Call to Arms
Research Agenda

The art of train driving: Flexing the boundaries to manage risk within an inflexible system
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Anjum Naweed,* Valerie O’Keeffe,b Michelle R. Tuckeya.

a Central Queensland University, Appleton Institute, 44 Greenhill Rd, Wayville, SA 5043, Australia;
b Asia-Pacific Centre for Work, Health and Safety, St Bernards Rd, Magill Campus, University of South Australia, SA 5081, Australia.

1. Introduction

Trains are the heaviest of land vehicles. In terms of design, railways are the most efficient and optimal way of mobilising these behemoths, but the task necessarily attracts risk. Human drivers are crucial to safe rail operations, but train driving is deceptively difficult. Although tracks guide the manoeuvrability of a train, very lengthy stopping distances mean that drivers must prepare to stop at places they cannot see. This is a safety concern, and inaccuracies and failures in this create the risk for one of the largest safety issues in rail – the “SPAD”, or Signal Passed at Danger. A SPAD is an occurrence where a train passes a signal displaying a stop indication without the authority to do so (1). SPADs describe a situation where a train has travelled beyond its envelope of safety, and in more technical terms, entered into a critical failure mode. Based on figures available for public consumption, over 1,000 SPADs happen on Australia’s railways every year (2, 3). SPADs carry a huge financial burden associated with loss of services, missed shipping windows, timetabling disruption, follow-on impact to other traffic, incident investigation, retraining, and regulator fines. They are seen as a major threat to system safety and have corresponding effects on the network and for driver welfare.

SPADs are usually a precursor to serious collision or derailment risk, and in Australia, vulnerabilities associated with SPAD safety are projected to become an even bigger problem in the future (4). The demand for rail services is growing and is predicted to double by 2020 (5). In response, the industry is deploying more trains and maximising its network capacities (4, 6). Given current safety statistics and rates of exposure to SPAD-producing conditions, the increase in risk is a concern. Some of the biggest rail accidents in recent memory have highlighted the importance of risk and perception of risk in train drivers [e.g. 7, 8, 9]. Unfortunately, risk and risk perception in train driving is understudied and there is a pressing need to address the research gap. Conventional rail operations are intensifying at rates faster than our ability to appropriately redesign them, or understand the impact to ways of working. Furthermore, corresponding advancements in technology and the rise of hybrid networks (i.e. automation on all or part of the driving task) is still an area in need of general study. There is a critical need to undertake research that understands how these sorts of changes will impact on the train driver in terms of their perceptions of and assessment for risk in day-to-day operations. This paper theorises the way that decisions based on risk are made in train driving and highlights the gaps in this area as a call to arms.
2. Risk Perception In Train Driving Is Based On A Highly Complex Task

Skilled train drivers can turn a brake lever to the stop position, fold their arms, and then kilometres later, watch the train come to a stop exactly where they wanted it to. Really skilled drivers can drive at line speed and keep to schedule in dense fog or near-zero visibility, relying on senses other than sight, tuning instead to the auditory cues, vibrations in the ground and forces in the train. They are a sort of “human barometer” and can use the way that the train feels and the railhead looks to gauge short-term changes in weather, and drive to the conditions. This description may sound fanciful, but it is not – it is empirical. The literature has established that train driving requires the human to process complex vestibular, kinaesthetic, acoustic, and peripheral visual information (10). The task has been compared to driving a car on ice (11) because driving steel wheels over steel tracks is so slippery, and this analogy has been extended even further to driving over ice with a blindfold on (12), mainly because railway curvature precludes long and/or clear lines of sight.

Risk perception in train driving is therefore based on a complex and highly task-oriented activity where drivers use a variety of non-technical skills to effectively predict future events and compensate for uncertainty. Seminal human factors and ergonomics work by Branton (10) describes traditional train driving skill as a sophisticated art and more recent work by Naweed (13) translates this notion to the modern rail setting. In both traditional and modern rail settings, decision-making remains a very fluid and ongoing process that attracts both deliberative and intuitive techniques for problem solving, for example, methodically eliminating potential causes for a train fault (deliberate) or immediately applying the emergency brake to avoid running through a stop signal (intuitive). The same may also be said for decisions based on risk with the implication that future research must extend the current literature to determine how train driving skills in traditional and modern settings correlate with decisions based on risk in both deliberative and intuitive modes.

3. Decisions On Risk Are A Dynamic Feature Of Safeworking

Trains can only travel in the direction they are given, thus while the drivers control the speed and velocity of their trains, the routing of the rails is controlled by another person in the system (i.e. signaller or controller). Train driving is engineered around complete subservience to the information communicated by railway signals, so driving skills are applied according to the specific demands of signalling. A theme of “constraint” undulates throughout the rail system; trains are physically constrained to the track, movement is constrained by speed restrictions, positioning is constrained by railway signals, and rail networks are constrained by how many trains can occupy track sections. The relative inflexibility of the environment and need to maintain safe separation between trains are just two elements of what is known in rail terminology as safeworking. This is a collection of rules and policies, and a form of predicted risk assessment and control that is used to mediate train driving in accredited training programs (14). Much like occupational health and safety, safeworking principles are grounded in an objective, quantitative approach that extracts risk from the socio-cultural environment (15). Whilst rail is performance-driven, the safety imperative means it is also highly regulated, so the view of safeworking as an objective, inflexible (and therefore inviolable) approach is the dominant view at the managerial level and a backbone of the systems culture. There are rules and codes for almost every aspect of the train-driving role, from acquisition of competencies in training regimes through to fatigue risk management on-the-job.

In many ways, constraints at the broad end impact directly upon job design. For example, in passenger operations, research has drawn conceptualisations of timekeeping as something that is watched closely, inspected, and maintained by order (16), too often putting performance and safety at odds or in direct conflict. Most rail networks have some form of technology that can intervene to stop the train by applying its brakes when it moves beyond a stop signal, but rail operators in Australia still rely on less “hardwired” countermeasures as the first line of defence to manage this risk and prevent it from happening in the first place. These include professional driving policies, and the practice of verbalising signals at high-risk locations (17). In practice, the approach to safeworking can be very subjective and depend on individual constraints and local knowledge (e.g.
infrastructure positioning, signal design), and the nature of the skill indicates that decisions on risk are a dynamic feature of safeworking. This begs the question, how do train drivers conceptualise risk? And further, are risk assessment processes in the actual driving task as rigid and inflexible as the system in which they operate?

4. How Do Train Drivers Conceptualise Risk?

Like the safeworking approach, cognitive models of train driving have a tendency to be derived from control engineering. Systems-based models provide a snapshot of the entire system and the driver’s position within it (e.g. 18, 19). On the other hand, skill-based models of train driving focus more on the train driving process itself, though they have a tendency to emphasise the objective and quantitative features of the environment (e.g. 13, 20). Although research has started to tackle how train drivers encode knowledge and service delivery requirements, it has not looked at how they actually perceive risk, in terms of both the material and immaterial (i.e. abstract) elements. Whilst cognitive models of train driving are starting to emerge that include risk, for example from driver distraction (17), we still do not know how risk is actually conceptualised in train driving. Understanding more about how train drivers do this is an area where further research is necessary. This would invariably tell us about how collision risk is actually managed, and inform better cognitive models of the task.

Recently, O’Keeffe et al (21) undertook work in healthcare and developed the concept of expert workers using flexible boundaries of risk assessment. Work within this domain presents clear tensions between patient care and nurse safety as part of its dynamic working environment. In their paper, based on nurses’ decision stories, O’Keeffe et al (21) argue that substantive decision-making is a fluid and ongoing process that occurs across a boundary of risk in terms of its assessment, acceptance and action. In this work, this boundary was described as flexible, and nurses applied it to assess risk, and manage and balance patient and nurse needs. They also used risk-based reasoning to determine the limits of the boundary, and in some cases, traded their own health and safety concerns off in order to achieve patient priorities.

The findings by O’Keeffe et al (21) highlight that, at the sharp end, risk management can be very dynamic, and both risk assessment and decision strategies can flex in response to evolving demands. In terms of a comparison with train driving, there are clear differences (operational and technical) in the ways of working between the two tasks, and with the risk profiles in healthcare and rail transport (e.g. patients versus passengers). However, the nature of the work, its characteristics, and the surrounding work context do overlap. Both are time-pressured, dynamic, and unpredictable, and both have opaque elements that would impact upon the perception and assessment of risk. Like train driving, nursing is a fluid and ongoing process that attracts both deliberative and intuitive techniques for problem solving. It is therefore worth considering if train drivers also use flexible boundaries to perceive and assess risk in rail.

5. Do Drivers Use Flexible Boundaries To Assess Risk In Train Driving?

Train drivers perform under considerable pressures and there is a requirement to drive punctually and/or maintain performance to meet service goals. In freight operations, it is the need to meet logistics/shipping windows, and in the case of passenger, to maintain the timetable. For the passenger mode, there is also a growing need for the driver to perform his or her own job as well as work that has traditionally been performed by train guards or passenger service attendants (22). In the wake of these job demands and organisational goals, research indicates that train drivers relax safety measures under certain circumstances, particularly when they experience competing pressures (4, 17, 22). They also respond to uncertainty by placing the needs of controllers above their own and make decisions that are influenced by concerns that others will form negative perceptions of their skill and level of professionalism (4). A good example of the latter is the desire to avoid a SPAD in order to prevent raising questions of competency, rather than to maintain rail safety (4).

Train driving work by its very nature appears to point to the flexible boundary, used as a means for assessing risk and as a practical mechanism for reducing it by taking account of the wider socio-cultural environment, and as a
barrier to shield drivers from psychological harm (17). In this literature, train drivers were reported to have devised strategies that enabled them to integrate safe techniques as habit and routine practice to provide a baseline level of safe performance. Thus, while the rail environment itself is highly inflexible and engineered to encourage compliance to safeworking (e.g. slow train down to 40km/h as soon as you see a caution/yellow signal), train drivers are more likely to re-assess the situation and flex the boundary between compliance and adaptation, whether it is by accepting unreasonably high levels of risk (e.g. not slowing down at all until they see a danger/red signal), or testing the boundaries before committing to a specific course of action (e.g. slowing down to 40km/h some distance after seeing a caution/yellow signal).

There are compelling reasons to assume that the findings from nurses’ decision stories can and do apply to train driving, as well as other industries. For rail and the train-driving task, the flexible boundary is likely to act as a way of affording decision latitude to the train driver. That is to say that it may provide the means of exerting personal control over situations that place drivers in highly demanding situations, or scenarios where service delivery objectives are in conflict with elementary safety goals. A flexible boundary may also foster the ability to make work-related decisions as a practical mechanism for shielding drivers from harm, including minimising adverse health consequences, such as stress and exhaustion, and feelings of frustration. Finally, it may be a way of providing train drivers with motivation and enthusiasm about the work they do, and enabling a sense of competency and professionalism with corresponding effects on increased efficacy within the workplace. Do train drivers use flexible boundaries to assess risk? It would appear so. The argument for use of flexible boundaries in train driving is convincing, such that it may be useful to see it as a valuable property of the work. However, to achieve this, much more research is needed at the individual level to obtain driver decisions stories. At the systems level, the more pertinent question is how would the rail environment and rail safety managers view this concept? As an environment predicated on very traditional notions of safety, more research is also needed on its association with change and development in rail organisational behaviour, and its place within organisational culture, and risk-based approaches to managing safety.

6. References


7. Singh H, Hanna J. India train derailment: 30 killed, 50 injured. 2015 (March 20).


