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Disinhibition and train driver performance

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ABSTRACT

Despite the gradual adoption of technology in the rail industry, such as automatic warning systems (AWS), train driving still remains a relatively complex form of human performance. In this paper we examine the key contextual and psychological factors that influence train driving performance and driving-related incidents. We argue that goal conflicts such as on time running and safe train management can contribute to poor driving performance and increased risk of incidents for disinhibited drivers. By drawing on a well-established model of disinhibition, namely, the response modulation model of Patterson and Newman (1993), we explain how impulsive behavior and negative emotions can arise in individuals with high threat sensitivity and low working memory when facing approach-avoidance conflict (a form of goal conflict). Disinhibited train drivers, we propose, have difficulty switching attention between competing tasks, which contributes to poor driving performance and increased risk of incidents. We also present the results from an experimental study involving 56 experienced train drivers that provides evidence in support of this proposition. Finally, we believe that the methods and measures used in this study could eventually improve the way train drivers are selected and trained.

1. Introduction

Over the last forty years our understanding of the psychological factors influencing human performance in the aviation and road transport industries has steadily grown, yet our knowledge of these factors in the rail industry remains considerably underdeveloped (Wilson and Norris, 2005; Zoer et al., 2014). This state of affairs is somewhat concerning since railways are a popular and growing mode of passenger transport worldwide, and despite the increasing rate of technological adoption, rail traffic is still largely controlled by human intervention. Few railways, for example, are fully automatic in terms of driver-less trains, while most still require train controllers to oversee automatic signalling systems and intervene when necessary. Arguably many train driving tasks have benefited from technological improvements, for example, automatic warning systems (AWS) and automatic train protection (ATP). However, full automation remains somewhat limited by the safety requirements of an open rail environment, namely, one accessible to non-railway workers (Wilson and Norris, 2005). Furthermore, there is a view that technology itself might increase driver distraction thereby increasing the risk of rail incidents and accidents (Zoer et al., 2014). This paradoxical relationship warrants closer examination, as it is often assumed that automation improves safety and driving performance (McLeod et al., 2005).

In general, train driving remains a relatively complex form of performance despite the gradual adoption of technology by most railway operators. It is widely acknowledged that train drivers require specialised skills and knowledge to ensure safe and consistent performance (Branton, 1979; Naweed, 2014; Naweed et al., 2013; Phillips and Sagberg, 2014). This is because train drivers operate in a complex and dynamic environment where they must anticipate future states, such as signal aspects and speed limits, during both high and low workload conditions (Naweed, 2013). Accordingly, train drivers rely on detailed knowledge of route conditions and signalling systems. In addition, they must maintain a working knowledge of numerous rules and procedures to guide their decisions and actions during normal, degraded (e.g., train fault or rail infrastructure failure) and emergency situations (e.g., fire on train). Drivers must also be prepared to respond quickly and competently to any unexpected event that might delay 'on time running' or threaten the safety of passengers and employees. Indeed, the goal conflict that drivers perceive between on time running and safe train management is regularly cited as a contributing factor to rail incidents and accidents (Naweed et al., 2015a; Tripathi and Borrion, 2016).

A review of the train driving literature highlights the broad and diverse number of situational and psychological factors that are associated with train driving incidents. However, a universal set

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of factors is not yet agreed, nor is the relationship between many of these factors and incidents clearly understood. There are at least three reasons for this. First, many train driving studies focus on signal-related errors, such as signals passed at danger (SPADs), rather than general train driving performance (Baysari et al., 2009; Naweed et al., 2015a). SPADs are a relatively low-frequency incident, yet a SPAD can result in a serious accident such as a train derailment or collision, which may account for the prevalence of signal-related studies. Nevertheless, poor train driving performance, such as ignoring speed limits, train fault indicators or procedural rules, can also lead to incidents and serious accidents. However, our understanding of the antecedents of train driving performance remains underdeveloped by comparison.

Second, much of the existing research describes and classifies various factors, such as workload and attention, but fails to define these constructs according to contemporary psychological theory. In addition, scholars often describe related constructs using interchangeable labels, or fail to explain the relationship between these constructs (e.g., attention, inattention and distraction). Many studies describe the contextual and psychological factors associated with inattention, yet few if any explain the mechanism by which inattention occurs. For example, Naweed (2013) suggests that distraction and inattention arise from multi-tasking and anxiety, yet does not explain the *mechanism* by which these factors lead to driver distraction and inattention. How, for example, does anxiety lead to inattention in a multi-task scenario? Understanding this mechanism is vital if we are to design and implement strategies that minimize driver inattention and reduce the prevalence of incidents such as SPADs.

Finally, and related to the previous point, rail safety researchers have mostly favoured inferential approaches, based on qualitative methods such as action or archival research. In contrast, theory-driven, deductive approaches, based on quantitative methods and statistical analysis are relatively rare. These qualitative studies have no doubt enhanced our knowledge of train driving in general, however, our understanding of specific causal factors could be further enhanced through quantitative methods. This is particularly relevant in applied settings where organizational practitioners seek evidence-based methods to select and train candidates for the train driving role. Many of these qualitative studies provide a rich *description* of train driving, often from a supervisor or driver perspective. However, as we will argue shortly, some of the psychological mechanisms responsible for driving performance are difficult to *explain* through direct observation or introspection (e.g., how and why inattention occurs). Furthermore, the insights gained from qualitative methods can be difficult to generalize (as noted in Zoer et al., 2014) and replicate across rail operators and train driving conditions (e.g., testing the effects of low versus high workload).

The aim of this study, therefore, is to examine the critical psychological and situational factors responsible for driver performance. We specifically focus on threat sensitivity, negative emotions and attention as the core psychological factors underpinning train driver performance (Patterson et al., 1987; Patterson and Newman, 1993). In addition, we examine the influence of goal conflict on driver behavior, that is, time limited situations that simultaneously activate and inhibit driver behavior (known as an 'approach–avoidance conflict'). We could find no study that examines the interaction between these psychological factors and goal conflict in the train driving literature. Our paper therefore offers a multi-disciplinary perspective by drawing on relevant psychological theory and in doing so marks a departure from traditional train driving research (e.g., Naweed et al., 2015b; Phillips and Sagberg, 2014). In addition, we broaden the scope of previous studies by examining driver performance and incidents, rather than focusing solely on SPADs or signal-related incidents. Finally, we test our hypothesis on a 'real-world' sample of train drivers and subsequently propose that our method and measures could potentially improve the way candidates are selected for the train driving role.

Our paper is structured in the following way. First, we review the extant literature on the situational and psychological factors believed responsible for train driver errors and incidents. We then draw on the response modulation model (RMM; Patterson and Newman, 1993) to develop our hypothesis, describing the psychological factors that influence train driver performance under goal conflict conditions. We then report the findings of a train driver study followed by the limitations of this study and suggestions for future research and practice.

2. Theory and hypothesis development

2.1. The situational and psychological antecedents of train driver performance

The need to be responsive and adaptable to complex and dynamic situations, while relying on in-depth knowledge of route information, signal systems and numerous rules and procedures, suggests that train drivers require a distinct set of psychological factors to perform successfully in their role (Zoer et al., 2014). However, the degree to which situational factors, such as workload and time pressure, impacts driving performance depends also on various psychological factors, such as anxiety and attention (see Naweed, 2013). We contend that a combination of certain situational and psychological factors influences train driver behavior and thus a driver's propensity for errors, mistakes and driving-related incidents.

It is generally agreed that train driving, for the majority of the time, involves relatively simple decisions and repetitive actions (see Baysari et al., 2009; Naweed, 2013; Zoer et al., 2014). Train drivers must remain constantly alert for long periods of time, often under monotonous conditions (i.e., low workload), while also remaining vigilant and responsive to environmental changes associated with signal states and speed restrictions, or critical events such as train faults or emergencies (Edkins and Pollock, 1997). Sleep related problems, stemming from shift work are also an inherent part of the train driving role and can compromise a driver's alertness (Cabon et al., 1993). However, train driving can also require intense concentration and high workload for relatively short periods of time, for example, when traversing an unfamiliar stabling yard or siding at night. Surprisingly, we could find no research specifically examining the relationship between high workload and train driver performance. After all, it is plausible that a degraded or emergency situation, requiring the correct and expedient application of a specific rule or procedure, would constitute a complex, high workload scenario and potentially a high risk situation.

Research from the airline industry, for example, suggests that "complex systems can generate unusual, rare and confusing states (Rasmussen, 1983) that require humans to *recall and implement* rules and procedures" (Clewley and Stupple, 2015, p. 939, emphasis added). In particular, Clewley and Stupple (2015) argue that rules and work scenarios that are uncertain and dynamic put pressure on rule-based responses leading to a failure in rule-based decision-making. In a similar way, train drivers also face uncertain and dynamic work scenarios that require them to accurately recall rule-based procedures, often under time pressure. Such conditions can create considerable cognitive demand (e.g., on working memory) and heightened negative emotions (e.g., increased fear or anxiety) that might impair decision-making and driving performance (e.g., Collins and Jackson, 2015; Eysenck and Calvo, 1992; Humphreys and Revelle, 1984). Naweed (2013), for example,