Cognitive fatigue at work: from the laboratory to the sea

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• What do we mean by fatigue?
• The narrow approach: “The decrement in cognitive performance as a function of time on task.”
• A wider approach: “The interplay between exogenous and endogenous factors that modify alertness and arousal”. 
Factors studied

- Time of day – e.g. working at night
- Sleep loss
- The “post-lunch dip”
- Workload
- Minor illnesses (e.g. the common cold)
- Individual differences
- Countermeasures
Fatigued individuals have more lapses of attention

- This can be seen very clearly in sleep-deprived individuals
Neuroscience and fatigue

• Reduced turnover of central noradrenaline and lapses of attention
Central noradrenaline and lapses of attention

PQ = Placebo/Quiet; CQ = Clonidine/Quiet; ICQ = Idazoxan/Clonidine/Quiet; CN = Clonidine/Noise
Beneficial effects of caffeine in low alertness situations may reflect increases in central noradrenaline. Caffeine reverses the effects of drugs such as clonidine that reduce the turn over of central noradrenaline.
Caffeine reverses the effects of clonidine
Real life impairments
Figure 19.2 Variations in 'real job' measures over the 24-h period. From Folkard and Monk (1979)
Simulations of real-life activities: Driving and the common cold

- Those with a cold drive too close to the car in front.
- Those with a cold are twice as likely to go through a red light.
- Those with a cold respond more slowly to unexpected events (e.g. pedestrians stepping off the kerb).
What’s wrong with this approach?

- Factors are usually considered in isolation.
- There are a few studies which examine combinations of factors e.g. sleep deprivation and factors which decrease or increase alertness.
Modifying Factors

- Factors which decrease alertness lead to greater impairments in the sleep deprived individual

- Factors which increase alertness reduce the negative effects of sleep deprivation
<table>
<thead>
<tr>
<th>Non-Task Variables</th>
<th>Effect</th>
<th>References</th>
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<tbody>
<tr>
<td>Fatigue</td>
<td>Increased by increasing fatigue.</td>
<td>Wilkinson, 1965; Johnson, 1982;</td>
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<tr>
<td>Motivation/Incentive</td>
<td>Reduced by increased motivation or incentive.</td>
<td>Lubin, 1967; Craig (Ch. 1); Englund &amp; Sucec (Ch. 6)</td>
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<td>Circadian Rhythms</td>
<td>Modulated by circadian rhythm</td>
<td>Horne &amp; Pettitt, 1985</td>
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<td>Exercise</td>
<td>Reduced if brief bout taken prior to testing or exercise moderate but increased if heavy and prolonged.</td>
<td>Kleitman, 1963; Rutenfranz et al, 1972; Akerstedt &amp; Gillberg, 1982; Tilley &amp; Warren, 1984; Babkoff et al, 1988</td>
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<tr>
<td>Experience of Sleep Deprivation</td>
<td>Increased by repeated experience</td>
<td>Wilkinson, 1961; Webb &amp; Levy, 1984; Webb, 1985a</td>
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<td></td>
<td>Warm may increase, cold may decrease</td>
<td>Wilkinson et al, 1964.</td>
</tr>
<tr>
<td>Drugs</td>
<td>Reduced by stimulants, increased by depressants.</td>
<td>Tyler, 1947; Kornetsky et al, 1959; Laties, 1961.</td>
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<tr>
<td>Stimulating Activity</td>
<td>Increased and increases sleepiness</td>
<td>Horne, 1976; Horne &amp; Minard, 1985</td>
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<td>Individual Differences</td>
<td>Decrements may be greater in elderly, extraverts or unfit.</td>
<td>Corcoron, 1962; Webb &amp; Levy, 1982; Webb, 1985a, 1985b; Pleban et al, 1985</td>
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Problems (contd)

• Need to look at combined effects of risk factors.
• Need to look at a wider range of outcomes e.g. health; wellbeing.
• Need a psychosocial model of fatigue.
Approaches to stress at work provide a good model for fatigue.
The revised DRIVE model

Individual Characteristics & Personal Resources & Demands

Work Demands & Work Resources – Risk factors for fatigue

Perceived fatigue

Health Outcomes
Job Satisfaction
Safety
Wellbeing

Mediating effect of Y, between X and Z

Main Effect

Moderating Effect
Seafarers’ Fatigue
Risk factors for fatigue

- Acute fatigue
  - Work organisation (e.g. working hours, task demands, physical environment)
  - Individual characteristics (both stable traits & current state)

- Chronic fatigue
  - Repeated acute fatigue
  - Failure to recover
Prevalence & consequences of fatigue at work

• General working population: 22%  (Bultmann et al 2002)

• Fatigue is associated with:
  – Impaired performance
  – Compromised safety
  – Ill health
Fatigue can be as bad as consuming a lot of alcohol
Fatigue in transport

- Fatigue is an accident risk factor in road, rail and air transport:
  - 20% of motorway accidents

- Research in other transport sectors can be applied to seafarers’ fatigue
  - Factors unique to seafaring must also be addressed
The Cardiff Research Programme

• There is a dearth of extensive research on offshore fatigue, so this programme aimed to provide the knowledge base to:
  – Predict worst case scenarios for fatigue, health and injury
  – Develop best practice recommendations
  – Produce advice packages
Methods

- A multi-method research programme including:
  - Literature review
  - Surveys of work characteristics and health
  - Diary studies of fatigue
  - Physiological fatigue assays
  - Sleep, motion, noise measures on board
  - Objective and subjective measure of mental function
  - Pre- and post-tour assessments
  - Analysis of accident and injury data
A combination of minimal manning, sequences of rapid turnarounds and short sea passages, adverse weather and traffic conditions, finds seafarers working long hours with insufficient opportunities for recuperative rest.

In these circumstances fatigue and reduced performance can lead to environmental damage, ill health and reduced lifespan among highly skilled seafarers who are in short supply.
Literature Review

- Accidents and Injuries
  - Seafaring a high risk occupation
  - Evidence of fatigue playing a potentially large role in marine accidents e.g. US Coastguard study
  - Reporting systems often not geared up to assess the role of fatigue
Results: Survey (N=1856)

- Risk factors for fatigue:
  - Operational (e.g. port visit frequency)
  - Organisational (e.g. job support)
  - Environmental (e.g. physical hazards)
  - Health (e.g. smoking)
  - Demographic (e.g. age)
Results: survey

Combined effect of exposure to risk factors

Fatigue measures
0 to 3 factors
4 to 5 factors
6 or more factors
Results: survey

• Consequences of fatigue:
  – Impact of fatigue on cognitive function and safety
  – Fatigue and perceived well-being and health
One-in-four seafarers said they had fallen asleep while on watch.

Almost 50% of seafarers taking part in the study reported working weeks of 85 hours or more.

Around half said their working hours had increased over the past 10 years, despite new regulations intended to combat fatigue.

Almost 50% of seafarers taking part in the study consider their working hours present a danger to their personal safety.

Some 37% said their working hours sometimes posed a danger to the safe operations of their ship.
Results: survey

- Collision awareness
  - Nearly half considered fatigue a key factor in reducing collision awareness
Results: survey – the worst cases

- Fishermen
  - 60% personal safety at risk because of fatigue
  - 44% worked to the point of collapse
  - 41% fallen asleep at the wheel
SEAFARERS’ FATIGUE – “THE WORSE CASE SCENARIO 2 – MINI-BULKERS”

• Mini-bulkers: ships carrying dry cargoes; rapid port turn-arounds; crew of 7-8 with only 2 watch-keepers; watches 6 on-6off.

• Both subjective and objective indicators of fatigue show major problems.
Mini-bulkers: questionnaire measures of fatigue

Table 1: Perceived fatigue and symptoms of fatigue reported by the mini-bulker crew and the crews of the other ships (Scores are the means, s.d.s in parentheses. High scores = greater fatigue)

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<tr>
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<th>MINI-BULKER</th>
<th>OTHER SHIPS</th>
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<tr>
<td>PFRS Fatigue</td>
<td>44.2 (5.6)</td>
<td>24.5 (10.8)</td>
</tr>
<tr>
<td>Symptoms of fatigue</td>
<td>3.96 (0.87)</td>
<td>2.63 (0.68)</td>
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</table>
Mini-bulkers: objective measures of fatigue (taken after 7 days of work)
[scores are the means; s.d.s in parentheses]

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<th>Other ships</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple RT (msec)</td>
<td>411 (55)</td>
<td>335 (61)</td>
</tr>
<tr>
<td>Number of lapses of attention</td>
<td>14.3 (5.3)</td>
<td>2.7 (5.9)</td>
</tr>
</tbody>
</table>
Effects of tour of duty

• A diary study across many different types of ship
Fatigue risk factors & daily fatigue

Survey risk factors
Log book fatigue (week 1): higher score=higher fatigue

0 or 1 risk  2 to 5 risks  6 or more risks
Too tired to start?

Travel to the vessel and subsequent fatigue at work among seafarers (N=520)

- Two-thirds (66%) had no opportunity for sleep before their first shift, and among this group 47% had travelled for 6 hours or more, 33% for 8 hours or more and 19% for 12 hours or more.
Prevention & management of fatigue

- European Working Time Directive (WTD):

  BUT Evidence of large numbers of seafarers working in excess (McNamara et al).

  + Where working hours sheets doctored evidence that seafarers’ actually *more* fatigued (Allen et al).
Working Hours Recording

Data
Deep-sea (n=320), Offshore (n=96) & Short-Sea (n=132).

Working time directive violation
• Almost a third of the sample (30.8%) did not regularly have the opportunity to gain 10 hours rest in every 24.
• Over ten percent (11.9%) did not regularly gain at least 6 hours unbroken rest within a 24-hour period
‘To your knowledge, have your working hours ever been deliberately under-recorded in order to comply with international regulations on hours of work and rest?’
Working Hours Recording

- Never: 37.3%
- Occasionally: 28.3%
- Frequently / Always: 11.7%
- Don’t Know: 22.8%
Working Hours Recording

• 40% of seafarers reported at least occasionally under-recording their working hours.

• Those who admitted to at least occasionally under-recording their working hours were found to be significantly more fatigued/less healthy than those who reported never under-recording.
Prevention & management of fatigue

IMO guidance on fatigue:

- Excessive focus on personal responsibility ignoring organisational factors
- Factors listed but little practical advice
- Little acknowledgment of the crucial role of economics in any strategy addressing fatigue
Prevention & management of fatigue

• **Conclusion:**
  - Diverse activities and different profiles of fatigue risk factors require a range of prevention and management strategies with all layers of responsibility involved.
Prevention & management of fatigue

**Conclusion:**

- Without reliable auditing systems success of interventions will be impossible to judge.

- Factors work in combination not alone. Indicators must cover a range of risk factors not just working hours.
Conclusions and recommendations of the final report

- **Evaluation of how working hours are recorded**
  - Auditing tools have to be valid before new interventions

- **Information campaigns & fatigue management** (e.g. THINK, AWAKE))
  - Seafarers’ must be empowered to intervene in operations when fatigue identified

- **Establish an industry standard measure of fatigue**
  - Perceived fatigue measure. Adoption of a universal measure will accelerate progress in terms of addressing seafarers’ fatigue

- **Develop a multi-factor auditing tool**
  - Risk factor checklist (based on combined effects approach)
Seafarers’ fatigue is an occupational health and safety issue that is common and widespread. It is not being adequately dealt with by current legislation, management or working practices and there is an urgent need to rectify the situation.
The Way Forward

Treat fatigue as a health and safety issue!
What does this mean?

• A fatigue policy
• Education – training to prevent and manage fatigue
• Tools for a fatigue audit
• Communication of fatigue-related issues
• Empowerment to change the nature of work to prevent and manage fatigue
More famous people than me have emphasised the importance of these factors

“ I think education is power. I think that being able to communicate with people is power. One of my main goals on this planet is to encourage people to empower themselves”

- Oprah Winfrey