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Walking the line: Understanding pedestrian behaviour and risk at rail level crossings with cognitive work analysis

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ABSTRACT

Pedestrian fatalities at rail level crossings (RLXs) are a public safety concern for governments worldwide. There is little literature examining pedestrian behaviour at RLXs and no previous studies have adopted a formative approach to understanding behaviour in this context. In this article, cognitive work analysis is applied to understand the constraints that shape pedestrian behaviour at RLXs in Melbourne, Australia. The five phases of cognitive work analysis were developed using data gathered via document analysis, behavioural observation, walk-throughs and critical decision method interviews. The analysis demonstrates the complex nature of pedestrian decision making at RLXs and the findings are synthesised to provide a model illustrating the influences on pedestrian decision making in this context (i.e. time, effort and social pressures). Further, the CWA outputs are used to inform an analysis of the risks to safety associated with pedestrian behaviour at RLXs and the identification of potential interventions to reduce risk.

1. Introduction

1.1. Rail level crossings

Across Australia, over the ten years between June 2002 and July 2012, there were 92 collisions between trains and pedestrians at rail level crossings (RLXs, Australian Transport Safety Bureau, 2012). In the state of Victoria, 17 fatalities and six serious injuries resulted from pedestrians having been struck by trains over five years between 2009 and 2013 (Transport Safety Victoria, 2014). Pedestrian fatalities at RLXs represent close to three times those of road vehicle occupants.

In Melbourne, Australia, RLX infrastructure operates in one of three ways. The first type of design provides static warning signs and indications to inform users that a rail crossing is present, but provides no indication of whether a train is approaching. The second type of RLX provides an alert that a train is approaching (through active warnings such as flashing lights and bells), whilst the third type provides active warnings and physical barriers (such as pedestrian gates and boom barriers, and road boom barriers) intended to prevent road users accessing and traversing the crossing while a train is approaching. The latter types of risk controls are generally considered to be the most effective in minimising collisions, at least for road vehicles (e.g. Wigglesworth and Uber, 1991). However, even with the widespread use of physical barriers, collisions still occur.

Modern safety science advocates a systems approach to the analysis and design of complex safety-critical domains (Leveson, 2004; Rasmussen, 1997; Salmon and Lenné, 2015; Wilson, 2014). Such an approach views accidents as emergent properties of the interactions within a system, rather than focusing on individual components which, even if addressed well, may not prevent future occurrences due to the variability in performance within modern complex systems and their dynamic nature. A review of the existing RLX literature found that no previous research has taken a systems approach to RLX safety based on criteria derived from a review of systems theory (Read et al., 2013).

Within the peer reviewed literature studies focussing on

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pedestrian behaviour at RLXs are sparse. Those available have tended to take a normative approach to understanding behaviour by focusing on the tasks pedestrians should perform to be safe, and comparing actual behaviour to this optimal performance. For example, studies have examined the effects of installing new safety measures through statistical analyses to determine the effects on pedestrian behaviour (e.g. Farradyne and Sabra Wang and Associates, 2002; Siques, 2002). An exception to this is recent work by Stefanova et al. (2015) who used focus group data to identify factors contributing to pedestrian errors and violations at RLXs. They used Accimap (Rasmussen, 1997) to represent the systemic factors influencing behaviour in two violation scenarios. While this work took a systems approach, to date the majority of studies have employed survey, interview or focus group methods, rather than collecting naturalistic data. Further, no published studies have taken a formative approach to understanding pedestrian behaviour at RLXs meaning that our understanding is limited to describing existing behaviour rather than all of the possibilities for behaviour available.

This article is a direct response to this key knowledge gap, describing an application of the cognitive work analysis (CWA) framework undertaken to investigate pedestrian behaviour at RLXs. CWA enables analysts to identify and represent the constraints of a complex system, capturing the breadth of potential system functioning and the possibilities for action available to decision makers (Rasmussen et al., 1994; Vicente, 1999). It is proposed that utilising this framework will provide an innovative perspective on pedestrian behaviour in the RLX context.

CWA has been applied to many varied complex systems including nuclear power generation (e.g. Burns et al., 2008), military command and control (e.g. Jenkins et al., 2008), air traffic control (e.g. Ahlstrom, 2005) and submarine systems (Stanton and Bessell, 2014). CWA has also been applied to road transport (e.g. Birrell et al., 2012; Cornelissen et al., 2012) and rail transport (e.g. Olsson and Jansson, 2005; Roth, 2008; Stanton et al., 2013) and has recently been applied in the RLX domain (Salmon et al., 2014; Salmon et al., 2016). CWA has also been recently applied in the pedestrian footpath context (Stevens and Salmon, 2014); however, this did not consider pedestrian behaviour at RLXs specifically. CWA is growing in popularity as means for understanding sociotechnical systems and was chosen for application to this area due its unique constraints-based approach, its maturity as a systems analysis and design framework and its previous application in related areas.

2. Data collection

Multiple methods of data collection were used to inform the CWA including document analysis, input from subject matter experts, naturalistic covert observations of behaviour, elicitation of verbal protocols during a naturalistic walking study and critical decision method interviews. The verbal protocols were used to derive data about the content and outcome of thinking processes undertaken by participants, a purpose for which this method is considered reliable and valid (Walker, 2004) and the critical decision method interviews elicited retrospective data about participants' decision making processes. The reliability of the critical decision method has also been previously established (Plant and Stanton, 2013).

Approval for the research and all associated data collection activities was obtained from the Monash University Human Research Ethics Committee and other relevant ethics committees prior to data collection commencing. Approval for access to coronial records was obtained from the Justice Human Research Ethics Committee prior to these records being accessed.

2.1. Document analysis

Publicly available documentation regarding RLX infrastructure design and operation were sourced and analysed including the Australian standard for traffic control devices at RLXs and the Victorian rail industry standard for pedestrian infrastructure at RLXs. Further, 37 coronial inquest reports of non-intentional pedestrian deaths occurring at RLXs in Victoria between 2000 and 2012 were sourced from the National Coronial Information System managed by the Victorian Department of Justice and analysed.

2.2. Familiarisation activities

In order to observe RLXs from a train driver's perspective and gain familiarisation with the train driving task at RLXs a familiarisation ride was undertaken in a train cab for approximately four hours. Further, a number of RLXs in metropolitan Melbourne were visited to gain familiarisation with RLX functioning and the various physical layouts and features present.

2.3. Observations

2.3.1. Site selection

Seven RLX sites located in metropolitan Melbourne were selected for naturalistic observations. The sites were selected based on the features of the crossing (e.g. infrastructure, equipment, types of warnings present) as well as incident history. The features of each site are described in Table 1. The site selection process ensured that a range of RLX features were represented including automatic gates, automatic gates with locked emergency gates, pedestrian boom barriers, pedestrian mazes, RLXs adjacent to stations and crossings adjacent to road RLX (exposing pedestrians to features such as flashing lights and road boom barriers, etc.). At three RLX locations (sites 2, 3 and 6), two sets of pedestrian gates operated independently enabling users to access an adjacent train station with an island or center platform when a train is approaching from the far track (i.e. a track that they need not cross to reach the train station). These RLXs were all adjacent to a road RLX. One RLX (site 3) had additional countermeasures implemented including a latch on the emergency gate to prevent pedestrians being able to open the gate from the approach side of the RLX, a 'red man standing' (RMS) display (similar to a road pedestrian signal however instead of showing green it extinguishes when no train is approaching), and an 'another train coming' (ATC) display (to indicate to waiting pedestrians that the gates remain closed because another train is approaching).

All sites had been identified within a list of the top 20 unsafe RLXs in Victoria, ranked according to the total number of incidents (collisions and near misses between pedestrians and trains) that had occurred since 2005 (G. Sheppard, personal communication, May 10, 2013). The ranking for each RLX is shown in Table 1. This data is collated by the agency that owns the railway land and infrastructure in Victoria.

All observations occurred on weekdays and were planned to occur in the mornings and early afternoon, based on an analysis of occurrence data that indicated the time of day when the majority of collisions and near misses occur. At some locations the planned observations were unable to be undertaken due to operational requirements restricting access to some rail signal boxes and other unforeseen delays.

2.3.2. Materials

A structured, paper-based form was used to record the behaviour of each user observed. The form enabled recording of the