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Situation awareness as a determinant for unsafe actions and subjective risk assessment on offshore attendant vessels

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ABSTRACT

Situation awareness (SA) is often argued to be a "sharp end" indicator of workplace safety, in the sense that inaccurate SA may be the proximal cause for operator error. However, traditional field or lab experiment measures of SA are difficult to combine with large-scale data collections to examine organizational influences on SA and the safety outcomes of SA. In the current study, offshore attendant vessel crew's SA was measured with a self-report scale. Authentic leadership was modelled as a predictor, while self-report of committing unsafe actions at work and subjective risk assessment were modelled as outcome measures. Structural equation modelling showed the captain's leadership style to account for variation in SA and some variation in unsafe actions. Further, SA accounted for variation in unsafe actions and in subjective risk assessment. The study supports the assumption that SA has a crucial role in maritime safety.

1. Introduction

1.1. Accidents in the maritime industry

Safety is a major concern in the petro-maritime industry due to accidents having potential for catastrophic consequences. The International Association of Oil and Gas Producers (2014) reported that the total recordable incident rate (TRIR, calculated per 1,000,000 man hours worked) in the offshore sector worldwide was 2.34 in 2013. While the types of accidents and potential consequences vary greatly, collisions between vessel and offshore installation are often regarded as a worst-case scenario, due to both vessel and installation being at risk, in terms of human causalities, economic loss, and maritime and coastal pollution (Flin et al., 1996). Between 2001 and 2010, 175 such collisions were reported in the Gulf of Mexico sector (Bureau of Safety and Environmental Enforcement, 2016). In the same time window, twenty-six collisions were reported on the Norwegian continental shelf, of which at least six were considered to have catastrophic potential (Kirschenbaum et al., 2000). Other types of incidents, such as fire, loss of propulsion or crane accidents, can also have serious consequences for the vessel and its crew.

In the organization where the current data collection took place, around 70 vessels attend about 55 offshore installations (subject to variations in operational demands) from seven different ports. In 2014, the organization recorded 57 incidents that led to injuries. While most were minor injuries, two were classified as having the potential for serious injury or death. This yields a TRIR of 1.26 for injuries in 2014. In addition, there were 20 incidents of vessels on a collision course with an installation, and two incidents of contact between vessel and installation.

1.2. Aims for study

Unwanted events take place in a complex interplay of technological, individual, and organizational factors (Dekker et al., 2010; Reason, 1990). Keeping this in mind, it may nevertheless be useful to examine the operator's behaviour as the immediate precondition for incidents. That is to say, the operator's action (or inaction) can be the proximal cause of an incident, although the action itself has other distal causes. The operators' cognitions are assumed to influence their actions, decisions and habits in ways that affect safety. The aim of the current study was to identify factors that predict safety and that can be subject to interventions from the ship-owner or the chartering company. The captain may have a key role in enforcing the organization's expected safety level on the vessel, and the captain's leadership style may be more or less suited to achieve this. Thus, our study addresses how safety is impacted by the overview that crewmembers have of the safety-critical aspects of their work-environments, and the kind of leader-

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ship that captains are offering in their daily interactions with the crew. Other factors, such as the structure of the work-task, task-load, stressors, workplace design, availability of tools, co-worker qualities, team-work, social support and communication, will also contribute to the operator's safety behaviour, but may be more challenging to measure through self-report, and to address by organizational interventions.

1.3. Proposed relationships impacting safety

In the present study, we wanted to examine how situation awareness and authentic leadership combine to influence safety-related outcome variables in terms of the crewmembers' risk assessment and whether they engage in unsafe actions. A cross-sectional self-report survey was performed among the operators of vessels on hire for a single hydrocarbon producing company. Possible mechanisms of interaction between the measured variables are discussed below and summarized in Fig. 1.

1.3.1. Situation awareness and safety

The concept of *situation awareness* (SA) refers to having an accurate representation of the crucial factors of your environments (Endsley, 2004; Sarter and Woods, 1991). SA develops as a result of a recurrent assessment of and interaction with one's surrounding, and feeds into the decision-making. SA is often described (see e.g. Endsley, 1995) as consisting of three different processes or levels of information; the perception of elements in the environment (level 1 SA), the comprehension of the situation (level 2 SA), and the projection of the situation into the near future (level 3 SA).

It should be noted that Endsley's (1995) three-level model has been questioned on epistemological, cognitive, pragmatic, and methodological grounds (Hone et al., 2006; Patrick and Morgan, 2010; Rousseau et al., 2010; van Winsen and Dekker, 2015). There are also competing theoretical accounts, such as *situated SA* (Chiappe et al., 2012), which argues that in addition to internal states, the operators also use cognitive elements embedded in the environment, *distributed SA* (Stanton et al., 2015), which focuses on the sociotechnical system rather than the individual operator's cognitions, and *sensemaking* (Klein et al., 2006), which describes a two-way process of fitting observations and mental model to each other.

Since SA influences performance and decision-making, it has been argued that SA has a crucial role in safety (Flin et al., 2008). In a given safety challenge, operators that have accurate SA may safely resolve an issue that would have led to an accident among operators with less accurate SA. One mechanism through which SA influences safety, may be that operators that have a poor overview of the safety aspect in their work are less able and motivated to work safely (and thus perform more unsafe actions). A number of factors have been suggested to determine the operator's SA, both individual, social, environment and task factors (Endsley and Jones, 2013). A suitable work-environment on board the vessel may be one that presents the information that the crewmembers need to work safely in an accessible, timely and understandable manner. In the current study, we focus on how SA may be influenced by the way the captain's leadership style encourages and inspires the crew to establish accurate SA.

1.3.2. Authentic leadership and safety

We propose that the captain's leadership qualities can create a climate for being mindful of safety and motivate the operator to take safety seriously. The concept of *authentic leadership* (AL) describes a relationship that is characterized by "(a) transparency, openness, and trust, (b) guidance toward worthy objectives, and (c) an emphasis on follower development" (Gardner et al., 2005, p. 345). Gardner and colleagues (2005) suggested that more authentic leaders will create organizational climates that are oriented toward developing strengths, and that are characterized by inclusiveness and commitment. Within safety critical industries, more authentic leaders should therefore be expected to create climates that prioritize safety. This proposition has been supported by previous research within the petro-maritime industry. For instance, Nielsen and colleagues (2013) showed that follower ratings of AL in high-reliability organizations were associated with perceiving risks to be low, and with positive ratings of safety climate. Similarly, Hystad and colleagues (2014) demonstrated that AL exerted a direct influence on ratings of safety climate, as well as an indirect influence through increasing core psychological resources in followers. A further suggestion tested in the current study, is that AL may increase safety through the captain's encouraging and inspiring the crew to work in a way that allows them to establish accurate SA.

1.3.3. Safety outcomes

We wanted to examine the impact of AL and SA on safety-related outcome variables. Serious accidents in the petro-maritime industry are thankfully too rare for us to use the number of accidents occurring within a data collection period as an outcome measure. Accidents of smaller consequences or "near-misses" are more frequent and there is usually a reporting system in place to measure them. However, there is some uncertainty as to the reliability of the reporting (Probst et al., 2008; Weddle, 1996), and to whether the frequency of reporting minor accidents corresponds to the objective level of risk for serious accidents (Rundmo, 1996). Further, the contractual relationships between the parties involved in our data collection prevented us from associating our survey measure to objective measures of reported incidents.

In the current study, we ask respondents to answer a scale of items about the extent to which they engaged in unsafe actions at work, or were "cutting corners" in their adherence to the safety regiment. We assume that performing such actions increase the likelihood of accidents occurring, and hence use this as a safety outcome measure. Crew members who are subject to poor leadership from their captain may be less motivated to or less able to follow the safety management system and commit more unsafe actions (see e.g. Clarke, 2013, for a review). Further, crew members with a poor SA may perform more unsafe actions due to inattention, lack of knowledge or resources (Sneddon et al., 2006b).

As an additional outcome measure, we asked the respondents to indicate what likelihood they believed various types of accidents had of occurring in the next 12 months, which constitutes a *subjective risk assessment*. While similar measures are sometimes referred to as "risk perception", we find this term to have unfortunate connotations to cognitive psychology (that it reflects a perceptual process) and to normativity (that there is an objective level of risk that the respondent can assess more or less accurately). The crew's subjective assessment of the level of risk could to some extent reflect the actual safety. Previous studies have found that workers can have accurate assessments of risks in the workplace (Flin et al., 1996), and that the assessment is associated with accident involvement (Kirschenbaum et al., 2000; Rundmo, 1996). Crew members who feel they sometimes lose control of the safety aspects of their work (i.e. having inaccurate SA) may correctly perceive their work as more risky (Sneddon et al., 2006a). Self-report studies of risk-perception (Rundmo, 1996) have indicated a complex relationship between offshore operator's subjective assessment of risk and the actual risk for accidents, where the two factors are associated although the causal direction is unclear. Our approach bears some similarities to a study by Sneddon et al. (2013), where self-reports from offshore drillers