Effects of motion on cognitive performance

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HSE BOOKS

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The present report reviews a number of areas which may influence performance efficiency on Floating Storage Production and Off-Loading vessels. The nature and extent of these will vary from one vessel to another. There is also no existing literature that predicts the magnitude of the effects. However, it is safe to assume that they may be at a level where operational efficiency and safety is endangered. It is recommended, therefore, that further research into the scale and costs of these effects is conducted. Further research should consider both acute and chronic effects of the above factors. The outcomes should include both performance of individual operators and also group performance. Special attention should be paid to safety critical operations although it is also important to monitor performance of more routine work as well. The extent to which problems are generic or context specific also needs detailed consideration as this will allow identification of the best preventative and therapeutic solutions. Until this research is conducted it is essential that there is close monitoring of these vessels to determine the nature and extent of occupational health and safety problems.

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CONTENTS

EXECUTIVE SUMMARY

The present report reviews a number of areas which may influence performance efficiency on Floating Storage Production and Off-Loading vessels. The nature and extent of these will vary from one vessel to another. There is also no existing literature that predicts the magnitude of the effects. However, it is safe to assume that they may be at a level where operational efficiency and safety is endangered. It is recommended, therefore, that further research into the scale and costs of the following effects is conducted:

- Problems associated with the design of the vessel
- Problems associated with the combination of two different working cultures
- Visual problems associated with motion
- Manual problems due to motion
- Motion sickness
- Peripheral fatigue due to adjustments of posture
- Central fatigue induced by motion
- Combined effects of motion-induced fatigue and
  - -Workload
  - -Shiftwork
  - -Loss of sleep
  - -Noise and vibration
  - -Other aspects of the physical environment
  - -Illness and medication.

Further research should consider both acute and chronic effects of the above factors. The outcomes should include both performance of individual operators and also group performance. Special attention should be paid to safety critical operations although it is also important to monitor performance of more routine work as well. The extent to which problems are generic or context specific also needs detailed consideration as this will allow identification of the best preventative and therapeutic solutions. Until this research is conducted it is essential that there is close monitoring of these vessels to determine the nature and extent of occupational health and safety problems.

GLOSSARY

Central fatigue: Fatigue due to changes occurring in the central nervous system

Peripheral fatigue: Fatigue due to changes occurring in organs such as muscle

VO_2 max: The maximum amount of oxygen which can be utilised by an individual, per minute, at sea level

Noradrenaline: A neurotransmitter produced mainly in the brainstem nuclei

(neurotransmitter)

Vestibular system: A receptor system in the inner ear that responds to mechanical forces, such as gravity and acceleration

Vagal: One of the cranial nerves (i.e. connected directly to the brain).

(of the vagus nerve) Motor and sensory nerves innervate the following organs: heart, lungs, gastro-intestinal tract, bronchi, trachea and larynx

Scopolamine: A drug which blocks cholinergic transmission by imitating acetycholine and combining with the post-synaptic

receptor

but not altering the permeability of the post-synaptic membrane

Cholinergic: Refers to cells which use acetycholine as their synaptic

(neurotransmission) transmitter

Clonidine: Clonidine can reduce the release of noradrenaline. It does this by binding with pre-synaptic receptors, resulting in a decrease of noradrenaline synthesis. Very high doses can also influence post-synaptic receptors. Clinically it is used as an anti-hypertensive drug, to treat anxiety disorders, in alcohol withdrawal and an anti-psychotic in schizophrenics.

BACKGROUND

FLOATING STORAGE PRODUCTION AND OFFLOADING VESSELS

The North Sea oil industry is moving to deeper water and smaller fields to find oil. For economic reasons the most efficient way to do this is to use a vessel which is tethered to a riser from the sea bed. These vessels carry out simple processing of the crude oil and store it prior to off-loading to another vessel for shipment to the shore. These vessels are commonly referred to as FPSO's (floating storage production and off loading vessels). They tend to be conversions from existing tankers, survey vessels or special new builds. Unlike normal vessels they have to remain on station in poor weather and pivot about the riser to face into the wind. There is every indication that motions are more unpleasant than a free moving vessel which can make headway to increase stability.

The marginal nature of the fields for which these vessels are being built has led to the use of "fast track" project management techniques. These management methods allow little time for issues raised within the project design and build phase to be addressed before the operational phase is reached.

DESIGN ISSUES

FPSO's are essentially a combination of an oil rig and a vessel. There is large variation in the way these two features have been combined (some are conversions from existing vessels whereas others are special new builds). The combination of two very different structures gives rise to the potential for a number of problems associated with the different designs. These may directly produce problems or they may require personnel to adapt to a novel situation. This is clearly undesirable and every effort should be made at the design stage to eliminate these problems. This initially will require much better communication between the architects responsible for the vessel design and those involved in design of the upper parts of the FPSO. At the moment there is potential for design problems to lead directly to an increase in physical hazards (leading to more trips and falls), to create problems for the process plant and for transfer of supplies and loads, and to impose additional demands that could influence safety critical process monitoring and control tasks. Similarly, unwanted design features may impair emergency response decision making and management performance. The decrements could be both acute (new arrival on the FPSO) and chronic, with a fatigued work force facing greater problems from poorly designed structures and instrumentation.

PROCEDURAL PROBLEMS

Another inherent problem of combining an oil platform and a vessel is that procedures are often very different. For example, different work-rest schedules are often used and there are many differences in how routine day-to-day operations are carried out. Problems may arise, therefore, because of a mismatch between two sets of procedures. Alternatively, if one set of procedures is adopted then at least part of the work force will be using unfamiliar working practices. This, again, has potential consequences for performance efficiency and safety.

In summary, the mismatch between the structures and procedures of the two working cultures (maritime versus process plant) leads to the potential for both direct effects on performance and indirect effects. The latter may be both acute, with new crew taking time to adapt, and chronic, with fatigue increasing the problems associated with unfamiliar (or mismatched) equipment or procedures. These issues are not the main focus of the present report. However, they are obvious areas where standard ergonomic practices can be applied to minimise risk. The next section considers some specific problems known to be associated with motion.

SPECIFIC PERFORMANCE ISSUES

Visual Problems

Movement and vibration leads to images on the retina moving which provides a potential mechanism for visual disturbance. This may occur because the viewed object is moving, the eye is moving, or both are moving. The main consequence of display movement is to reduce the ability to see fine detail in displays (see Griffin, 1992). For a moving person there may be little difficulty with pitch head-motions when viewing a fixed display and no difficulty with translational motion (i.e. in the x-, y - and z-axes) when viewing a distant display. The greatest problems are likely to occur with translational head motion when viewing near displays. Indeed, when both the person and display oscillate together in phase (at low frequencies) problems are less than when either the display or observer move separately. Similarly, changes in display size will often reduce the adverse effects of motion on vision. However, other factors can often increase the size of the motion effect. For example, if you are holding something with both hands and trying to read it then the motion of the arms may results in the display being different in magnitude and phase from both the head of the observer and where they are sitting or standing.

Manual Problems

The extent to which motor functions are impaired by motion will depend on the characteristics of the task and type of motion. Continuous manual control may be influenced by direct mechanical jostling of the hand leading to unwanted movement of the control. This effect may be modified by the design of the control (e.g. the position of the control or the position of an arm rest). Duration - dependent effects of motion require further study as they are likely to be dependent or at least influenced by complex central factors such as motivation and fatigue. The fact that many effects of motion on manual control also appear to be very sensitive to the specific nature of the task being performed also suggests that it is going to be difficult to make strong generalisations about the extent of the problem. Indeed, a combination of tasks analysis and consideration of the influence of non-specific fatigue would appear to provide a useful way forward here.

Motion Sickness

The incidence of motion sickness has been widely studied (see bibliography). The main concerns have been to examine relationships between characteristics of the motion and seasickness, to determine effects on performance, and to assess the impact of antimotion sickness drugs. It is clearly apparent that sea sickness will be prevalent in rough seas. Some individuals will be susceptible even when motion is slight and although there may be adaptation in the short-term there is little likelihood of complete habituation. The sickness can also be very debilitating although less is known about sub-clinical effects or 'after-effects' (i.e. how long before being sick impairments are observed for and the duration of the effects in convalescent). Similarly, caution is necessary in the use of certain anti-motion sickness medications as these can potentially also lead to performance impairments.

In summary, although motion sickness has been widely studied we have little direct evidence on the link between motion sickness symptomatology and performance. Clearly extreme cases will prevent a person from working which may then have an impact on the collective performance of the crew. A worker who feels nauseous but is not actually sick may also be impaired as may be a person who is taking medication or recovering from sickness. These issues are discussed more fully in the section on motion-induced fatigue.

Motion-Induced Peripheral Fatigue

Motion influences postural stability which has important implications for operational efficiency. Again, a number of different effects have been reported. Motion induced interruptions occur and the precise impact of these will be task dependent. Motion induced fatigue (MIF) has also been studied and it has been suggested that one reason for MIF is the extra energy required to maintain balance during work in a moving environment. Indeed, experiments have shown that increases in human energy expenditure were in the region of 15-20% when personnel were exposed to pitch and roll motions (Wertheim et al., 1993). Other research suggests that increases in energy expenditure do not account for the level of perceived fatigue (Wertheim et al., 1994) although this may reflect an underestimation of workload levels in a moving environment by traditional measures of oxygen consumption. Indeed, Bilzon and Rich (1997) conclude that "submaximal work during simulated motion should be expressed as a percentage of VO_2max as measured under stationary conditions without prior exercise. In order to model the MIF phenomenon, other markers and precursors of human fatigue should be considered during valid submaximal work tasks".

Overall, the peripheral fatigue induced by motion is likely to have a large impact on many aspects of performance. Detailed models of this effect have been developed and the generally agreed norm for acceptable working conditions during on eight hour working day is that oxygen uptake during any particular task should not exceed 40% of VO_2max (Evans et al., 1980; Astrand & Rodahl, 1986). However, it should be pointed out that most researchers agree that MIF models require more sophistication. For example, a reduction in muscular activation may be greater following work in a moving environment and this could be incorporated into the MIF model. Fatigue may also be central rather than peripheral (Davis, 1995) and this is considered in more detail later in this report.

FATIGUE

CENTRAL FATIGUE AND MOTION - A POSSIBLE MECHANISM

Fatigue or reduced alertness can be induced in many ways. Physical fatigue is usually studied by investigation of prolonged work whereas changes in cognitive function have been examined in relation to circadian alertness (e.g. having to work at night), sleep deprivation, minor illness and sedative drugs. At a neurotransmitter level it is known that several neurotransmitter systems are involved in changes of alertness. This provides a basis for both global effects and also those which may be specific to certain factors. Indeed, Broadbent (1971) speculated that at least two arousal mechanisms were necessary and this view has been able to account for the profile of the combined effects of different stressors.

Recent research (Smith & Nutt, 1996) has shown that the performance profiles associated with low arousal states can be produced by pharmacological challenge. Volunteers were given the drug clonidine, which reduces the turnover of central noradrenaline. This quickly produces a state very similar to sleep deprivation and the performance impairments produced by the drug were identical to those seen in sleep deprived individuals (e.g. an increase in lapses of attention). Furthermore, it has been shown that loud noise reduces the effects of sleep deprivation and this was also found for volunteers in the clonidine/noise condition. Overall, this shows that reduced central noradrenaline produces an identical profile to sleep deprivation. Further research must now examine which other low alertness (fatigue) states reflect reduced levels of central noradrenaline.

In the case of motion-induced fatigue there is another mechanism that can plausibly account for the low arousal (fatigue). Vestibular stimulation affects the vagal pathway which leads to increased cholinergic stimulation. This is in turn responsible for the nausea and sickness produced by excessive movement. Indeed, many forms of motion sickness medications include scopolamine to reduce cholinergic activation. If motion produces fatigues in this way then it will be of major interest to determine whether this is independent from changes produced in other neurotransmitter systems or whether the central fatigue is a product of the state of all the neurotransmitter systems. At this stage it is best to assume that it will have some similar effects on cognitive performance to other types of fatigue. This necessitates a review of the effects of fatigue on cognitive function. Secondly, it is advisable to assume that the cholinergic system may be especially vulnerable to the effects of motion. This suggests that results from pharmacological studies of cholinergic drugs may be relevant here.

The next section considers some of the other factors which may be related to the extent and nature of fatigue on FPSO's.

OTHER FACTORS INFLUENCING FATIGUE AND PERFORMANCE EFFICIENCY

It is important to consider other factors which will influence performance efficiency and well-being on FPSO's. These will include environmental, social and organisational factors and cover the full 24 hour day and the entire time period spent by the worker on the FPSO.

Important dimensions are likely to include:

- The physical environment
    - motion has already been discussed
    - lighting
    - noise
    - vibration
    - air quality
    - space - dimensions, access, privacy, passage ways
- Organisational factors
    - shifts
    - organisation of teams, manning policy
    - work/rest schedules
    - sleeping/eating/recreational arrangement
- Class of FPSO

- Health status
    - physical health, use of medication
    - mental health, stress

- Prior experience; ability of operators; motivation of work force
- Type of activity
    - situational awareness in complex environments
    - resource allocation, including physical resources and man management
    - monitoring tasks over long periods
    - operation of computer systems
    - galley operations
    - heavy equipment handling
    - routine manual tasks
    - maintenance of complex and routine systems
    - watchkeeping

Tasks may be especially vulnerable to effects of fatigue if there is built in uncertainty that requires continuous alertness to ensure that nothing is missed. Monotonous tasks where the operator has little to do for long periods are also vulnerable to fatigue effects. Demanding tasks, where it is difficult to perceive relevant information, will also be particularly affected by the deleterious effects of fatigue. Tasks involving physical effort will be impaired by peripheral fatigue whereas decision making may be more sensitive to central fatigue. Indeed, it is now essential to review the effects of fatigue on performance to determine whether predictions can be made from the existing literature about the possible effects of motion-induced fatigue on cognitive performance. Before doing this it is important to emphasise that ideally one should consider combinations of factors rather than treating each in isolation. This is discussed in the next section.

COMBINED EFFECTS

There has been previous research on a large number of workplace hazards. These include those arising from the psychosocial environment as well as those due to working hours and physical agents. For the most part the nature and effects of these are considered in isolation. This is not often representative of the real-life situation where employees are likely to be exposed to multiple hazards (e.g. noise, shiftwork, organic solvents). There is limited information on the combined effects of these hazards on health and performance efficiency. Indeed, there have not even been any systematic reviews of the existing literature, no attempt to produce a coherent framework for studying these factors, and a dearth of studies using multi-methods to investigate the topic.

Epidemiological studies have for a long time shown that combinations of hazards are present. However, the usual approach has been to focus on a single factor and to treat others as potential confounders. For example, it has long been acknowledged that jobs with high noise levels also have other features which may lead to accidents (e.g. potentially dangerous machinery). However, instead of looking at the combinations of these factors studies of accidents have tried to identify the variance associated with individual hazards.

Interactions between stressors have been studied in the laboratory for a long time. Indeed, the first systematic review appears in Broadbent's (1971) book "Decision and Stress". This shows that certain factors have largely independent effects whereas others interact. Broadbent interpreted this in terms of a two-level arousal theory, with some variables influencing the lower level and others altering the function of the upper control mechanism. The studies also showed that it was difficult to predict the combined effect of two factors from their individual effects. For example, noise and sleep loss both increase momentary lapses of attention but in combination they cancel one another out (sleep loss reducing arousal, noise increasing it).

The early laboratory studies were very artificial but led to the realisation that combinations of factors needed to be considered in more realistic designs. For example, Monk and Folkard (1985) argue that "such influences (environmental factors), like those of other stressors such as noise and fumes, must be regarded as an integral part of the shiftworker - performance question".

Some areas have been studied in detail because the combination is the defining characteristic of a particular workplace problem (e.g. noise and vibration - see Griffin, 1992). However, even within a particular domain there is still a tendency to consider factors in isolation.

One of the most widely studied combinations has been noise and nightwork. These are both large scale issues and it has been estimated that in the EEC 20-30 million people are exposed to levels of noise equivalent to continuous noise exceeding 80dBA, and that about 20% of the workforce are involved in some kind of shiftwork (Smith, 1990). Results from studies of industrial accidents and absenteeism suggest that noise and nightwork have independent effects (Cohen, 1973). Similar effects have been obtained in laboratory studies of acute effects of the two factors (Smith & Miles, 1985; 1986; 1987a, 1987b).

In addition to physical agents and working hours a number of other features of jobs have been shown to be important (see Cox, 1990). These are summarised in Table 1. It is clearly desirable, therefore, to look at the impact of combinations of these factors on health and efficiency.

Combined effects can also be considered in terms of individual differences (how characteristics of the person modify the effects of a factor). Individual differences may take the form of stable characteristics (e.g. personality; psychosocial characteristics such as social support or coping styles) or more temporary changes in state (e.g. minor illness). The transactional approach to stress (Lazarus & Folkman,1984) argues that the influence of any stressor will be moderated or mediated by a person's psychosocial resources. Such an approach clearly has great potential for the investigation of workplace hazards.

Recent research has also shown that when a person has minor illness, such as a cold, they are more susceptible to factors like exposure to noise (Smith et al., 1993) or prolonged work. This suggests that what is considered safe for the healthy worker may be inappropriate for a person with even a minor illness.

Table 1.

Features of the working environment that should be covered in a study of occupational stressors

Organisational culture: e.g.	· Poor task environment · Lack of definition of objectives · Poor problem solving environment · Poor communication · Non-supportive culture
Role in organisation: e.g.	· Role ambiguity · Role conflict · High responsibility for people
Career development: e.g.	· Career uncertainty · Career stagnation · Poor status · Poor pay · Job insecurity and redundancy · Low social value of work
Decision latitude/control: e.g.	· Low participation in decision making · Lack of control over work · Little decision making in work
Interpersonal relationships at work: e.g.	· Social or physical isolation · Poor relationships with superiors · Interpersonal conflict · Lack of social support
Home/work interface: e.g.	· Conflicting demands of work and home · Low social or practical support at home · Dual career problems

Table 1 cont/d

Content of job/task design: e.g.	· Ill defined work · High uncertainty · Lack of variety · Meaningless work · Under-utilisation of skill · Continual exposure to client groups
Workload: e.g.	· Lack of control over pacing · Work overload or underload · High levels of pacing or time pressure
Work schedule: e.g.	· Shift work · Inflexible work schedule · Unpredictable working hours · Long or unsociable hours
Physical environment: e.g.	· High level of noise · Poor heating/ventilation

FATIGUE AND PERFORMANCE

The technical use of the term fatigue is imprecise. Indeed, the variety of the fatigue inducing situations, the time course and the outcomes, suggest that it unlikely that we are considering a single set of processes leading to a specific underlying state. This makes integration of the existing literature very difficult. A person may feel fatigued, performance may deteriorate and the body's physiological functioning may be affected. These three outcomes, subjective perceptions, performance and physiological change are usually recognised as the core symptoms of fatigue. The condition is usually recognised by the reporting of fatigue and the objective outcomes then assessed. This review focusses on fatigue and performance and there are two important aspects of this. First, how does the fatigue influence continued performance of a given task, and, secondly, will the fatigue have longer lasting effects that carry over to subsequent performance of the same task or another one. The use of interpolated tasks in the field is based on the assumption that after-effects exist and that fatigue may generalise from one task to another. This has important implications for the scheduling of activities. Initially, this review will consider fatigue as a product of continuous work. Following this fatigue induced by sleep deprivation, working at night and produced by minor illnesses will be briefly considered.

A BRIEF SUMMARY OF EARLY RESEARCH

- Early attempts to find decrements in simple mental activities paralleling those observed in physical work found little evidence of fatigue-induced decrements.
- Emphasis then moved towards investigation of complex tasks and changes in the variations and timing of responses.
- These studies led to a focus on fatigue and
    - momentary lapses of attention
    - forgetting of priorities
    - increased riskiness of decisions and responses
    - lowered standards
    - reduced effort.

FATIGUE AND COGNITIVE PERFORMANCE

Early research (reviewed by Craig & Cooper, 1992) showed that it is very difficult to find an effect of fatigue on work using gross measures of efficiency. This cast a serious doubt on the simple mechanical metaphor of mental functioning and fatigue and led to more complex notions. Bills (1931) focused on the occurrence of occasional pauses in a prolonged sequence of fast responses. These 'blocks' became more frequent as the task progressed and errors also tended to occur in the same time periods as the blocks. Fatigue had no effect on the average work rate but did increase the variability of responding. Bills interpreted the blocks as rest pauses, motivated shifts of attention away from the task, and he regarded the fatigue effect to be one of deterioration of voluntary control mechanisms. Indeed, Rabbit (1981) has suggested that both blocks and errors reflect failures of the control process involved in keeping performance at an appropriate speed-error trade-off. Similar results have been found when the effects of fatigue on other tasks (e.g. tracking tasks) have been considered. Overall, these studies show that fatigue leads to periodic reductions in alertness resulting in reduced orientation and an interruption of corrective efforts.

Most of the very early research on fatigue focused on discrete activity tasks. However, military priorities then led to research on the disintegration of complex skills when fatigued. Simulation studies of pilot error led Bartlett (1943, 1953) to the following conclusions.

- Fatigue increases the irregularity of the internal timing of the successive elements of performance that have to be repeated in carrying out the task.
- Right actions might be done at the wrong time
- Appropriate actions might be omitted completely
- Selection of appropriate information deteriorates and there is increased attention to task irrelevant stimuli (discomfort, hunger, etc).

At this point it should be noted that the fatigue effects observed in the simulator were not reflected in an increased number of aircraft accidents with flight time (at least up to 10 hours). Indeed, it has been suggested that feelings of stress or anxiety rather than fatigue were the cause of the performance deterioration in the simulator, and recent work confirms the role of these factors in high workload situations (Hockey & Wiethoff, 1990).

One of the tasks which did appear sensitive to fatigue during these studies of 'pilot error' was the vigilance task. These tasks were designed to mimic military target surveillance and had the common features of sustained attention for the uncertain arrival of a rare event. Research has shown that such tasks are especially vulnerable to the effects of any adverse state (e.g. noise, sleep deprivation, alcohol, drugs - see Broadbent, 1971).

Another finding from studies of prolonged flights was that the fatigue persisted beyond the task itself. This often manifests itself in terms of a trade-off between risk and effort. For example, Shingledecker and Holding (1974) found that a fatigued group showed a lowered preference for a high effort/high probability of success choice. This suggests that a major effect of fatigue may be shift strategies used to do a task. Indeed, a number of studies show that a fatigued person is less reliant on working memory than a fresh, alert person. Operating methods or standards may be changed by fatigue. For example, in a study of air traffic controllers Sperandio (1978) found that fatigue initially reduced the amount of information about each aircraft that was attended to, and then eventually forced the operator to stop working or ask for the workload to be split between operators.

Much of the research on fatigue has been concerned with tasks lasting for a very short time period. Often fatigue is not a problem until normal rest and sleep do not lead to full recovery before the onset of the next set of demands. This may be a major problem for shift workers or those working prolonged hours. The next section considers the extent to which fatigue produced by prolonged work produces similar effects to those seen when the person is sleep deprived, has to work when circadian alertness is low (e.g. working at night) or when the reduced alertness has been induced by a minor illness.

SLEEP DEPRIVATION AND COGNITIVE PERFORMANCE

This topic has been covered in a number of reviews (e.g. Tilley & Brown, 1992). It is relevant to the present report in that (a) motion may impair sleep, and (b) fatigue due to motion may be combined with sleep deprivation induced in other ways.

The main effects of sleep deprivation on cognitive performance are summarised below:

- Many aspects of human performance are quite tolerant to changes in the duration of preceding sleep episodes
- Even when sleep is reduced by as much as 50% for as long as several months a wide range of functions are unimpaired (see Campbell, 1992)
- Sleep at the inappropriate circadian phase is more fragmented, shallower and less restful. This disruption in sleep continuity is more detrimental to subsequent performance than changes in sleep duration
- Sleep deprived individuals are not in an optimum state to attend to, register and process and act upon incoming information
- Attention will wander, information processing will be degraded and responses will be slow or inappropriate
- Other factors which decrease alertness (e.g. long, boring tasks; working at night) are likely to increase the effects of sleep loss
- Factors which increase alertness (interesting tasks; high motivation, caffeine) are likely to reduce the impact of sleep loss
- Performance may be impaired following awakening from sleep due to sleep inertia. This is a problem if sleep deprivation is countered by taking a nap
- Sleep deprivation may reflect poor sleep quality which may lead to the use of sleeping pills. These can have effects on performance the next day.

TIME OF DAY AND PERFORMANCE

People's ability to perform is not constant but shows temporal variation. The exact pattern depends on the type of task being considered. The profile of changes is summarised below:

- Perceptual-motor tasks are performed more quickly but less accurately later in the day. Performance of these is impaired at night
- Tasks involving immediate memory are performed best in the early morning. Working memory tasks are performed best in the middle of the day. Neither type of task is impaired by nightwork

- Retrieval from semantic memory is quicker later in the day. This is impaired at night
- Vigilance tasks are impaired after lunch and at night
- Time of day effects may reflect endogenous rhythms, exogenous factors (workloads; meals) or motivational changes. It is likely to be the combination of these factors and an individual's interpretation of them which determines the nature of the observed time of day effects in performance.

MINOR ILLNESSES AND PERFORMANCE

- Minor illnesses, such as the common cold, can influence performance efficiency (see Smith, 1992, for a review). The effects depend on the nature of the illness and the type of task being carried out. The effects of upper respiratory illnesses can be summarised as follows:
- Influenza impairs performance of tasks where the person is unsure where or when a signal will appear.
- In contrast, colds impair psychomotor performance slowing the speed of response and reducing hand-eye co-ordination.
- Effects are not restricted to the time a person is symptomatic. Performance is impaired prior to the development of symptoms and can persist into convalescence.
- Minor illnesses make individuals more susceptible to the effects of other factors such as prolonged work or noise. This means that recommended safety limits, based on data from healthy subjects, are inapplicable when the person has a minor illness.

OTHER INFLUENCES ON PERFORMANCE

Most research has considered the effects of different factors in isolation and yet in the real-life situation it is likely to be the combined effects which are crucial. Little is known about the different combinations of factors likely to be encountered on an FPSO and this is clearly an important topic for further research.

POTENTIAL EFFECTS OF MOTION-INDUCED FATIGUE AND OTHER FEATURES OF FPSO's ON COGNITIVE PERFORMANCE: OVERVIEW AND SUMMARY

The present report has identified a number of areas which may influence performance efficiency on FPSO's. The nature and extent of these will vary from one vessel to another. There is also no existing literature that predicts the magnitude of the effects. However, it is safe to assume that they may be at a level where operational efficiency and safety is endangered. It is recommended, therefore, that further research into the scale and costs of the following effects is conducted:

- Problems associated with the design of the vessel
- Problems associated with the combination of two different working cultures
- Visual problems associated with motion
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Further research should consider both acute and chronic effects of the above factors. The outcomes should include both performance of individual operators and also group performance. Special attention should be paid to safety critical operations although it is also important to monitor performance of more routine work as well. The extent to which problems are generic or context specific also needs detailed consideration as this will allow identification of the best preventative and therapeutic solutions.

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