Research article

Monotony in the rail industry: The role of task demand in mitigating monotony-related effects on performance

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Abstract

Background: Although monotony is widely recognised as being detrimental to performance, its occurrence and effects are not yet well understood. This is despite the fact that task-related characteristics, such as monotony and task-related fatigue, have been shown to contribute to performance decrements over time. **Aim:** To investigate the effects of varying task demands on experiences of monotony and performance and their relevance to the rail industry. **Method:** Study 1 was a state-wide survey of train drivers investigating aspects of drivers' experiences of monotony and fatigue and what they perceive to be the factors contributing to these experiences. Study 2 used a computer-based train simulator to determine the effect of varying levels of task demand on the subjective experience and performance of train drivers when driving prolonged monotonous routes. **Results:** Survey results indicated that monotony and fatigue are issues that many drivers face on a regular basis and they are issues that can have a detrimental effect on drivers' train management skills. Drivers highlighted various factors they felt contributed to their experiences of monotony and fatigue, as well as the coping strategies they utilised. Results from study 2 clearly showed the effect of task demand on the performance of an otherwise monotonous task, with superior driving performance exhibited by those in the high demand condition. There was also a clear indication of a time-on-task effect in all conditions, as performance deteriorated towards the end of the test session. **Conclusions:** Monotony is an inherent characteristic of transport industries, including rail, aviation and road transport, which can have adverse impact on safety, reliability and efficiency. These studies highlight possible strategies for mitigating these adverse effects.

Background

Historically, monotony has represented an important topic in the field of workplace and organisational psychology since the beginning of the 20th century. More recently, with advances in technology and machinery, as well as the ever-increasing implementation of automation, the nature of many tasks has changed with systems now placing more cognitive demands than physical demands on workers [1]. Combine this with sleep-related issues associated with the increasing reliance on 24-hour operations in many safety critical industries (such as transportation, healthcare, military, mining, and energy), and states of reduced operator alertness have become an obvious area for concern. A variety of different constructs and factors are related to states of reduced operator alertness, such as fatigue, boredom, and underload, and all may be linked to performance decrements, however, the problem of monotony per se is often ignored.

Monotony is generally defined as an objective task-related characteristic of an environment that is unchanging or that changes in a repetitive and predictable way [2, 3]. The subjective experience of monotony, or perceived monotony, is primarily associated with feelings of boredom and fatigue, but also with lack of interest and desire for change [4]. Previous research has shown that increasing the cognitive demand of a monotonous task through the introduction of a secondary task may be beneficial to performance [5]. It is unclear, however, if these beneficial performance effects are the result of a reduction in the perceived monotony associated with the increased cognitive demand of the task. Alternatively, the higher cognitive demand associated with the introduction of a secondary task may have resulted in a greater investment of task-directed effort, which would subsequently have a beneficial effect on performance. Further investigation is necessary to clarify the source of these beneficial performance effects.

One particular population that would seem to be at risk of experiencing problems associated with monotony and fatigue is train drivers. Train driving combines the need for prolonged sustained attention with extended periods of low demand activity interspersed with periods of high activity. Train drivers also have to withstand the monotony of the driving task as well as the monotony of the environment. Surprisingly, however, there is very little available research on monotony in the Australian rail industry.

The aim of these two studies was to establish the relevance of issues such as monotony and fatigue to the rail industry by exploring train drivers' experiences of monotony and fatigue whilst driving trains. Further investigation of the impact of task demand on the performance and subjective experience of an otherwise monotonous train-driving task was also carried out to explore possible strategies to mitigate adverse monotony-related effects on performance. A control group was also included for comparison to determine if train drivers

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may be more inherently equipped to deal with monotonous situations due to the nature of their job and their regular exposure to monotonous working conditions.

Method

Study 1:

A short 4 page survey was developed and distributed via the Rail, Tram and Bus Union (RTBU) to freight and passenger train operators in New South Wales, Australia. Five hundred were distributed to freight operators and 500 to passenger operators. Of the 1000 surveys distributed, 207 were returned, giving a return rate of 20.7%.

The survey was designed to be self-administered and took the train drivers about 10 minutes to complete. No personal identifying information was collected and all information remained anonymous and confidential. The survey consisted of four main sections: demographic information about the drivers and the work they do; drivers' experiences of boredom and monotony while driving trains; drivers' experiences of fatigue and tiredness while driving trains; free response section for general comments.

Study 2:

A total of 56 males participated in the study (28 train drivers and 28 controls). The average age of the train driver group was 40.2 years ($SD = 9.7$) and the average age of the control group was 32.1 years ($SD = 13.1$). All participants completed one of two simulated train-driving scenarios using a computer-based train simulator and a replica train controller consisting of a throttle and brake to control the train's speed. Both simulator scenarios were defined as monotonous, as they incorporated little variation in scenery (i.e. flat green grass interspersed with trees) and track layout (i.e. no variation in gradient with few curves), and the driver only had to control the speed of the train, which involved repetitious movements of the throttle and brake. The difference between the two scenarios was in the level of cognitive demand required (i.e. low demand or high demand). In the low demand scenario, speed signs displayed the required speed as a number, for example a speed of 70 kilometres per hour (km/hr) was displayed as '70'. However, in the high demand condition, speed signs displayed the required speed as an addition or subtraction problem that the participant had to complete in order to determine their required speed. For example, 70km/hr was displayed as '45 + 25'. Half of the train driver group and half of the control group completed the low demand scenario and the other half completed the high demand scenario resulting in four conditions with 14 participants in each (i.e. train driver/low demand; train driver/high demand; control/low demand; control/high demand).

There were a total of 30 speed changes over the entire route, which equated to one speed change every 6 minutes (± 3 minutes). Performance on both the low and high demand tasks was based on the number of errors made in each speed zone. An error was counted as anytime the speed of the train deviated outside of the 2km/hr boundary of the required speed limit. Participants' were instructed to keep the speed of the train within this 2km/hr boundary and to respond to speed changes as quickly and as accurately as possible. For example, if the required speed was 75km/hr, the participant could drive within a boundary of 73km/hr and 77km/hr. Any time the speed of the train went either over or under this boundary was counted as an error.

Participants driving performance in each scenario was compared over a period of approximately 3 hours of continuous driving. Participants also completed a number of self-report measures that allowed for comparison of their subjective experience of the task. These included pre and post-test fatigue rating scales, the NASA-TLX to assess mental workload [6], as well as rating scales of a number of characteristics of the task (i.e. how boring, engaging, monotonous, effortful, tiring, and stimulating they thought the task was).

Results

Study 1: Survey results

Respondents were mostly males in their mid-forties, ranging in age from 21 years to 65 years of age. They had been employed as train drivers for an average of almost 17 years, with a fairly even split of passenger and freight drivers (51.7% passenger). Freight drivers reported working significantly more hours per day than passenger drivers (9.6 hours/day versus 8.1 hours/day respectively), however, there was no difference in the number of days worked per week (i.e. 5 days/week). Average commuting time to work was significantly longer for passenger drivers than freight drivers (34.5 minutes versus 23.1 minutes respectively).

In regards to work characteristics, passenger drivers were much more likely than freight drivers to drive suburban routes (77% versus 10%). Freight drivers, on the other hand, were much more likely than passenger drivers to drive long distance routes (97% versus 15%). Passenger drivers were also more likely than freight drivers to work on a regular rotating roster (33% versus 19%), whilst freight drivers were much more likely than passenger drivers to work on an irregular rotating roster (77% versus 37%).

Overall, three quarters of drivers reported that they find their job of driving trains to be boring and/or monotonous, however, passenger drivers were more likely than freight drivers to find their job boring and/or monotonous (82% versus 69%). More than a third of both freight and passenger drivers reported that they experienced boredom and/or monotony on at least half the shifts that they work and two thirds of drivers reported that their train management skills were adversely affected when they were experiencing boredom and/or monotony.

When asked to indicate when they were more likely to experience boredom and/or monotony, the majority of drivers reported that this was more likely to occur if they drove the same route a few times in a row. This was particularly true of passenger drivers with 60% reporting that driving the same route a few times in a row was a factor that contributed to their experience of boredom and/or monotony. Freight drivers, on the other hand, placed more emphasis on sleep-related factors, with early morning shifts (3am – 6am), if they're feeling tired, and if they didn't get enough sleep commonly reported as contributing to experiences of boredom and/or monotony.

Strategies used to cope with monotony and/or boredom while driving were limited and dependent on availability. Passenger drivers were more likely to listen to music or the radio than freight drivers (61% versus 36%) whilst freight drivers were much more likely than passenger drivers to talk to their co-driver (54% versus 9%). Other commonly utilised strategies were eating or snacking while driving and drinking caffeine.

Overall, nearly all the drivers reported that they find their job of driving trains to be fatiguing and/or tiring, with no difference between freight and passenger drivers. Roughly half of these drivers reported experiencing fatigue and/or tiredness on at least half the shifts that they work and just over 80% reported that their train management skills were worse when they were fatigued and/or tired.

When asked to indicate when they were more likely to experience fatigue and/or tiredness, the majority of both freight and passenger drivers reported that this was more likely to occur during early morning shifts (3am – 6am). Other factors that drivers commonly reported as contributing to their experience of fatigue and/or tiredness included if they didn't get enough sleep, during late night shifts (12am – 3am), and if they had really early shift starts.

Strategies to cope with fatigue and/or tiredness while driving were also limited, with most drivers favouring the use of caffeine. Other commonly utilised strategies were eating or snacking while driving and listening to music or the radio, with freight drivers also favouring talking to their co-driver as a useful coping strategy.

Study 2: Simulator results

Overall, the fatigue rating scales showed a clear increase in subjective fatigue from pre to post-test. The control group reported higher fatigue ratings post-test than the driver group and the low demand task also resulted in higher fatigue ratings post-test than the high demand task. In terms of comparing the subjective experience of the low and high demand tasks, individuals in the four conditions (i.e. driver/low demand; driver/high demand; control/low demand; control/high demand) rated both tasks as equally high on scales of monotony, boredom and tiredness and low in stimulation and engagement. Individuals who completed the high demand scenario, however, rated the task significantly higher on the NASA-TLX subscale of mental demands and the task rating scale of effort required. Thus, the differences in the subjective experiences of the two tasks were in the level of mental demands and the effort required.

The error data from the 30 different speed zones was grouped into blocks for the purpose of analysis. Each block comprised error data from 6 consecutive speed zones. For instance, error data for the first 6 speed zones were averaged for block 1, the next 6 speed zones were averaged for block 2 and so on up to block 5. Hence, increasing block number also represented increasing time on task. Figure 1 shows the mean number of errors per block for all four conditions. In terms of performance, there was no difference between the drivers and controls but there was a significant difference between the low and high demand tasks. Overall, participants in the low demand task committed a greater number of errors throughout the entire task than those in the high demand task. There was also a clear time-on-task effect as performance deteriorates significantly in block 5 for both the low and high demand tasks. Further testing on the block 1 data revealed that performance in the low and high demand tasks was not different from the outset of the study but that performance in the low demand task deteriorated during the third speed zone.

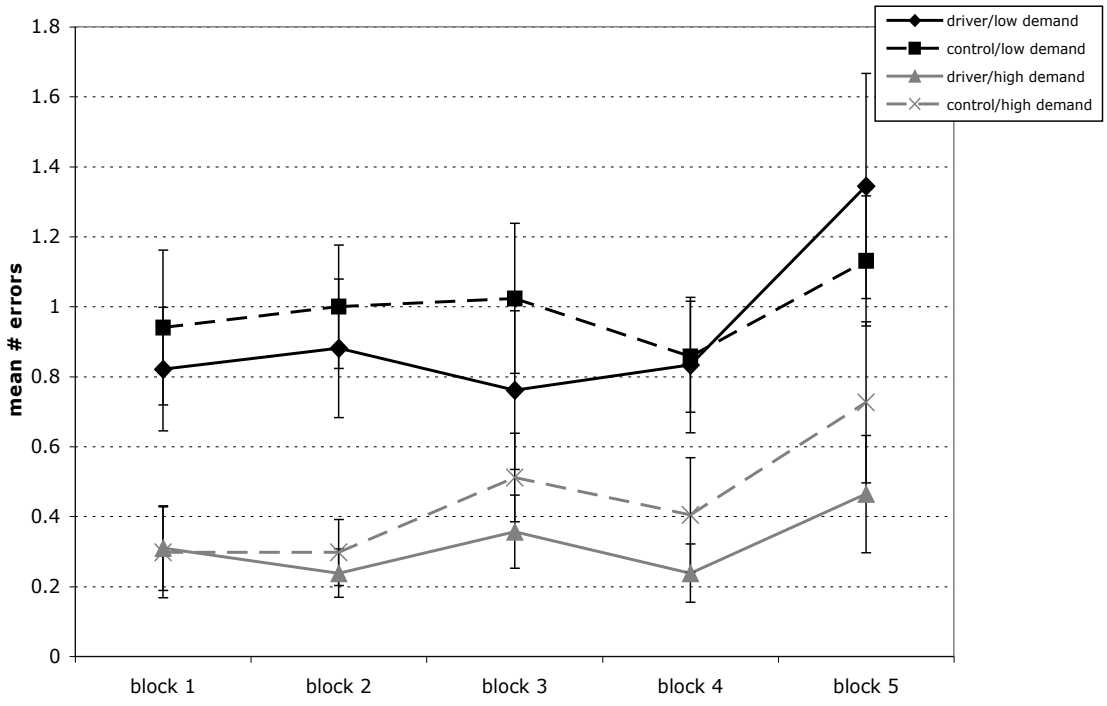

Figure 1. *Mean number of errors per block for drivers and controls compared across the low and high demand conditions (error bars = ± 1 standard error).*

Discussion

The results of this survey indicate that train drivers do experience monotony and boredom on a regular basis when driving trains for work and, similar to fatigue and tiredness, these experiences may adversely affect drivers' train management skills. Passenger drivers were more likely to report experiencing monotony and boredom than freight drivers, however, nearly all drivers reported experiencing fatigue and tiredness. This could be an indication that the fatigue management rules, guidelines or principles that the various train operating companies in the state of New South Wales employ may not be having the desired effect. Given that the majority of drivers indicated that their train management skills were worse when they were bored or fatigued, this also has serious implications for the safety and reliability of the rail system.

Four of the top five contributing factors to experiences of fatigue and/or tiredness related to time of day and lack of sleep, which are factors well recognised as contributing to the development of sleep-related fatigue [7]. The major contributing factor to experiences of boredom and/or monotony, on the other hand, was repetition (i.e. driving the same route) with over half of drivers indicating that this was a contributing factor. In terms of coping strategies, caffeine was favoured by the majority of drivers to cope with experiences of fatigue and/or tiredness. This is not surprising given that moderate doses of caffeine have been shown to increase alertness and may help ward off fatigue, although only for a limited time [8]. Listening to music or the radio was favoured by passenger drivers to cope with monotony and/or boredom whilst talking to a co-driver and eating or snacking while driving was favoured by freight drivers.

This indicates that despite having similar outcomes and performance effects, drivers are able to distinguish between the experience of monotony and the experience of fatigue, which provides the foundations to start creating strategies that are better able to target drivers' experiences of monotony. Clearly, monotony and fatigue are negative aspects of the job of a train driver, however, they are issues that can be addressed, which may subsequently improve the working conditions of the drivers and the safety of the system as a whole. For example, allowing passenger drivers to listen to music and not requiring them to drive the same route repeatedly could potentially reduce the monotony associated with the train driving task.

The results of the simulator study clearly show that increasing the level of cognitive task demand in an otherwise monotonous task facilitates performance and delays subsequent monotony-related performance decrements. As expected, the high demand task resulted in superior performance overall with participants making far fewer total errors and consistently fewer errors across the entire test session than those in the low demand task. Performance in the low demand task, on the other hand, started deteriorating within the first block of performance data. Further testing revealed that this deterioration in driving performance occurred after only three speed zones, equating to approximately 15 minutes of driving. After this initial deterioration in the low demand task, performance remained relatively stable until towards the end of the test session when performance declined. This is a clear illustration of a time-on-task effect, as both the driver and control groups in the low demand and high demand task showed performance related decrements.

The self-report scales revealed that the subjective experience of the task was very similar across all four conditions. There were some minor differences between the train driver and control groups although this did not translate into performance effects. The performance differences between the low and high demand tasks appear to be due to the increased cognitive demand in the high demand task, which subsequently resulted in an increase in task-directed effort. This may have acted as a buffer against the monotony of the task and the resulting fatigue. The results of this study show that if the task is monotonous and low demand, a secondary interactive cognitive task, such as the trivia task used by Gershon et al [9], may be effective in maintaining individual's alertness by increasing the effort required, thereby reducing the performance effects of monotony and fatigue.

Conclusion

In summary, the results of these two studies highlight that passenger drivers may be at an increased risk of experiencing monotony due to the fact that they are isolated in the front of the train with no one to talk to. Listening to music is now also not allowed for passenger drivers on some networks due to the potential for distraction, however, if listening to music helps drivers maintain their alertness and cope with monotony then it is hardly a distraction. The current trend of sectorisation of the New South Wales rail network, where drivers are assigned to specific routes that they drive every shift, may also increase the problem due to an increase in repetition. These results indicate that solutions to monotony involve increasing cognitive demand and task-directed effort. This could be achieved via the introduction of a secondary task, which rather than being a simple button press response to a light like the current vigilance device, is more mentally demanding and requires more effort to formulate a response. This could potentially mitigate the negative performance effects associated with monotony by keeping the driver more attentive and engaged in the task at hand.

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