future work.

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## 1. Introduction

This paper sets out to explore the interactions which take place within teams that have performed well and compare these to teams that have performed less well. Understanding the dynamics of team performance has captured the attention of researchers and practitioners alike, with team cognition being considered an important driver of team performance (Salas et al., 2010). Team performance depends on shared goals, interdependence of team members and their actions and on the division of labour that exists within the team (Millot, 2015). Within the Distributed SA (Stanton et al., 2006) approach team SA is seen as an entity that is separate from individual team members (Salmon et al., 2008). SA is, in this perspective, a characteristic of the system itself. Salmon et al. (2008) stated that “Distributed SA approaches assume that collaborative systems

possess cognitive properties (such as SA) that are not part of individual cognition” (p.312). Consistently, Artman and Garbis (1998) proposed that team performance in complex environments should take a systems view of the team and consider SA as distributed across the agents who make up the team as well as the artefacts they utilise, thus viewing SA as an interaction-based phenomenon (Artman, 2000). Distributed SA draws on the theory of distributed cognition (Hutchins, 1995a, 1995b; Stanton et al., 2006). Hollan et al. (2000) argue that one can expect to find systems dynamically configuring themselves to bring subsystems into coordination to accomplish different functions, and state: “Distributed cognition extends the reach of what is considered cognitive beyond the individual to encompass interactions between people and with resources and materials in the environment” (p.175). Distributed cognition is the shared awareness of goals, plans and information that no team member can hold individually (Nemeth et al., 2004).

The focus for measurement, when taking a distributed cognition or Distributed SA approach, becomes the interactions between

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human and non-human agents (e.g. Stanton et al., 2010; Salmon et al., 2009b; Sorensen and Stanton, 2011; Stanton et al., 2015a). Patel et al. (2012) argued that “collaboration involves two or more people engaged in interaction with each other [and] working towards a common goal” (p.1). Interacting with fellow team members, therefore, can improve individual agents SA, or improve the SA of others (Stanton et al., 2006; Salmon et al., 2009b). Salmon et al. (2008) suggested SA as the glue which binds the system, and team, together (Salmon et al., 2008). The interaction between human and non-human agents is, consequently, vital to maintain the Distributed SA of the team (Salmon et al., 2008).

### 1.1. Coordinating teamwork through communications

Team members hold different roles and as a result view and use information differently to other team members (Stanton et al., 2009a). It is not necessary for everyone in the team to be aware of the same information. It is more important to ensure that the right information is communicated to the right team member at the right time (Gorman et al., 2006; Stanton et al., 2006). The interdependent characteristics of communication means that one team members task output become a critical input for another team member's task (Bowers et al., 1996). Similarly, Stanton et al. (2009b) state that “[in line with] system theoretic principles the transaction between system elements implies some sort of conversion of the information received, meaning that information elements will undergo change when they are used by a new part of the system” (p.486).

Communicative acts make sure that information is passed on in the team and represent one form of SA transaction (Sorensen et al., 2010, 2011; Stanton et al., 2009a). Visual displays portraying key information to team members represent another SA transaction (Endsley and Robertson, 2000) which is not considered here. According to Cartier (1959) communication occurs when “a source transmits a message to a receiver with conscious intent to affect the latter's behaviour” (p. 9). Communication is an important part of teamwork, as highlighted by Kennedy and McComb (2010), who establish that considering communication processes and outcomes can shed light on team performance. Communicative acts ensure that the required information is passed on to the right team member at the right time and seek to inform the execution of individual and shared tasks. Taking a systems approach, Fioratou et al. (2010), argue that the unit of analysis of surgical teams should be the interaction between team members and their environments. This line of argument has been supported by studies in military and transport domains (e.g. Sorensen et al., 2011; Stanton et al., 2009a, 2009b). Rafferty et al. (2010) found that good communication can prevent errors, whilst poor communication can cause errors, in military teams. Effective communication has therefore been linked to effective SA (Stout et al., 1999; Rafferty et al., 2010; Stanton et al., 2010; Salmon et al., 2009a).

### 1.2. The role of transactional SA in teamwork

Stanton et al. (2009a) explained that transactions of SA can occur at points during task performance where the SA of individual team members is compatible. A recent study by Sorensen and Stanton (2015) reported that team members influence each other's schemata and alter them as a result of team interaction, engaging in a process of testing their ideas on the whole team and furthering their understanding of the environment (Sorensen and Stanton, 2015). Team members engage in information exchanges as they perform tasks. Exchanges can, for instance, take the form of ‘requests’, ‘orders’ or ‘situation reports’ (Stanton et al., 2009a). These exchanges “tells the recipient what the sender is aware of” (Stanton et al., 2009a, p.52). To be effective team members need to

have knowledge of their own tasks as well as those of the other team members with whom they interact (Dickinson and McIntyre, 1997). A transaction is therefore an exchange of information which updates each team member's awareness in different ways (Stanton et al., 2009a). The information received will be utilised according to the requirements of the recipient (Stanton et al., 2009a). By taking a distributed approach to the study of SA in teams it is possible to consider coordinated activity, which is the focus of this paper (Stanton et al., 2009a).

Interacting with fellow team members enables an agent to improve their own SA or the SA of others (Stanton et al., 2006). It is clear that the interaction between human and non-human agents is vital to maintain the Distributed SA of the team (Salmon et al., 2008). This is further supported by Wegner (1986) who states that “agents in collaborative systems can enhance each other's awareness through SA transactions” (Wegner, 1986 p. 316). A transaction then represents an exchange of SA relevant information, from one agent to another (Salmon et al., 2008). Wegner (1986) go on to describe how “a systems transactive memory, in terms of knowledge of who knows what in the system, allows them to engage in SA transactions in order to give or receive information required for SA” (p.316). Information shared by individuals are negotiated and manipulated through externalised development of problem formulations or decisions (Mitchell and Nicholas, 2006). This is supported by Klein's (2015) naturalistic investigation of sensemaking which finds that people do not merely select data but actively construct the data.

The importance of communication to effective team performance has been recognised in a shift in focus for training teams away from specific skills to training for cooperation and communication skills (Helmreich et al., 1999). This has been continued in the work on non-technical skills adopted by industries such as aviation with crew resource management (Helmreich et al., 1999) and the marine industries with bridge resource management (Crichton and Flin, 2004; Flin et al., 2008).

Transactive memory means that team members do not need to know everything other team members know (Salmon et al., 2008; Stanton et al., 2015a). Rather, team members can be aware of information they require to fulfil their interdependent tasks (Moreland et al., 1996). According to Zajac et al. (2014) dimensions of team cognition support the teams in adapting to their environments through the mechanisms of shared mental models and transactive memory.

In their proposal of a theory of Distributed SA Stanton et al. (2006) explained that it is the interactions between individuals and their environments in a system that leads to the emergence of Distributed SA, a claim that has been supported by an ever-growing body of research (e.g. Salmon et al., 2008, 2009a; 2009b, 2009c; 2010; Stanton et al., 2009a, 2009b; Sorensen et al., 2010; Sorensen and Stanton, 2011, 2013; Flin et al., 2002; Fioratou et al., 2010; Walker et al., 2011; Stanton, 2014; Stanton et al., 2008). The nature of SA transactions therefore merit exploration, as they aid the emergence of Distributed SA in teams and support the coordination of teamwork. Jentsch and Bowers (2005) suggests that frequency of communication and patterns of interaction observed within teams offer a means by which teams may be scrutinised. This paper reports a case study in which the transactions of SA in teams which are known to have either performed well, or less well, on the same an experiment task.

By considering the interactions between team members, with regards to communicative acts, this study seeks to answer the following research questions:

1. Are higher frequencies of communication found in more effective (e.g. high performing) teams compared to less effective (e.g.

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