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Brain Meets Train: The Role of Cognitive Science in Rail Human Factors Engineering

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Introduction

To deliver safe, efficient and resilient rail operations, the everchanging interactions between people, processes and technology must be clearly understood and carefully managed. Understanding and managing human-system interactions within increasingly complex rail networks presents significant challenges though as traditional technology design and safety engineering approaches fail to account for the subtleties of human performance in complex, socio-technical environments. Consequently, systems are becoming brittle and the demands placed on the human factors teams working in the rail sector are growing.

The Need for a Solid Foundation

Whilst the focus of human factors research has moved from the ironies of automation (Bainbridge, 1983) to human-machine teaming (National Academies, 2021) and the ironies of artificial intelligence (Endsley, 2023), rail human factors practitioners are still wrestling with the foundational, unsolved, problems of yesteryear – that is, humans with limited capacity being placed into poorly designed, ill-conceived (and often uncontrolled) situations. In tandem, well-meaning investments in technology-focussed interventions (and rapidly re-configured business processes) are not delivering the benefits they promise and mismatches between mental models and process models abound. Sitting in the gap that separates work as imagined from work as done, Network Rail's Ergonomics and Human Factors team is developing cognitive methods and systems approaches to harness theoretical frameworks as building blocks for practical applications that will help address current problems and embrace future opportunities.

Cognitive Science to the Rescue

Constructs such as distributed cognition (Hutchins, 1995), ecological psychology (Gibson, 1979), predictive processing (Clark, 2013), embodied cognition (Varela et al,1992; Wilson, 2002) and cybernetics (Wiener, 1948) offer an extraordinarily rich set of ideas and concepts that can be used to shape rail human factors work. However, despite this, the same narrow set of approaches (many of which are based on bottom-up reductionist methods rather than systems theory) are used time and time again without critique or questioning. This leaves significant untapped potential in the foundations of cognitive science and systems theory which, given the current state of the world (with AI everywhere, increasing cost and resource pressures and the rapid acceleration of change), should not be ignored or taken for granted.

Catch and Correct

By understanding the semantics, semiotics, symbols, affordances and connections that underpin the processes of perception, attention, memory and communication, additional varieties of control and feedback can be designed into future human-machine systems to improve the decision making of humans, teams and machines. Using this principle in conjunction with approaches from cognitive systems engineering and cognitive science, Network Rail's Ergonomics and Human Factors team has created actionable and repeatable processes to amplify, augment and extend existing methods. This presentation will explain how combining cognitive-first approaches with the team's research, insight, design and evaluation (RIDE) process is helping to address the complexities of everyday work. Real-world examples of current progress and future opportunities will be used to demonstrate applications for level crossings, signalling systems, maintenance work, driver advisory systems and electrical control.