Tenth International Conference on Managing Fatigue: Abstract for Review

{Title} Predicting Sleep/Wake Behaviour in Operational Settings.

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NO MORE THAN A 1000 WORDS

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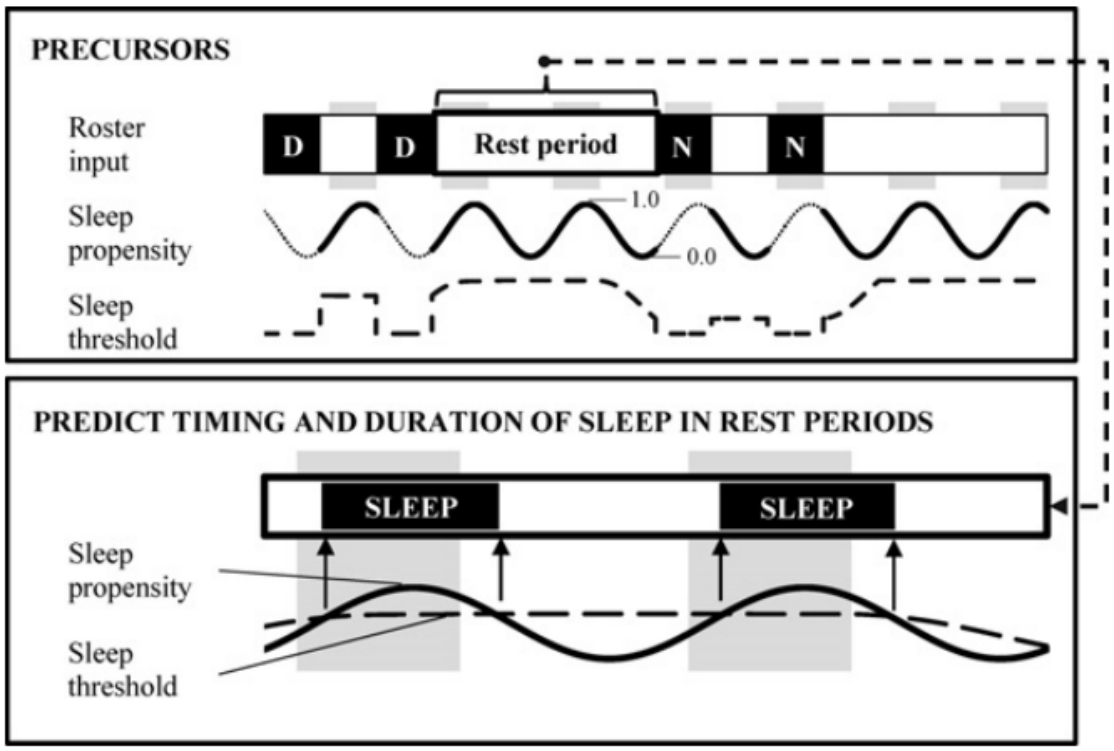
Problem {100 words}

Sleep is a major determinant of the biological processes that regulate alertness. Obtaining accurate estimates of sleep is therefore critical to the validity of all biomathematical models of alertness. Although the current range of biomathematical models continue to play an important role in the management of fatigue-related risk in industrial settings their development emphasis has focused extensively on performance outputs, and in particular the potential for individulasized alertness predictions. Only a limited number of analyses have focused on predicting the timing and duration of sleep in shiftwork settings. The general aim of this paper is to present and validate a model (FAID® Quantum) that predicts the timing and duration of shiftworkers' sleep using sleep data collected during the course of normal shiftwork operations (Darwent, Dawson, Roach 2012)

Method {250 words}

15,000 days of work/sleep data was collected from Australian rail and aviation industries. Half the data is from long haul aviation operations of which 1/3 is West bound, 1/3 East bound and 1/3 North bound. The remainder is regional aviation and rail. Half this data was used to parameterize a sleep prediction algorithm and the other half used to validate the parameterized algorithm.

The authors report that the FAID Quantum algorithm uses two procedures to predict sleep timing and duration: (1) estimate the total amount of sleep likely to be obtained in a given rest period; and then (2) estimate the timing and duration of sleep periods within that rest period. The sleep predicted in the second procedure are generated such that their combined sum is *a priori* equivalent to the total amount of sleep predicted in the first procedure.



From the predicted sleep or user supplied sleep data Karolinska Sleepiness Scale (KSS) scores are calculated utilising the Three Process Model.

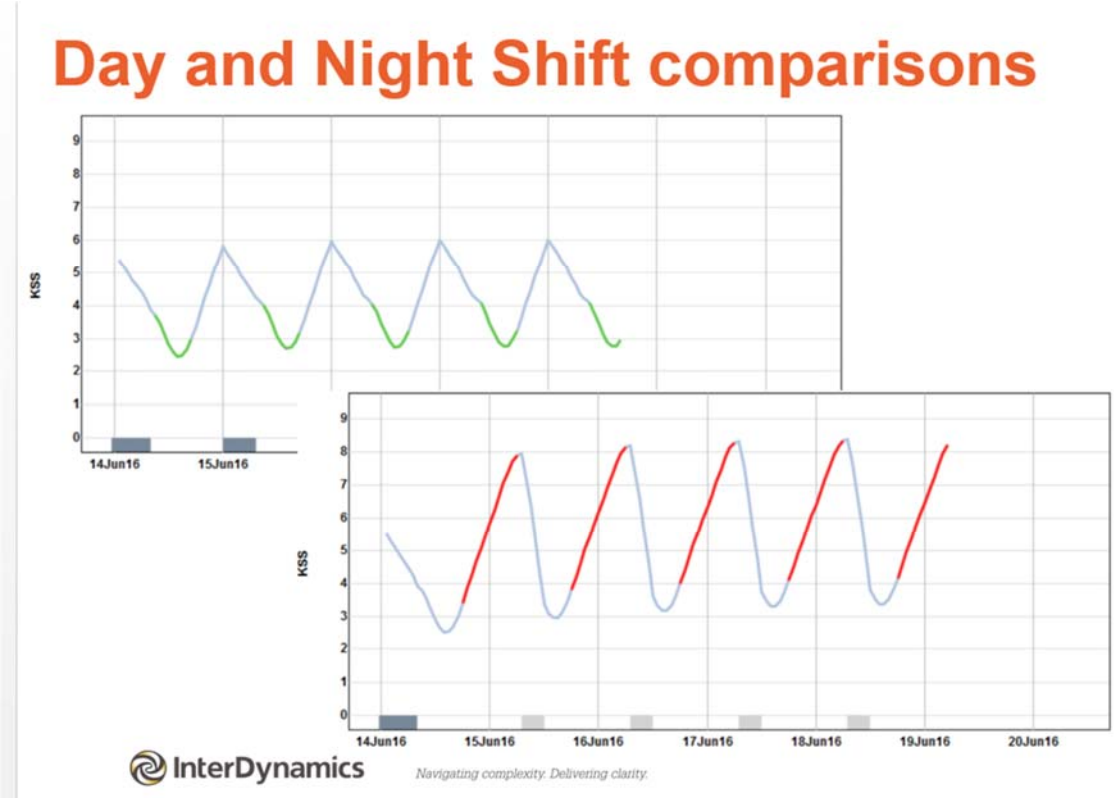
FAID Quantum predicts the amount and timing of likely sleep from work/rest data that is normally available as input data from workplace rostering systems.

Results {250 words}

Darwent, Dawson and Roach (2012) reported that the sleep predictor model used as the basis for FAID Quantum yielded accurate predictions of shiftworkers' sleep, indicating that agreement between observed and predicted sleep periods was a robust 85%. Intra-individual agreement between serial episodes of sleep behaviour in matched rest periods was similarly robust (90%), but nonetheless associated with an intrinsic level of behavioural variation in the order of 10%. The scope for improvement in the outputs produced by the sleep predictor model is minor indeed (i.e., 15 − 10 = 5%).

An example of KSS scores achieved by the model for a typical 5 Day Shift roster starting at 09:00am and finishing at 17:00pm (40 hours of work) is 4.1 and for a typical 5 Night Shift roster starting at 23:00pm and ending at 07:00am (40 hours of work) is 8.4.

The following graphic demonstrates the Day and Night Shift KSS score comparisons for the roster period.



The algorithm has also been parametrized to account for circadian adaptation resulting from international long-haul work involving the crossing of time zones east and west.

Adaptation will be zero or negligible in fast turnaround situations where individuals stay at their destination less than 24 hours before returning to the home time zone.

If individuals stay longer than 48 hours at their destination, then adaptation will start to occur. There is a 'grey zone' in research knowledge between 24 hours and 48 hours.

It is also generally considered that when operations occur within three time zones of the home time zone, there is no significant impact due to circadian adaptation.

Discussion {250 words}

The researchers at the Appleton Institute have used what may be the largest database of quality sleep-wake data in the world, incorporating nearly 15,000 days and nights of data collected from various industries, including rail and long-haul aviation, to underpin predictions.

Models of sleep have traditionally been based solely on the biological processes of sleep homeostasis and circadian rhythmicity. Variation in sleep between individuals has likewise been viewed as the product of trait-like, inter-individual differences in these biological processes. While this paradigm has proven sufficient to explain sleep phenomena observed in laboratory settings, the emphasis on biology has overshadowed the role of non-biological factors that influence sleep timing and duration in everyday settings.

The biological processes that regulate the sleep/wake cycle can be mediated by voluntary decisions that preference social imperatives over sleep. The contribution of these decisions is not always obvious because individuals normally choose to be asleep when the biological drive for sleep is strong (i.e., at night) and when social imperatives to be awake are weak (i.e., also at night). This is not the case for shiftworkers who are routinely required to sleep at times of the day when the social imperatives to be awake are comparatively strong. To manage conflicting demands, shiftworkers develop a range of behavioural strategies (e.g. anticipatory napping, split sleeps) often accompanied by pharmacological (e.g. caffeine, sleeping tablets) and/or technological aids (e.g. alarm clocks, bright lights).

With older biomathematical models of fatigue, predictions were based on average patterns of sleeping and waking but, with FAID Quantum, actual sleep and wake patterns are used to predict future alertness.

Summary {150 words}

FAID Quantum has been developed using scientific research and knowledge gained over several decades on circadian factors, the effects of shift lengths, timing of shifts and the importance of previous work periods on fatigue and performance. The software contains two bio-mathematical models of human alertness response to work and rest patterns associated with trans-meridian travel. The software has been designed to be a powerful decision support tool based on what can be known with confidence: working hours or duty periods. The software uses work hours in UTC and local time as its inputs to predict the effect on fatigue and performance of different duty periods or work schedules, taking into account rest time and the number of time zones crossed. It models human biology and is best used as a statistically significant indicator of general human response, but not as a predictor of an individual's condition. This is true of all models given that variations in sleep requirements and tolerances do exist within the human population.