Naturalistic Decision Making on the Ship’s Bridge

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ABSTRACT

Introduction: With the maritime industry having been the subject of relatively little Human Factors research, an exploratory study was conducted to investigate decision making by captains on the ship’s bridge. Method: Ningbo University’s ship bridge simulator was used to assess the decision making, communications and training requirements of novice and expert teams. Results and discussion: Interview transcripts were mapped onto the Recognition Primed Decision (RPD) model and compared to communication and video data, indicating that novice participants may struggle to provide an accurate account of events. This may be due to the pressure associated with their position and cultural factors relating to perceived loss of face. The potential for a decision-making oriented tool to support training is also discussed.

KEYWORDS

Ship’s bridge; Maritime industry; Critical Decision Method; Recognition-Primed Decision Model.

INTRODUCTION

The maritime industry appears to be lagging behind other transport domains in terms of Human Factors research (Hetherington et al., 2006). This is despite the fact that the maritime domain is extremely complex and, according to much of the literature, highly prone to ‘human error’ (e.g. Chauvin and Lardjane, 2008; Gregory and Shanahan, 2010; Hetherington et al., 2006). Human issues including fatigue, stress, time pressure, communication, environmental factors and long working hours all affect the performance of decision makers on the ship’s bridge (Hetherington et al., 2006). These issues contribute to the loss of an average of two ships every day in the global shipping industry, and although mechanical failures are decreasing, the overall number of vessel incidents is not (Gregory and Shanahan, 2010). In order to reduce risk in the maritime industry, the behaviour of human operators must be understood: only then can systems be designed to mitigate error.

This study was designed as a preliminary exploration of behaviour on the ship’s bridge. A descriptive approach was taken to examine a range of phenomena, including decision making, communications, training, and the performance of novice and expert teams. In this paper, we describe our initial findings with the aim of highlighting issues which are specific to decision making in the Maritime domain and which can be taken forward for further investigation.

METHOD

Participants

Twelve participants (all male) were split into four groups each consisting of three team members: 1 captain, 1 watchman and 1 helmsman (the roles were allocated to participants randomly). 6 participants (two groups) were students on Ningbo University’s Maritime Navigation degree course: these were classified as ‘novice’ participants. The novice groups had only experienced classroom- and simulator-based training and had no experience on a real ship’s bridge. The two novice captains were aged 21 and 22. The other six participants (2 groups) were experienced sailors: these were classified as ‘expert’ participants. The two expert captains were aged 51 and 36, and had 15 and 12 years’ experience on the ship’s bridge respectively. All participants were native Chinese speakers but had English as a second language (the tests were carried out in English).

Equipment

The tests were conducted in Ningbo University’s ship’s bridge simulation facility, shown in Figure 1. The bridge interface is made up of 9 display screens, simulating the complete range of information on a standard ship’s bridge, including Electronic Chart Display and Information System (ECDIS) and radar. High resolution projectors offer a 260 degree field of view. Weather, sea, and tide conditions, along with the movements of other vessels are completely controllable. Communications from the Vessel Traffic Service (VTS) and other vessels reach the bridge via a two-way radio and communications from the engine room come via a telephone located on the bridge. Communications from the VTS, Chief Engineer and other vessels were made by a single ‘actor’
located away from the bridge simulator, in a separate control room: this person was an experienced navigator and trainer who had detailed knowledge of the scenario.

![Figure 1. Novice group operating Ningbo University’s ship bridge simulator](image)

**Procedure**

The captains from each team were asked to complete a demographic questionnaire to collect information on age, gender and experience. Each team completed the same scenario, lasting approximately one hour. During each scenario, three incidents were programmed to occur in a fixed order:

1. Failure of the ship’s main engine
2. Visibility becomes reduced due to fog
3. Another vessel passes in close proximity to the ship, presenting a potential collision risk

The ship bridge teams were instructed to navigate into Ningbo Port and to interact and communicate with each other in the way that would be expected on a real ship’s bridge. They were not made aware that any incidents would be simulated during the scenario. The team also had to communicate with the Ningbo VTS, the ship’s chief engineer and captains of other vessels in the port and surrounding area. Each team’s performance was recorded (video and audio) during the scenario and all communications were transcribed following the tests. Notes were also made during the scenarios to assist the transcription process and to capture extra detail.

Semi-structured interviews were constructed around the CDM cognitive probes and were conducted post-test to elicit information from the captains about their decision making during each incident in the scenario. The interviews were conducted in English; however the CDM probes were converted into Mandarin and asked by an interpreter where necessary. The interviews were audio-recorded and later transcribed.

**Data Analysis**

The CDM data was compared to the communications transcripts in order to evaluate the validity of the interviews. The CDM data was coded (using QSR nVivo) according to the stages of the Recognition-Primed Decision (RPD) model, in order to investigate the nature of decision strategies between novices and experts.

**RESULTS AND DISCUSSION**

**Comparing the CDM and Communications Data**

Comparisons between the interview data and the communications transcripts highlighted discrepancies in response reporting by novices. For example, describing the engine failure incident, one novice captain stated: ‘First, I must send information, like err ‘pan pan’, second I must communicate with the Ningbo VTS, third I must call other vessels, fourth I take some measures like stop engine and check vessels crossing.’ Later in the interview, the captain reports a different sequence of events for the same incident: ‘When the accident is dangerous, first I must stop my engine right now, second I will give orders to the helmsman or the watch officer, third I communicate with the other vessels to let them know my vessel is having problems and that I am dangerous, so to keep clear of me.’

The order of actions performed by the novice captain and his colleagues is not clear from the CDM information; it was therefore necessary to examine the videos and communications transcripts for this incident, in order to find out exactly what happened. According to these sources, the captain first sent a radio message to all ships in the vicinity, initially reporting ‘I have a problem with engine..., with steering’. He then called the Ningbo VTS
and (incorrectly) reported a problem with the ship’s steering gear. Later, the VTS had to request position information from the captain, rather than him providing it as a matter of course. This behaviour is contrary to the two descriptions provided retrospectively by the captain, for example, the captain did not mention his confusion over whether the problem related to the engine or steering gear at all in the interview. This may have been caused by the captain forgetting what he had done and this is a fairly common problem with retrospective techniques, however, the interviews were conducted immediately following the simulations, so it is unlikely that memory would have been the problem here. An alternative explanation is a lack of confidence on the part of the novice captain, which may have resulted in him responding to the probes in a way that he thought the interviewer expected, rather than providing an honest account of what happened in the scenario.

Populating the RPD
To further explore decision making, the CDM data was coded according to the different stages of the RPD model. The coded extracts were mapped on to the RPD model diagram: this is illustrated in Figure 2, which shows an example for an expert captain dealing with the passing vessel incident. This exemplifies the serial decision making strategy identified by Klein et al. (1989), as the captain seemed to quickly recognise that it would be easy for him to maintain course and immediately asks other vessels to allow him to do so. However, when the other vessel refuses to change her course, the captain re-evaluates his decision and changes course. There was significant time pressure involved in the decision as both vessels were moving closer to a collision, so the captain would not have had time to evaluate alternative strategies (i.e. concurrent option evaluation) before deciding on and declaring his course of action. Klein et al. (1989) suggested that by focussing on non-routine events, the CDM can elicit tacit knowledge from operators and the mapping exercise highlighted evidence of this. Figure 2 shows that the captain evaluated the likelihood of success of his decision (see ‘Will it work?’) based on tacit knowledge about the difficulties in communicating with the captains of smaller ships. Although the CDM – RPD model mapping was very clear for the expert captain illustrated in Figure 2, interpretation of the novice captains’ CDM interviews was more difficult. The RPD identifies mental simulation of action as a stage in the decision making process; however, for the novice captains it was impossible to know from the CDM data if the participants were doing this during the incident or whether they were just constructing a retrospective simulation of actions. The CDM probe ‘Did you imagine the possible consequences of this action?’ is designed to elicit this information; however, in this study the novice captains seemed to interpret this as a requirement to perform some retrospective walk through of the situation rather than describing what they actually did at the time of the incident. Furthermore, with the novice participants there seemed to be a concern that they should answer this question in a certain way, i.e. by providing a number of possible actions; however, it seemed likely that they were creating these alternatives in response to the interview. This problem needs to be considered particularly for novice participants, who are likely to feel under more pressure to give answers that they think the interviewer expects and that reflect positively on their own performance. Furthermore, there may also be cultural factors which influence the information provided by participants, for example the issue of loss of face is particularly significant in Chinese culture and the novice captains may have been affected by the perceived pressure of being ‘assessed’ by higher level colleagues (Chow et al., 1999).

CONCLUSIONS AND FURTHER WORK
This exploratory study of decision making on the ship’s bridge highlighted some problems with using retrospective interviewing as a method for eliciting decision making information, for example, the pressure felt by participants to give a positive, but not necessarily accurate, account of an incident. In this case this behaviour seemed to be influenced by experience level and cultural factors. Our initial findings suggest that mapping the CDM interview responses onto the RPD model is a useful way of modelling the decision making strategies of novice and expert captains. Part of this exploratory study focussed on the training needs of future captains as the Ningbo simulator is used extensively as a training facility. The RPD model appears to have potential value as a training tool to encourage students to consider how they make critical decisions. For example, students could go through each stage of the RPD for a case study task and, rather than learning rules, this would encourage them to explore their own decision making strategies and to identify the knowledge that they need to acquire in order to make the transition from novice to expert captains. Decision making ‘games’ have also been suggested as a training tool by Chauvin et al. (2008). This is recommended as an area for future work in the maritime domain.

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