Acute Mental Fatigue And Cognitive Performance In The Medical Profession

A thesis submitted by

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Dedicated to Gill, Jess and Chris. For the patience and understanding.
Abstract

Fatigue induced deterioration in cognition has significant implications for working practice within the National Health Service. Although attitudes are changing, few safety measures have been implemented to reduce fatigue related error. The World Health Organisation Operative Checklist is one error prevention strategy developed to address error preoperatively.

With rising negligence costs (1) there is an argument for error rates persisting, if not increasing, despite the European Working Time Directive (EWTD). Although work hour limitations have attempted to be met by employers, the ability to take four hourly breaks is not easily manageable or regulated due to impingement by patient care. Requests by employers for staff to opt out of the EWTD have occurred due to the system being unable to function within the directive. Fatigue caused through variations in circadian rhythms is not accounted for by the EWTD.

Fatigue is a recognised cause of memory lapses, impaired communication and judgement. Individuals can experience emotional blunting, lapses in attention and experience difficulty in maintaining focus. Public complaints reflect the aspects of care that they see. The fatigue related breakdown in inter-personal skills is certainly a contributing factor.

Clinical information forms the basis for decisions on which we act. Inaccurate information, uncertainty in our recollection or inability to recall important facts can place patient safety at risk. This thesis investigates the impact of fatigue on the recall of clinical information in the non-sleep deprived state. Chapter 1 is the introduction.
and discusses the principles of the National Health Service (NHS) and why acute mental fatigue should be prevented. Chapter 2 introduces the concept of “memory” and the theories to its mechanism of action. It provides background on the approach to improving the recall of information. Chapter 3 is a systematic review of Acute Mental Fatigue in the non-sleep deprived state and highlights the impact of fatigue within healthcare organisations. Chapter 4 describes neuroenhancement and reviews the pharmacological agent Modafinil, discussing its possible applications for use in cognitive fatigue. Chapter 5 is a survey to provide background levels of fatigue in NHS doctors post EWTD. Chapter 6 is a randomised crossover study investigating recall of clinical information in the mentally fatigued, non-sleep deprived state. The subsequent Chapter 8 and 9 develop cognitive and pharmaceutical intervention strategies to improve recall of clinical information. Chapter 8 investigates the recall of clinical information after a working day in a randomised crossover study comparing a computerised handover checklist (using cognitive cues) to current handover methodology. Chapter 9 compares neuropharmacology to cognitive strategies of cue based recall to enhance recall of clinical information.

Finally, the discussion in Chapter 10 reflects on the strengths and weaknesses of these studies and possible implications for the clinical practice.
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Statement of Originality

I certify that this thesis and the research to which it refers are the product of my own work, and that any ideas of quotations from the work of other people, published or otherwise, are fully acknowledged in accordance with the standard referencing practices of the discipline.

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Objectives

1. To determine fatigue within different healthcare organisations.

2. To determine the impact of acute mental fatigue on healthy individuals in the non-sleep deprived state on the recall of clinical information.

3. To determine if cue based recall intervention strategies can improve the recall of clinical information.

4. To determine if the wake promoting agent, Modafinil can improve recall of clinical information in acute mentally fatigued, healthy individuals in the non sleep deprived state.
Chapter 1  Introduction

Healthcare provision in the United Kingdom is defined by a formal constitution (2) that was recommended in ‘High Quality Care For All’, a ten-year plan first published in June, 2008 (3). Prior to this process, it had evolved through Common, English and European Union Laws.

One of the guiding principles of the constitution is that the National Health Service (NHS) aspires to the highest standards of excellence and professionalism – in the provision of high quality care that is safe, effective and focused on the patient experience’. Further to this, it defines rights concerning the ‘Quality of Care and Environment’. In this, patients are entitled to ‘treatment with a professional standard of care, by appropriately qualified and experienced staff in an organisation that meets required levels of safety and quality’.

With fatigue related error increasingly prominent in the literature (4-6), one questions:

- ‘Is enough being implemented to prevent, if not inhibit, the effects of fatigue on patient and worker safety?’

It is interesting to note that the final stage of the European Working Time Directive (EWTD) (7) was implemented in the same year as the NHS Constitution’. It defined 48 hours as being the average working hours limit per week, over a 26-week reference period. The EWTD was instigated in an attempt to prevent excessive working time
being cited as a major cause of stress, depression and illness, some of which could be considered to be fatigue related (8).

The attempt to limit work hours to improve workers health and by inference reduce fatigue related effects, although laudable, had profound impact on healthcare within the NHS. Rota re-organisation led to a move towards shift work and concerns were raised regarding reduced training hours(9,10). It is interesting to note that, today, only six years after full implementation, NHS facilities frequently provide ‘opt out’ documentation for workers to sign that excludes the 48 hour work legislation limit (by increasing it to 56 hours) but not other aspects of the working time directive. Staff have increased exposure to effects from shift work, arguably reduced training (compared to pre-EWTD), but also increased work hours compared to EWTD defined standards.

Healthcare worker fatigue has significant implications for the provision of care services in the UK. It could be argued that current assumptions are that fatigue and sleep deprivation are synonymous. Thus, the EWTD is the predominant drive to reduce fatigue related effects and improve workers health. This is not helped by the fact that ‘tiredness’ is used to describe both effects outside of, and at times inaccurately within, the scientific community. Combined with the lack of a globally accepted definition of fatigue, this creates a dysfunctional approach to its management. Although symptoms of sleep deprivation overlap with fatigue, fatigue is a process that can resolve with rest, as well as sleep.

The EWTD addresses sleep deprivation (and fatigue) through the limitation of the number of hours of continuous work (11 hours continuous rest in 24 hours), limitation
of ‘time on task’ effects through the prescription of 20-minute breaks after six continuous hours of work, and defines a maximum number of hours that can be worked in a single shift. The circadian effects upon cognitive function and job specific task effects that induce fatigue are beyond the directive to police.

The airline industry has implemented ‘Fatigue Risk Management Strategies’ (FRMS) in recognition of the cumulative effects of fatigue. The pre-flight checklist is an example of an FRMS system. Flying is considered to be one of the safest methods of transportation, which is not a result of chance. An error during a flight may have profound safety consequences, thus error prevention strategies are paramount within the industry. Unfortunately, commercial interests regularly oppose current fatigue management strategies, due in part to the methods of fatigue reduction, for example, reduced flight hours. This would significantly increase staffing costs and the profitability of the company in a competitive global market. As such, fatigue management needs to be regulated at the highest level of governance - international levels for aviation, to maintain corporate competition.

With safety in mind, the European Aviation Safety Agency was established in 2003 by the European Union, in order to regulate safety across Europe. It is interesting to note that new regulations to harmonise flight duty times and rest requirements across the European Union created objections by pilot unions. In the UK, the regulations increased the possibility of continuous flight hours to a maximum of 22 hours, and lowered the standards set by the United Kingdom regulatory body. Maximum hours that are worked in 7 days are increased from 55 to 60 hours. The maximum rolling flight hours for a 12 month period was recommended to increase from 900 to 1000 hours.
The medical profession is frequently linked with the EWTD. There is no European Governing body that controls the equivalent of the General Medical Council in the United Kingdom. Such imposed regulation would be strongly resisted especially if it lowered safety requirements, thus opposing the constitution. Equally the structure of the NHS is markedly different from international equivalents. Thus, regulation for fatigue in the medical profession would currently need to be driven at a national level. The difficulties with locally driven fatigue reduction programs are similar to that in the airline industry. With Primary Care Trust’s (PCT’s) awarding contracts for work, there is competition for efficiency and cost reduction. Unless near miss events lead to administration reassessment of a local hospital pathway, there will be little impetus for change.

The limitation of flight hours in a twelve month period is an interesting concept. This has not been considered by the medical profession, arguably with due reason. The concept of trying to limit the amount of continuous flight hours without a rest period is inherently understood, as it attempts to limit acute flight fatigue. However, there is little evidence to implement a twelve-month limitation, and one could argue the concept of the proverb ‘practice makes perfect’. An evidence-based approach to error management for fatigue is essential. There is a significant contrast to ruling that a pilot can perform 55-60 hours of duty in a week but a maximum of 900/1000 hours flight in twelve months. It is also interesting to note that two of the key industries reliant on safety, aviation and healthcare, now seem to be exempt from the EWTD 48 hours work legislation.

Societal expectations are of high quality care for all, 24 hours a day. Failure of this provision is becoming costly in our increasingly litigious society, with rising costs to
the NHS (1). Until recently, fatigue related effects have had little emphasis in the
development of quality of care. Previously, emphasis has been placed on drives for
reducing times for high quality treatment. In some instances this has been successful,
by improving efficiency through system re-organisations of out dated methods and
streamlining services. However there has arguably been an increase in workload as a
result. This contrasts with work conditions necessary to prevent fatigue.

Currently, there is no defined level of fatigue that can be used to assess the NHS
workforce. We do not have the evidence to identify when a worker becomes a risk to
himself or herself or the patient. There is no objective assessment system that can be
implemented to monitor the fatigue process and subjective assessments are
insufficient.

Innovative equivalents to the FRMS in the airline industry are few in number within
the medical profession. However, some examples of error prevention do exist, for
example the ‘World Health Organisation (WHO) Surgical Safety Checklist’ (11). This
was a national implementation in an attempt to improve patient safety and reduce
error (possibly fatigue related) in the operating theatre.

In a publicly funded healthcare system that is becoming increasingly scrutinised by a
society that finds it unacceptable for the occurrence of preventable error, further
development of fatigue reduction error avoidance systems should be considered.
Fatigue induced error has been identified as a key target in patient safety and error
preventions strategies (4), in particular at handover where important information is
disseminated from ‘out going’ to ‘on coming’ medical personnel. To improve the
handover process, one must understand cognition and the influence of fatigue. The
following chapter discusses the concepts of memory, information recall and how through the understanding of this process, we can apply cognitive psychology to improve handover.
Chapter 2  Memory

In order to understand how fatigue influences the recall of information, it is important to understand the process through which memories are created. This chapter gives a brief overview to the cognitive psychology of memory. Thus we can develop strategies that target specific aspects of memory in an attempt to improve information recall and dissemination in an effective, safe, fatigue resistant manner.

Recall is one of three key processes in memory. One must first encode information for storage prior to recall. With evidence that dissemination of clinical information to medical personnel is at high risk of error or emission of important information (12), especially if fatigued, patient safety is of concern. It is therefore imperative that new approaches to information recall and error production are explored.

Encoding of memory occurs when an individual identifies an item of information that they wish to remember. This information is converted into a ‘construct of biochemical information’ able to being stored within the brain. Storage of information occurs if information is required for a prolonged time period.

2.1  Multi-store Model of Memory

The Akinson Shiffin Model of Memory (1968) (Fig. 2-1) is one explanation of the memory process. It is the concept of the flow of information through a system and describes three distinct types of (sub-memory) storage. This multi-store model of memory has been adjusted since its original conception to include ‘Sensory memory’. There are as follows:
a) Sensory Memory
b) Short-Term Memory
c) Long-Term Memory

Figure 2-1: The Multi-Store Model Of Memory

The Multi-store Model of Memory depicts the flow of information through a system. Information is transferred from Sensory Memory (outside of cognitive control) to the low capacity Short-Term Memory. Information requires mental rehearsal to be maintained in Short-term memory otherwise it will be displaced/forgotten. Information that is not discarded or lost in short-term memory can be transferred in to Long-Term Memory for storage.
2.1.1 **Sensory Memory**

Sensory memory is of short duration and considered to be an automatic response outside of cognitive control. It consists of large quantities of high-resolution sensory information that is modality specific. Thus storage for Visual stimuli is in ‘Iconic Memory’, auditory stimuli are in ‘Echoic Memory’ and tactile stimuli are in ‘Haptic Memory’. This detailed information can be extracted and processed by the Short-Term Memory system. Sensory Memory is not involved in higher cognitive functions such as consolidation of information and as such will not be discussed further in this thesis.

2.1.2 **Short-Term Memory**

Short-term memory is storage of immediate past memory for a short duration of time. It subsequently degrades, becoming inaccessible. The exact time period of retention of information is variable and dependent on information type. In 1959, the degradation of short-term memory was demonstrated to occur within 5-10s when participants were prevented from rehearsing information (13). More recently, Muter *et al* (14) have shown that most items of information are forgotten within 4 seconds if the individual is not expecting to be tested.

The capacity of short-term memory was classically described as 7 +/- 2 pieces of information (15). This popularised number was initially produced for a one hour presentation with the + or - 2 demonstrating some error in the ‘magic number’. However it did highlight important evidence for the newly developing field of cognitive psychology. This suggested that the estimate of 7 items of information
could be stored in the immediate consciousness of an individual and was a significant step in the psychological field.

Memory was observed to retain up to seven ‘chunks’ of information where a chunk is the largest meaningful unit of the information provided. Chunking is used by short-term memory to keep groups of information accessible for easy recall. The more familiar the individual is with the information, then the better the information storage works.

Under circumstances where a chunk of information is a single item, and rehearsal of information is prevented (e.g. by the verbal repetition of a meaningless phrase during testing) again the number is of items retained is approximately 4. Currently the implication of this research is that there is a time limitation to short-term memory storage, with a limitation to the number of chunks of information. Baddeley et al (16) have shown that lists of words that required an increased amount of time to pronounce had inferior recall compared to shorter, thus quicker to pronounce, word lists. It would take an increased amount of time for the longer words to be mentally recited. Time limited storage of information is an important part of the theory of working memory.

Research suggests that short-term memory recall of information is dependent on the type of information presented – span is approximately 7 for digits, six for letters and five for words (17). ‘Chunking’ is used to group information in short-term memory so that it is easier to recall.

Although the number of chunks appear to be limited for unfamiliar information, there have been demonstrations that have shown significant improved recall with training.
(15). If there is enough knowledge to back up the individual on the topic of study, a large quantity of information can be stored in the immediate memory. This was demonstrated in a student who was trained to increase his digit span recall from the usual approximation of 7 to 80 digits over a 1-year period. The participant initially improved to repeat 20 digits presumably from 5 or 7 chunks of information, but later developed the ability to create ‘super-chunks’ that when combined allow the recall of 80 digits of information(18). This ability is usually restricted to the type of information presented.

2.1.3 Long-Term Memory

If information is not discarded or lost by short-term memory, it can be transferred into ‘Long-Term Memory’. Long-term memory is the continuing storage of information by the brain. Consolidation is the transfer of recent short-term information into long-term memory. It takes a much longer time period for information to be lost from long-term memory’ (i.e. days to decades).

2.2 Difference between Short and Long-Term Memory

Short and long-term memory may differ by duration and the capacity of information stored. The reasoning for the distinction between the different types of memory is that information in short-term memory will decay over time without active use. With a capacity limit to the amount of information stored, then information cannot remain for an indefinite time period without being displaced by new information.
The Working Memory Model (19)

The Working memory model (Fig. 2-2) uses the multi-store memory model as a starting point prior to redefining short-term memory. This is termed “working memory” which is used not just to describe passive short-term storage memory but also the manipulation of information. The original model comprised of three components:

a) The Central Executive

b) The Phonological Loop

c) The Visual-Spatial Sketch Pad
The Working Memory Model depicts the short term storage and manipulation of information. The model originally composed of:

- **The Central Executive** is the control centre for information processing.
- **Phonological Loop** is the temporary storage of auditory information.
- **Visual-spatial sketch pad** is the recollection of images.

With the **Episodic Buffer** being added to explain storage and co-ordination of information.
The Central Executive

This is a control centre for the co-ordination of the “phonological loop” and “visual-spatial sketch pad” (slave systems). It processes information but has minimal storage capacity. It has been linked with attention, and the regulation of time allocation between tasks when multi-tasking. Answering a question whilst operating is thus stretching the central executive.

The Phonological Loop (slave system)

This is a temporary storage of auditory information. Baddeley et al (16) suggested this capacity is of approximately 2 seconds. Thus it can hold more shorter than longer words. An example of this process is when you are asked a question whilst being distracted. You are able to recall the question without it being repeated.

The Visual-Spatial Sketch Pad (slave system)

This stores visual information and is also of a limited capacity. It involves the recollection of images to a sketchpad in the memory. An example is when asked where an object was situated you would picture the object and its position prior to answering.
2.2.1 Episodic Buffer

An amendment to the theory of the working memory model was made by Baddeley (20) to explain the need for storage and the co-ordination of information from the previous three components and working memory. This fourth component was termed the “episodic buffer”.

Evidence from PET scans do corroborate the theory of a multi-component system (21). This model is the focus of current research and may undergo refinement in the future.

2.3 Levels of Processing

Initially proposed by Craik and Lockhart in 1972 (22), the Levels of Processing theory (Fig. 2-3) focuses on the understanding of what is perceived. It does not consider different memory stores. The focus of the theory is that of that of the depth of processing of the stimulus and its analysis. The deeper the processing or analysis of the information, the stronger the memory link and thus improved recall capability.

Information was originally proposed as being extracted from a series of levels of increasing depth of analysis. Thus increased understanding is extracted with increasing depth of analysis. When initially exposed to an item of information, there would be a shallow level of processing with the formation of a basic structure of the
Figure 2-3: Levels of Processing Theory

- **Structural processing** is the encoding gained from the appearance of the stimulus (i.e. the orthographical appearance of the word).

- **Phonological processing** is the encoding gained from the sound of the stimulus (i.e. the sound of the word).

- **Semantic processing** is the encoding of the understanding gained from the stimulus, relating it to similar words with similar meanings.
information interpreted (structural processing) or from the basic sounds of the wording involved (acoustic processing). A deeper level of understanding may then be achieved when processing the information (semantic processing).

The amount of memory retention is dependent on the level of understanding gained at the time of the encoding of the memory. This is the main prediction of the Level of Processing theory. Thus meaningful material is more memorable than non-meaningful material due to the level of processing that was performed. As a result the amount of information recalled can be predicted by the level to which processing has progressed. This theory suggests that information must be processed prior to storage in long-term memory. It argues that maintaining of information in consciousness or simple repetition of information is not sufficient for long-term storage of information.

The Levels of Processing theory has required amendments since it was initially proposed. Craik and Tulving (23) amended the theory suggesting that instead of a sequential process, structural, acoustic and semantic processing occur in parallel, with semantic processing allowing for the elaborate encoding of information, unlike the non-semantic forms. Elaborative encoding is the formation of associative connections with other memory traces. This occurs in its most effective form with meaningful associations taken from the information that is supplied. Semantic encoding creates stronger associations with a more lasting trace (23,24). The concept of elaborative encoding is that the semantic process creates a large number of links associated with items already in long-term memory. This link becomes incorporated within the network of memory traces each of which acts as a potential activation point for the retrieval of the new information. Thus, there is an increased ease in access of the new
information through the strengthening of the inter-item associations and creation of more retrieval routes by elaborative encoding (25).

From the clinical perspective this has implications for dissemination and retention of information by clinical staff. Depending on seniority, a registrar may retain different information compared to a house officer, due to the level of processing, prioritisation and selection of relevant information. This will effect recall and dissemination of information.

2.4 Classification of Long-Term Memory

Long-term information can be divided into two types:

a) Declarative (Explicit) Memory

b) Procedural (also termed Non-declarative/ Implicit) Memory

2.4.1 Declarative Memory

Declarative Memory is the conscious recollection of information concerning facts and events. It is information that can be explicitly recalled. It can be sub-divided into episodic and semantic memory.

- *Episodic memory* contains autobiographical information that can be recalled at any point throughout our lives. It is the recollection of events that have occurred and the experiences felt at the time.
• **Semantic memory** refers to facts and the understanding of concepts and knowledge that are independent of personal experience. Semantic memory can be derived from episodic memory but is transferred losing the emotional connection. Examples in surgery are being able to distinguish between an inguinal or a femoral hernia, or the difference between laparoscopic instruments. Semantic information can be supported by episodic memories.

### 2.4.2 Procedural Memory

Procedural Memory is the unconscious memory of skills and performance of tasks, i.e. surgical knot tying. These sensorimotor behaviours are deeply embedded to the point that no conscious effort is required and one is able to automatically perform the task. The subject implicitly knows how to perform the task. These can be through previous learnt experiences.

### 2.5 Temporal Direction

An alternate classification for long-term memory is by temporal direction:

a) Retrospective memory

b) Prospective memory

• **Retrospective memory** can therefore contain semantic, episodic, and autobiographical information. It can be Implicit or Explicit.
• **Prospective memory** is future intentions that can be event or time based. These can be triggered by memory cues, time based, for example a 10am Doctor’s appointment, or event based intention cue, for example on passing a chemist – need to collect prescription.

### 2.6 Ebbinghaus Forgetting Curve

The first memory experiments started with Ebbinghaus in 1885. The experiment used nonsense syllables to assess the rate of forgetting.

The forgetting curve represents the degradation of memories with time (when there is no attempt at retaining it). The speed of forgetting is dependent on the information leant (how meaningful), its representation and physiological factors such as stress and fatigue. The initial rate of forgetting occurs rapidly prior to a gradual levelling off in the recall of information (26) (Fig.2-4). This is important when considering recall of newly acquired clinical information at handover, especially when fatigued. Information that is deemed less clinically relevant is easily forgotten.
2.7 Process of Recall Theories

2.7.1 Two Stage Theory

This theory attempts to clarify the superiority between recognition and recall memory by describing a two-stage process of memory retrieval as follows:

- **Recall memory** requires a search and retrieval process followed by the identification, *recognition*, of the correct information required.

- **Recognition memory** therefore only requires a single process (27). Although Recognition is regarded as generally being better than recall, this is not an
absolute process, with a word sometimes being recalled at a later time point when it was initially not recognized (28).

2.7.2 Encoding specificity

The ability to retrieve information from memory is dependent on the specificity of the cue in matching the stored memory trace. The concept was developed by Tulving (1972) (29) and termed the ‘Encoding Specificity Principle’. It proposes that the cue for retrieval of information will only be successful if it contains some of the same specific information as the original input. Hence, the amount of ‘feature overlap’ between retrieval cue and the input determine the chance of obtaining the desired memory trace. Elaborative processing increases the likelihood of feature overlap and memory trace retrieval.

The closer the match of a retrieval cue to the original item of information then the more likely that the subject will be successful in locating the desired memory. For example, if the original input was acoustic, then acoustic tasks are superior in retrieving the desired information. This is ‘Transfer Appropriate Processing’ and arguably provides evidence for the Levels of Processing theory and elaborative encoding principle (Lockhart 2002). The deeper the Levels of Processing, the more likely it is to be transfer-appropriate.

It is interesting to note that the medical profession is generally resistant to a proforma led approach due to concern regarding loss of cognitive flexibility when treating patients (30). There is an argument that each patient requires their own management plan and therefore should not be checklist driven. However, it should be acknowledged that when we consider any treatment pathway we are automatically
following a checklist pathway from our memory for specific therapies for an identified condition. The process is more fluid than a paper version of a checklist but it follows the same principle. The reluctance towards checklist implementation may arise due to disagreements over the need for prompts to guide management (31) or whether checklists will prevent errors (32). This is understandable, but when we consider Levels of Processing theory and patient safety we should not be relating this to the most experienced individual. It is these individuals who are able to retain information and retrieve trace memories. They are more likely to use elaborative processing when presented with the information by the patient. When confronted with patient safety we need to consider the whole of the workforce and those who are likely to treat the patient and instigate initial basic investigations and management. It is this aspect of the workforce that is likely to have a reduced depth of processing and elaborative processing. From this theory it would be my opinion that their recall of information would be less and subsequently would have a reduced ability to access the desired trace memories. When implementing a cued recall strategy we must therefore encompass this aspect of healthcare professional along with the more experienced group. The system is only as strong as the weakest point in the process.

2.8 Memory Retrieval

Recall memory is the re-accessing of information that has previously been encoded and stored within the brain. This process stimulates the brain to reactivate a series of neural pathways that were created when the original memory was formed. These pathways are not limited to a single area of the brain but in multiple areas of the brain linked by neural networks. Retrieval of the memory could be considered as retrieving
parts of a jigsaw puzzle rather than the information being on a single page in one location.

From the Levels of Processing theory, recall of information relies on the strength of the memory pathway that was formed when encoding the memory. The weaker the link, the more difficult the retrieval of the information. Recall returns information for use in short-term memory. Once the purpose for the retrieval of the memory has occurred the information is re-encoded back into long-term memory, consolidating the information and strengthening the neural pathway.

Memory retrieval does not rely on the sequential scanning of information method of data retrieval used by a computer system. The majority of information is recalled by direct retrieval of information. Other aspects of information retrieval rely on hierarchical inference where a specific question is linked with a group of facts about the required information point.

There are two main methods to access memory – recognition and recall.

### 2.8.1 Recognition Memory

‘Recognition Memory’ is considered superior to ‘ Recall Memory’ for the retrieval of information. This is due to it involving a single process familiarity decision regarding the object of study. This contrasts with recall memory where the two-stage theory of memory states there must first be a search, and then a retrieval of items of information before the selection of the correct piece of information. Unlike Recall Memory,
Recognition memory does not require the full activation of all of the neural pathways that were created during the consolidation process.

2.8.2 Recall Memory

This form of memory involves direct retrieval of facts, events or items of information that are not physically present. Recall can be classified into three types:

2.8.2.1 Free Recall

Free recall can be classically described as a list of items an individual has been asked to recall in any order without any aids for recollection. ‘Primacy’ and ‘Recency’ effects are often displayed. Primacy is where an individual remembers items towards the beginning of the list earlier and more often, whereas Recency is when items towards the end of the list are displayed earlier and more often. This is the serial position effect (33) where recall accuracy varies with the position of the information on the list. Recency seems to occur prior to the primacy effect. Middle words are least recalled.

2.8.2.2 Cued Recall

Cued Recall occurs when the brain receives a clue to assist retrieval of the required information. To be an effective stimulus the cue must relate to the way the subject interpreted them at the time of consolidation. An example of this is if one was to interpret the word ‘foot’ as a distance, one would not immediately associate the word
to the cue ‘toe’. However, if the interpretation of ‘foot’ was anatomical, then the stimulus would be a helpful cue.

Cues can be more subtle. The interpretation of an event can also lead to recall the correct information. Winter and Uleman (34) demonstrated that the cue word ‘helpful’ was able to stimulate recall of the statement “The librarian carries the old woman's groceries across the street”. This type of association is termed trait inference and demonstrates the complexity of the process of encoding memory. What is inferred at the time of encoding can significantly affect recall of information at a later time point.

### 2.8.2.3 Serial Recall

Serial recall memory is the recollection of information in the particular order in which they occurred. This is important for the recall of autobiographical memories and appears to occur in a continuum extending from most recent memory. The more recent the memory the easier it is to recall.

There is a difference in serial recall in short and long-term memory. For consolidation to occur, the sequence of information needs to be repeated until the list of information is stored as a single unit. The interrelationships between the individual items of information do not therefore need to be remembered. For serial recall in short-term memory, one theoretical method relies upon the inter-relationship and position of the items of information recalled. A second method of recall relies on associations between the items of information; this is referred to as ‘chaining’. In medicine, one could describe the associated description of pain as chaining if given the cue for
appendicitis. There is the immediate description of a constant, migratory pain from the central abdomen to the right iliac fossa. There are multiple points of information contained in the single sentence associated with the primary cue – hence a chaining effect.

Immediate serial recall from short-term memory has been demonstrated to be better if it contains related information (35). This is termed “homogeneous conditioning” and (for example) is used by clinicians when recalling patient information. Baddeley et al (36) have demonstrated that words which are similar or dissimilar in sounds are recalled differently by immediate short-term serial recall, with similar sounding words having a worse recall rate (suggesting short-term memory coding is acoustic not semantic).

As with free recall, serial recall is susceptible to primacy and recency. Increasing list length also reduces the ability to recall the information, along with shorter words recalled more accurately than longer words.

2.9 Checklists and Cognition

The concept of ‘getting the basics right, first time, every time’ was introduced to the NHS by the review ‘High Quality care for all’ (3) linking safe care with effective care. This concept is a key principle for checklist implementation in healthcare, where avoidance of errors can reduce morbidity and mortality through improvements in patient safety. In surgical practice, the concept was demonstrated by the WHO Surgical Safety Checklist in 2008 (11). Significant improvements were identified
indicating that substantial differences can be made when implemented appropriately (37). Checklist implementation in the workplace is aimed at addressing common safety issues through the improvement in team situational awareness, dynamics and communication.

Checklists use a combination of recognition and recall memory to ascertain accurate information in an attempt to reduce error. The use of information cues presented in a specific format to the participating medical team by design, removes the need for free recall of information, shifting information to a cued recall response or that of recognition memory, if a confirmatory response is required to the information provided.

With evidence emerging that checklists have wider applications within healthcare (38), high risk, error prone procedures would be appropriate areas for further investigation for the suitability of checklist implementation. Hence, one could consider the dissemination of critical patient information at handover where outgoing medical staff are at risk of experiencing acute mental fatigue, an appropriate area for further study. This thesis attempts to apply cognitive psychology to the recall of clinical information in the state of acute mental fatigue, and the influence of recognition memory and cue based recall in handover.

2.10 Stimulants and Memory

Fatigue management strategies can involve the intake of caffeine or other legal stimulants to resist degradation in cognitive performance (39). Recent developments
have been in the conscious application of neuropharmacology, such as Modafinil, to improve the cognitive state (40). These waking promoting medications can improve alertness when fatigued and have been demonstrated to improve cognitive performance (41). The relevance of neuropharmacology is discussed in Chapter 4. How the medication compares to non-pharmacological interventions in improving recall of clinical information is unknown. This will be explored in Chapter 9.

2.11 Application of Cognitive Psychology to the NHS

By understanding the concept of memory, its relevance to working practice is apparent. It is possible to use methodologies in the work place to improve the transmission of key information between individuals. In the NHS, good communication between medical professionals, for example at patient handover, is paramount to patient safety. Poor communication or errors in the transmission of information can impact upon patient care (42,43). One must consider that it is not just the encoding, storage and recall of information by the fatigued worker handing over the information, but the receiver has to perform a similar process in a short time for information that is required throughout the shift.

Equally but less recognised is how the recipient of the handover encodes and consolidates the information for future recall. This recall is usually a free recall process or may involve cues from a handover sheet. There is little evidence for what items of information are required for adequate cues for the recall of patient information. This is currently being performed inefficiently at a subconscious level. Errors in patient handover are compounded by the fact that the transmission of
information is usually by a fatigued staff member at the end of their shift (4). One must therefore consider not only what interventions can improve recall of information but also whether it is effective in the fatigued state. A broader review of fatigue and its impact on working memory will be discussed in the next chapter.
The lack of consensus within the scientific community and the inability to create an agreed definition of fatigue and its causation is an inherent problem in the detection and management of fatigue within society. Fatigue is typically defined as extreme and persistent tiredness, weakness or exhaustion—mental, physical or both (44). Fatigue can be acute or chronic. It is exhaustion triggered by stress, medication, overwork, illness or disease.

Epidemiological studies have indicated that between 20% (45) and 24% (46) of the US population have reported fatigue. The prevalence rate of fatigue was found to be 22% in a Norwegian study (47) and 18% in the UK (48). A higher proportion of females are affected by fatigue than males.

Acute fatigue is a normal, reversible, phenomenon that resolves after a period of rest or through a reduction in the intensity of the task performed (mental or physical). The impact of fatigue on society is frequently overlooked. At a single point in time, whether the fatigue is acute or chronic does not negate the importance of the fact that the individual is physically or mentally impaired. Within a working environment, workers who are in an acute state of mental fatigue are at a higher risk of errors, placing their safety, that of their colleagues, and in the medical profession, patients, at risk (4,49,50). Perceived work based fatigue is recognised in industry to reduce productivity and more recently it has been gaining recognition within the healthcare profession as a detrimental effect on staff performance.
3.1 Why is fatigue important?

The higher cognitive processes of an individual can be regarded as being a limited resource. Exposure to tasks that involve a high mental workload can impact upon and cause, the temporary depletion of these processes. Prolonged, low stimulus, monotonous tasks can also cause an effect. It is this resource depletion that creates the symptoms of mental fatigue. It is generally accepted that fatigue causes overall effectiveness to be reduced through compromised problem solving, memory lapses, impaired communication with slow or faulty information processing and judgment. There is also a reduced motivation, irritability, impaired communication with indifference and loss of empathy (51). The focus and attention of an individual can be significantly impaired by fatigue causing reduced vigilance. The reduction in vigilance can also be demonstrated through the increase in lapses of attention (52). Mental fatigue causes a reduction in goal directed attention. The decrement in the ability to concentrate and focus on a task, i.e. increased distractibility, can lead to a stimulus driven attention response (53).

When performing a task, the deterioration in attention over time is known as the time-on-task effect. The rate of deterioration of the time-on-task effect is variable between individuals. Fatigue related effects are not task specific, but persist for any task requiring the same cognitive functions (54).

The resting level of neural activity may determine the vulnerability to fatigue, with dopamine being one of the resources affecting this. The level of the Dopamine Receptor Gene DRD4 has been linked with the subjective feeling of energy depletion (an aspect of fatigue) (55). DRD4 has also been linked to Attention Deficit Hyperactivity Disorder, a condition where attention is impaired.
3.2 Testing for Fatigue

Objective markers for fatigue are scarce (52). Currently measurements are impractical for routine testing of fatigue and would be inappropriate for use at work for fatigue detection and assessment. Current methods of detection have involved the use of Electroencephalography (EEG) (56), Event Related Potential (measured by EEG) and Electrocardiogram (ECG) (57). The EEG can detect differing levels of alertness, an aspect of, but not unique to fatigue. Similarly, ECG changes can be detected to indicate a fatigue process is occurring.

Flicker fusion eye frequency has been used to assess the degree of fatigue (58). The participant is exposed to a flickering lamp with its frequency increasing until the flickers appear to fuse into a continuous light. The frequency that this occurs is called the critical flicker-fusion frequency (CFFF) and decreases in this measurement can be used to indicate fatigue.

Psychomotor tests, an example of which is the Psychomotor Vigilance Task (PVT), can be used to assess the fatigue state. The PVT is a sustained-attention, reaction-timed task that measures the speed of a response to a visual stimulus. Other psychomotor tests measure perception, interpretation and motor reactions. These tests can be reaction time based (like the PVT), skill tests or simulation based (e.g. a driving simulator) as a basis for assessment of impairment.

There is significant emphasis on subjective rating scales for fatigue diagnosis. With no agreed definition, questionnaires are based on individual concepts of fatigue. Unidimensional (59) and multidimensional scales (60-62) have been produced to assess the fatigue state. These questionnaires focus on fatigue for a variety of conditions and
also in healthy individuals. The condition and/or the environment (e.g. work) must be considered when contemplating the assessment of the fatigue process.

The diagnosis of fatigue can be difficult with available questionnaires as they identify sleepiness as well as fatigue, and vice versa for sleep questionnaires. The context in which the questionnaire is used is an important factor. Part of the reason is due to a poor distinction between sleepiness and fatigue in the literature (63,64). Excessive Daytime Sleepiness is related to sleep propensity in general and to primary sleep disorders (e.g. sleep apnea, narcolepsy) whereas fatigue is the associated exhaustion and lack of energy that needs rest not necessarily sleep for recovery (65). Both conditions are associated with impaired concentration and short-term memory (66).

Over the last decade, the automobile industry has tried to develop onboard monitoring devices for fatigue detection that attempt to predict fatigue or monitor deterioration in performance. These devices evaluate head nodding (from tiredness), sudden steering corrections or lane tracking performance, and reaction time monitoring. These may be suitable for driving environments but not appropriate to other operational settings such as in surgery. Long-term risks associated with the introduction of monitoring should be considered. Increasing user reliance and ‘misses’ by the monitoring systems could lead to avoidable errors, especially in protocol driven work settings.

Actigraphy is used by the US Military and the Federal Railroad Association (67). It is a wristwatch that through wrist movement monitors sleep and awake intervals. This data is used with the Fatigue Avoidance Scheduling Tool, a computer application of the Sleep, Activity, Fatigue, and Task Effectiveness (SAFTE) model prediction tool that have been used to calculate a fatigue score in other occupational settings (68,69).
3.3 Work Based Fatigue

The construction industry recognises the impact of fatigue and it being a factor in the high injury rate in the construction sector (70). Time pressures for construction necessitate night shifts, continuous work and extended shifts in order to compress time schedules and achieve deadlines. Cognitive and physical fatigue is produced through repetitive tasks for extended shifts and the mental demands of continuous communication between individuals or teams. This description is equally fitting for the healthcare sector.

Limitation to the number of work hours performed is the traditional approach to managing work based fatigue as it is recognised that long working hours produce subjective fatigue (71). A major study performed in the United States during and after World War II compared total hours of work in employees who had changed from war time to peace time schedules (72,73). It found an 8-hour day and forty hour week superior to longer daily and weekly work schedules.

Initial evidence was from investigations on manual production work, performed by the Industrial Fatigue Research Board in the 1920’s. They assessed work-based performance in repetition tasks by reorganising work length schedules. Similar studies were performed in Germany and in the US (74). These studies originally defined the optimal length of a week’s work of 48 hours, with a workday length of 8-9 hours along with periodic short rest breaks. A more recent Japanese study of 715 workers recommended less than 60 hours work per week should be performed (75). Unfortunately most of this evidence in based on manual labour, performing monotonous, low stimulus tasks. This calls into question the validity of the specific time restrictions in current work based settings that are predominantly cognitively
demanding, such as medicine, within the NHS. We are currently using time-based restriction according to manual labour assessments rather than a more specific approach to the effects of high cognitive loading has in causing fatigue. Current guidelines reflect a generalised approach that implies high cognitive workload fatigue occurs within the same time frame as that experienced by a manual labour workforce.

The period of time spent at work influences mental fatigue. A study involving 18 male bus drivers assessed the impact of preceding working hours on mental processing efficiency. A memory search task (76) was performed at 12:30-13:30 hours after four different conditions. The first was during a day off, with a late (14:30-23:30 hours), day (09:00-16:30 hours) and early shift (05:30-12:30 hours) being the different work conditions assessed. Four days separated each condition and the order was balanced within the group. It was found that after 3 1/2 hours of work, participants in the study were found to exert the same effort but have a reduced reaction time during a task performance. The study found drivers who performed the task after 7 hours of work did not respond to 31% of stimuli. This was high compared with responses of 9%, 8% and 6% for late shift workers, day off and day workers respectively (74). The impact of temporal structuring of work times implies that prolonged work hours with the possibility a sleep deprived state, may effect mental performance. The implications to health from the increased physiological stress are uncertain.

A significant amount of fatigue research has concentrated on driver fatigue. Drowsiness and hypo-vigilance frequently occur during highway driving (77) increasing risks of error and accidents. Fatigue occurs early in monotonous driving conditions. Increased Steering Wheel Movements occur through time on task effects
and are fatigue related. Eighty minutes of continuous driving is a recommended safe limit (78). Reaction times increase and overall driving performance decreases as time on task increases. When driving, fatigue scores have been found to gradually increase and plateau, with the desire to rest being at similar score levels. Although the time to reach this score is individually specific, recommendations were made for drivers to rest between 1 and 2 hours after starting a journey (79).

Modern aviation has unpredictable working hours. It is recognised that pilot fatigue can be a significant problem (80,81). The Aerospace Medical Association adopted a position paper (82) that highlighted pilot fatigue and possible countermeasures. This paper highlighted in flight countermeasures such as cockpit napping, activity breaks and bunk rest/sleeping, along with appropriate in flight rosters and lighting. Cockpit napping has been authorised by some air carriers (Air Canada, British Airways etc.) and it has been shown to almost eliminate inadvertent lapses of alertness. Pilot work hours are not dissimilar to that of the medical profession. It is surprising that hospitals are removing any sleep areas and are actively preventing staff from naps (even on a break) on night shifts. This is against the evidence in the literature.

A study involving officers in high speed maritime operations found day shift workers accumulated fatigue over a two day period (83). Night shift workers were found to manifest a higher level of fatigue compared to day shift counterparts. The work assessed was described as requiring intense concentration and rapid responses. Continuous communication was required with associated workers. The description of job intensity and requirements were similar to those described for construction workers, and feasibly could describe work within the NHS.
A review of health and safety in relation to long working hours (84) found that the
effects of fatigue have been extensively studied relative to shiftwork. Sleep pattern
disruption contributed to overall fatigue concern. Although health and safety is
influenced by a variety of factors, fatigue is involved, with safety more likely to be
compromised during night shift. This incidence is increased when night shifts are
coupled with extended working hours.

Fatigue is associated with long-term and short-term sick leave (85). The Maastricht
Cohort Study of Fatigue at work studied 45 companies over three years (1998-2001)
by 4 monthly questionnaires. The six months following the baseline questionnaire
were used to analyse worker sick leave absence (7495 participants analysed). It was
found that long-term absence is particularly influenced by fatigue.

Mental fatigue was studied by analyzing performance and mental effort in a memory
search task in relation to the temporal structuring preceding a work period (74). This
study found individuals attempted to protect their performance by spending more
effort in unfavorable conditions. In the least favorable condition (eight hours of work
combined with sleep loss) individuals were unable to maintain performance with
increased effort. This could be interpreted as significant mental fatigue.

Although the deleterious effects of shiftwork are well established, organisations still
struggle to manage work-related fatigue. The limitation of working hours is a method
by which institutions attempt to manage this. Limitations apply to the maximum
length of shift and minimum break durations. The intensity of the task or the
physiological determinants of fatigue (e.g. night shift work and the influence on the
circadian rhythm) are not taken into account. The reasoning for a rule-based approach
is that it can be applied throughout the work force. However, such applications do not assess the impact of fatigue on different schedules of work or take into account the tasks performed. The development of fatigue-based models to assess the impact of specific work based tasks is needed to assess fatigue in a 24-hour workplace such as the NHS. It is the impingement of costs and simplicity of implementation across a workforce that is a limiting factor.
3.4 Fatigue in the NHS

The Joint Commission assessed the impact of fatigue on Healthcare workers (4). They concluded that fatigue was still caused by extended hours or insufficient sleep that contributed to errors at work. The Accreditation Council for Graduate Medical Education (ACGME) has twice recommended reductions in work time for medical trainees due in part to concerns about fatigue (86).

Levels of fatigue in the NHS workforce were found to be assessed in a large (7720 NHS Staff) survey involving 19 NHS trusts (87) (Table 3-1 literature review summarising fatigue data). Overall fatigue was significantly higher (p<0.001) than in the UK or US general population. Physical aspects of fatigue were reported by 13.6% (muscle pain at rest) and 21% (muscle pain after exercise). Similar levels of fatigability appeared to be reported by this paper and the general population. Doctors, nurses and ‘professionals allied to medicine’ reported the highest levels of general fatigue. Female doctors reported more fatigue than their male counterparts. High work demand significantly predicted high levels of fatigue (p<0.001). General fatigue was found to be associated with high levels of mental ill health and high work demands. The study concluded that health service workers experience high levels of fatigue.

In a systematic review of patient safety and empirical working hours by the Jefferson Medical College Duty Hours Review Group (88), laboratory studies of performance on clinical simulations, and tests of cognitive and fine motor skills in the sleep deprived state suggested that limits on duty hours should have strong positive effects on patient safety. The difficulty is that few measurable effects for patient safety have been demonstrated in follow-up studies on the impact of the duty hour regulations.
### Table 3-1: Literature Review of Fatigue in Healthcare

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<th>Summary Of Findings</th>
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<td><strong>Hardy et al 1997 (87)</strong></td>
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<td><strong>Gander et al 2007 (89)</strong></td>
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<td><strong>Patterson et al 2012 (5)</strong></td>
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<td><strong>Cammu et al 2012 (90)</strong></td>
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<td><strong>West et al 2009 (91)</strong></td>
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<td><strong>Hamadani et al 2013 (92)</strong></td>
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<td><strong>Dembe et al 2009 (93)</strong></td>
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<td><strong>Ayas et al 2006 (49)</strong></td>
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<td>Harewood et al 2008 (96)</td>
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<td>Maeda et al 2011 (97)</td>
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<td>Eastridge et al 2003 (103)</td>
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Unfortunately, the report does not highlight how the hour’s reduction affects the general fatigue of doctors.

A report requested by American Congress and the Agency for Healthcare Research and Quality (AHRQ) recommended that doctors should perform no more than 16 consecutive hours of work without sleep (106). It recommended better supervision of residents and improved protocols for transfer of patients from clinicians between shifts or patient handovers. It is interesting to note that at the time the advice was not to reduce the 80-hour week limit, but rather to provide adequate rest periods between times of work. Handovers at shift changes were identified as a substantial source of medical errors. Structured handover protocols were recommended along with shift overlap to improve communication. It is feasible that these errors are fatigue based rather than just from sleep deprivation.

The European Working Time Directive was implemented in an attempt to protect workers health and safety. It recognised that excessive working time was a major cause of stress, depression and illness, with fatigue certainly being an underlying factor. European Union workers were allocated a minimum number of holidays each year with rest of at least 11 hours in a twenty-four hour period; restricting excessive night duty and making it a default right to work a maximum of 48 hours on average over a 17 week period.

The implications of this legislation are that doctors’ hours have been reduced, with the necessity of the on-call team handing over the care to another team within a 24 hour time period. Even with reduced hours worked, the intensity will remain the same, if not increased, in an attempt to maximize productivity efficiently for the time
the staff are present. The result is that staff are experiencing episodes of high cognitive load and thus acute mental fatigue. A survey on work patterns and fatigue in Australian doctors (89) highlighted the fact that the associated fatigue was not only from work patterns and that other aspects of work should be considered. They recommended a comprehensive risk management approach to healthcare to improve fatigue and patient safety.

In a study involving 37 surgical residents, psychomotor and cognitive feedback was assessed after a night on call using a virtual reality simulator with haptic feedback (98). Surgical proficiency as assessed among junior and senior-level residents was significantly impeded when fatigued. There was an increase in the number of cognitive errors, decreased psychomotor efficiency and an overall reduction in task performance. Cognitive skills were more impaired than psychomotor skills. Reduced cognitive performance was similarly reported in 10 doctors when assessed after a weekend on call (107). They were found to have reduced concentration, less confidence and were subjectively more confused. Decrements in working memory were similarly found in a US study involving 39 residents (101). On call involved 30hr shifts every fourth night. Working memory recall scores were significantly impaired when on call and more maths errors were also recorded. Deterioration in working memory may impair judgement however; the study did not assess clinical errors.

A review of the effects of fatigue on surgeon performance and surgical outcomes concluded there was little evidence to inform on the effect of fatigue on surgical performance (108). It found less experienced surgeons were more susceptible to making errors when sleep deprived compared to senior counterparts. The review did
not analyse time on task (fatigue accumulated during a working period) effects, physical fatigue or fatigue from prolonged sleep deprivation. Most of the evidence used virtual reality to assess performance without correlating their findings to a clinical setting.

Extended work shifts significantly increase fatigue and impair performance and public safety (99). Cognitive performance has been shown to be equivalent to a 0.1% blood alcohol level when sleep deprived for 24 hours (109). This blood alcohol level is above the legal driving limit in the UK. Traditional 24 hours on-call shifts demonstrate 36% more serious preventable adverse events (compared to a 16 hour shift pattern). Doctors also have been found to have twice the number of attention failures (100) at night and a 61% increase in needle stick/sharp injury after 20 hours of work (49). There is a 1.5-2 standard deviation deterioration in performance compare to baseline measurements for clinical and non-clinical tasks (94). There are reportedly five times the number of serious diagnostic errors and a 300% increase in fatigue related serious adverse events causing patient death (50).

A study of 511 emergency service workers found that 55% of the respondents were classified as fatigued while at work (5). The highest fatigue levels were among full-time workers (63.3%). Participants working 6 to 15 shifts per month, 24-hour shift workers, and respondents with fair or poor self-rated general health all scored highly. 91 (17.8%) had been injured in the previous three months, with the odds of a fatigued worker being injured being 1.9 times higher than a non-fatigued worker. The odds of a fatigued worker having perceived that their safety had been compromised were 3.6:1 compared to a non-fatigued worker. The odds of a medical error or adverse
event occurring in a fatigued worker were 2.2 times higher than a non-fatigued worker.

A survey involving 260 Obstetricians found increasing perceived fatigued if their work limit exceeded 60 hours per week (90). Of concern, 19% of obstetricians in the survey perceived they had performed a medical/surgical error. A higher incidence of injury has been found in healthcare professionals who work over 60 hours a week (93). This evidence reinforces the fact that workers who are in an acute state of mental fatigue are at a higher risk of errors, placing their safety, that of their colleagues, and in the medical profession, patients, at risk.

Small studies have suggested a decrease in cognitive performance in physicians over a day or night shift. A study involving 13 emergency department doctors (95) found significantly decreased word recall in both day and night shifts (but not between the two). The difficulty of the shift correlated to the magnitude of post shift fatigue. Night shift doctors predominantly recalled the most recent information, displaying recency serial position effects (see Memory Chapter).

There is evidence to suggest that fatigue and sleep deprivation cause a significant deterioration in a surgeon’s cognitive skills (98). This study assessed 37 surgical residents pre-call and post-call and exposed them to psychomotor and cognitive assessments using a virtual reality simulator with haptic feedback and hand-motion recording. An increase in cognitive errors and a significant decrease in proficiency of cognitive task performance ($p<0.1$) in the post call state was identified. The study found that the fewer the number of reported hours of sleep, the more cognitive errors performed (98).
A recent study (67) involving orthopedic residents (n=33) found that they experienced fatigue 48% of the time. They were classified as being ‘impaired’ 27% of the time that they were awake (calculated using the SAFTE model). The increase in medical risk was predicted to be increased by 22% compared to historical controls. It is interesting to note that conforming to EWTD with shift changes to achieve mandated working hours may have made fatigue worse not better (110).

The impact of endoscopist fatigue has received increasing recognition. Operator fatigue has been highlighted as a possible factor in increasing extubation times throughout a session (96). Endoscopist workload has increased due to the requirements for colonoscopy in an aging population. Key quality measures of endoscopy are caecal intubation, lesion detection and withdrawal times. Polyp detection rates have been shown to decline with successive procedures (111). There also appears to be a trend with increasing insertion times (96). Increased intubation times during the list may reflect attempts by the endoscopist to compensate for fatigue. In contrast to these findings, there is evidence from laparoscopic research suggesting that basics skills may be retained for simple procedures when fatigued (104-5). However this may depend on experience due to other laparoscopic studies demonstrating degradation in speed, accuracy and increased error (102-3).

A small study (n=7) assessing the impact of fatigue on imaging reporting by radiologists (97) used CFFF to objectively measure fatigue, along with a subjective questionnaire (a Visual Analogue Score - VAS). There was no correlation between VAS scores and CFFF. If a subject had reduced sleep the night before, CFFF was found to be lower, but this did not correlate with the VAS, suggesting participants were unaware of their fatigued state. Although only a small sample was used, CFFF
was found to decline after reporting and could be useful as an indicator of fatigue induced by radiology reporting.

The World Health Organization (WHO) identified fatigue as a leading factor in medical error and injury in health care (112). Worker fatigue in the NHS has large cost implications that range from sick leave to negligence claims from medical errors. The NHS litigation authorities bill for 2011-12 increased to 1.2 billion pounds (1). A fatigue reduction plan may reduce errors, improve patient and staff safety and reduce complaints from patients regarding lack of empathy and caring. A US survey found 43% of residents that were surveyed had perceived they had made a medical error in a single year of training. This group also reported greater fatigue (91).

Compassion fatigue is also becoming a problem. The accumulation of frequent, repetitive exposures to trauma and high levels of stress can lead to compassion fatigue. Society is frequently critical about lack of empathy by NHS staff. The increasing expectations of a critical public and press have little insight into what is likely a presenting symptom of mental fatigue of the carer.

It is quite feasible that a significant proportion of complaints concerning staff behavior and attitudes are as a result of fatigue. This combined with fatigue related errors would have significant cost implications related to compensation claims. This does not take in to account the morbidity, mortality or emotional disturbance to the patient.

In my opinion, the NHS is disregarding other causations of fatigue, focusing on reduced hours. Work intensity of clinics and practical procedures, such as endoscopy, have increasing patient numbers and time pressures. It is the accumulation of multiple
work-based factors that result in increasing cognitive fatigue and ultimately errors. Tasks need to be performed perfectly, first time, without complications. It is a skeletonised system driving for maximum efficiency, contrasting with the need for surplus time to prevent any delays or allow for the management of unforeseen complications.

The assumption that error is inevitable is a false premise, but one that has developed in an overburdened system. This is unacceptable in a system where any mistake can have life changing consequences to the patient (or staff member). Aviation has adopted change to improve safety. The consideration of the impact of shift length, pattern, accompanied by tasks specific assessments for jobs performed during a working day should be considered. These can significantly influence fatigue in the workforce and ultimately error, worker and patient safety.

The difficulty in taking regular breaks, and the removal of rest rooms will effect the cognitive state of workers. The nutritional requirements of staff have also been ignored during night periods, with no food available apart from that dispensed by a machine. Adequate nutritional intake is required to avoid physical and mental fatigue. The cost cutting approach to reduce hospital debt may be costing the NHS through increased litigation from fatigue-based errors.

Systems should be created to avoid fatigue related errors. Where the relay of information is critical, there should be a pathway in place to help prevent inadvertent errors by an individual. Examples of these measures are evident in the airline industry in which communication is essential. The WHO checklist was created to mirror the airline approach to safety due to circumvention of regulations by medical
staff in preparation for surgery. Avoidable errors were occurring due to miscommunication, and due to fatigue in certain individuals (113).

It is therefore surprising that patient handover is not standardized. The Joint commission issued a statement ‘Action Urged to Fight Healthcare Worker Fatigue’ (114) and one of the alert recommendations was to examine the processes of patient handover as the risk from error is compounded by fatigue at these times. The method of ‘handing over’ varies between individuals and institutions. The healthcare environment is a complex, dynamic, increasingly specialized field. Fragmentation of information through the poor transfer of patient information undermines the ‘building blocks’ for improved patient outcomes and an enhanced patient delivery system. In todays high technological age it is remarkable that staff use paper as a source of information transfer and that there is no national database that different specialties could use for a documentation summary.
3.5 Conclusion

When managing fatigue we should not focus on just the number of hours worked, but rather the numbers of consecutive hours worked without break, shift intensity and type of task(s) performed during the shift (see recommendations Table 3-2).

With handover being publicized as an area at high risk of fatigue related error, the impact of fatigue on this process needs further evaluation. To explore this a reproducible method of creating acute mental fatigue needs to be established. In the non-sleep deprived state, fatigue can be produced when exposed to a cognitively demanding task (115). In the literature, the continuous performance N-Back task has been used for this purpose (115). I propose to use the N-Back task to create acute mental fatigue in participants to assess the recall of clinical information under high and low cognitive loads in the non sleep deprived state prior to creating an intervention aimed at improving recall of clinical information.
Table 3-2: Recommendations

<table>
<thead>
<tr>
<th>Recommendations to Reduce Fatigue In the Workplace</th>
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<tr>
<td>1. Education of staff on importance of fatigue – not just clinical staff but non-clinical e.g. managerial staff, in order to effect change.</td>
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<td>2. Adherence to 48 hour week EWTD guidelines</td>
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<td>3. Regular breaks during shift work (every 4 hours)</td>
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<td>4. Assessment of time on task effects of procedures and clinics to limit the number or types of procedures performed in a specified time period</td>
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<td>5. Adequate nutrition available to staff 24/7</td>
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<td>6. Adequate facilities to take rest breaks</td>
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<td>7. Regular monitoring of staff fatigue to identify problem areas – become proactive rather than reactive</td>
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<td>8. Consideration of procedures e.g. long, difficult operations, to be performed by two qualified surgeons.</td>
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<tr>
<td>9. Creation of Evidence Based Protocols for high-risk communication tasks to limit the impact of fatigue on the transfer of critical information. E.g. Patient handover</td>
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Societal pressures of job security, financial stability or potential economic reward are influential in creating the atmosphere in which healthy individuals attempt to gain an advantage over colleagues or competitors. The term ‘neuroenhancement’ has been used to describe interventions used by healthy individuals to improve their cognitive, emotional and motivational functions (116). Pharmaceutical neuroenhancement is the term used for pharmacological enhancement of cognition.

Medications are available that have been designed to modulate specific areas of the brain for treatment of disorders such as Narcolepsy or Attention Deficit Hyperactivity disorder (ADHD). These medications target the catecholamine system, stimulating executive functions in the recipient. It is the enhancing properties of these medications that can be used for neuroenhancement. The catecholamine effect on the executive working memory appears to improve most healthy individuals as well as that in the target group of patients(117). This improvement allows individuals to focus their attention, manipulate information in working memory and flexibly control their responses.
4.1 Modafinil

An example of a pharmaceutical used for neuroenhancement is that of Modafinil (Fig. 4-1). It is licensed by the United States Food and Drug Administration as an analeptic drug for the treatment of Narcolepsy, Shift Work Sleep Disorder and Excessive Sleepiness Associated with Obstructive Sleep Apnoea. In Europe, the European Medicines Agency has licenced the medication for use with Narcolepsy.

Figure 4-1: Modafinil Molecule (118)

Modafinil Molecule (2-[benzhydryl sulfinyl] acetamide; US brand name ProVigil). This is a racemic compound (equal amounts of left and right handed enantiomers of a chiral compound).
The main route of elimination (90%) is primarily via liver metabolism with subsequent renal elimination of metabolites (40). In plasma the main metabolites are Modafinilic acid and Modafinil Sulfone. In urine, it is predominantly Modafinilic Acid. These are inactive metabolites. Its excretion is primarily renal with less than 10% that of unchanged Modafinil. After administration of radiolabelled Modafinil, 80% of the radioactivity was excreted renally and 1% was excreted in faeces (119) (over an 11 day period). Patients with severe chronic renal failure (creatinine clearance of <20ml/min) do not significantly influence the pharmacokinetics of Modafinil but were found to have concentrations of Modafinilic acid that was 9 fold that of normal individuals. Dosage of Modafinil should be decreased in patients suffering from hepatic impairment as clearance is reduced by 60% and the steady state concentration in the plasma is double that of normal patients. Cytochrome P450 enzyme systems CYP1A2, CYP2B6 and CYP3A4/5 are modestly induced by Modafinil and CYP2C19 system is suppressed in vitro studies (120,121). Thus the clearance of substrates such as cyclosporine, steroidal contraceptives and theophylline may be increased. Elevated levels of tricyclic antidepressants may also occur.

4.2 Mechanism of Action

The precise mechanism of action of Modafinil is still unclear. As with other stimulants, Modafinil has been shown to increase release of Monoamines – the catecholamine’s, norepinephrine and dopamine at the synaptic terminals. Unlike these stimulants it also causes an increase in hypothalamic histamine levels (122). It is for this reason it can be considered to be a ‘wake promoting’ medication instead of an amphetamine-like stimulant.
The effects of Modafinil may be mediated by activation of noradrenergic \( \alpha_1 \) receptors. In mice, the wake promoting effects of Modafinil appeared to be negated by blocking an \( \alpha_1 \)B-antagonist (40). The motor effects of Modafinil were also found to improve when \( \alpha \) receptors in mice were attenuated with stress.

Animal studies have demonstrated Modafinil interacts with dopamine transporters. This is the same transporter used by agonists in the treatment of cocaine dependence (123). In the human brain, Modafinil blocked dopamine transporters and increased dopamine (including the nucleus accumbens) (124). Although it has been recognized to have low abuse potential, this has raised questions as drugs that increase dopamine in the nucleus accumbens have the potential for abuse. A more recent study has suggested that there is a potential reward experience from Modafinil, particularly in cocaine addicts, but the typical low dose prescribed may account for the lack of addiction seen in humans(125).

### 4.3 Safety

The safety of Modafinil is well documented (126) (127). A review of six studies totalling 1529 patients administered Modafinil or placebo found that overall discontinuation rates of placebo and Modafinil were similar (16% vs. 18%). The commonest side effects were that of headache (34% vs. 24% placebo), nausea (11% vs. 3% placebo). Only headache was found to have a dose related effect. Modafinil was not associated with any clinically significant changes in mean vital signs, ECGs or impedance of sleep when desired. Modafinil was not found to significantly elevate
mean blood pressure or heart rate more than placebo in patients at risk of significant cardiovascular events (patients with Obstructive Sleep Apnoea) (126).

In a 9-week, multicenter, randomized, double-blind, placebo-controlled, flexible-dose study in six to seventeen year olds (127), the tolerability of Modafinil was also assessed. In total, 248 children were enrolled into the trial with 164 receiving Modafinil. The commonest side effects reported were that of Insomnia (48 patients [29%] compared with 3 [4%] in the placebo group), Headache (32 [20%] compared with 12 [15%] placebo) and a decreased appetite (26 patients [16%] compared with 3 [4%] in the placebo group). Only Insomnia and the reduction in appetite were statistically significant. No subject discontinued due to these side effects. In the Insomnia group, 58% found their symptoms to resolve during the study period. 73% (19 of 26) of the group with reduced appetite also found resolution of their symptoms during the study. There were three severe adverse events in this study – 1 insomnia, 1 erythema multiforme, within the Modafinil group and one headache in the placebo group. The authors also stated that five days after finishing the study one seven year old boy was diagnosed with Steven Johnson Syndrome. The patient had an underlying viral illness but the possibility of it being drug related could not be excluded. One eight year old was also diagnosed with duodenitis, a peptic ulcer and hypotonia but this was not found to be drug related. Five (3%) Modafinil and three placebo (4%) treated patients discontinued from the trial. In addition to the two aforementioned serious adverse events, the remaining Modafinil treated patients discontinued due to somnolence, dystonia and tachycardia. In the placebo group, one patient discontinued as a result of nervousness and emotional lability and 1 each as a result of hostility and hyperkinesia.
Long-term implications of Modafinil have yet to be determined. Although it is relatively safe in the short-term, like Prosac it too works on pathways that are not completely understood (128).

4.4 Modafinil And Working Memory In the Healthy Non-Sleep Deprived State

Modafinil has been used in healthy sleep deprived and non-sleep deprived individuals to assess a range of functions and its effects on the prefrontal cortex. This thesis is focussed on the deterioration of cognition with acute mental fatigue in non-sleep deprived healthcare professionals. The following review explores the literature for use of Modafinil in the healthy non-sleep deprived state. In Summary (Table 4-1):

- Modafinil does not demonstrate dose related effects.
- Multiple small studies indicate limited cognitive enhancement in the non-sleep deprived state. There is some evidence to support improvements in short-term recall and recognition memory (Table 4-1). Hence a possible pharmaceutical intervention to improve recall at handover.
- Formal assessment of the actions of Modafinil on fatigue in the non-sleep deprived state is lacking.
- Evidence suggests that the effects from Modafinil may be increased in individuals with a lower baseline IQ.
Table 4-1: Literature Review of Modafinil Use in Non Sleep Deprived Healthy Participants

<table>
<thead>
<tr>
<th>Author</th>
<th>Modafinil Use In Healthy Non-Sleep Deprived Individuals</th>
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<tr>
<td>Randall <em>et al</em> 2005 (129)</td>
<td>Double blind parallel study. 60 students allocated to placebo, 100mg or 200mg Modafinil. Modafinil had limited effects that were not clearly dose related and at 100mg, effects were limited to the span of immediate verbal recall and short-term visual recognition memory. Non-sleep deprived individuals may display task specific effects</td>
</tr>
<tr>
<td>Finke <em>et al</em> 2010 (130)</td>
<td>Counter balanced double blind crossover study. 18 volunteers administered 400mg of Modafinil, 40mg Methylphenidate or placebo. Modafinil and Methylphenidate enhanced perceptual processing speed in participants with a low baseline (placebo) performance.</td>
</tr>
<tr>
<td>Turner <em>et al</em> 2003 (131)</td>
<td>Double blind randomised study. 60 male adults allocated Modafinil 100mg or 200mg. Digit span, visual pattern recognition memory, spatial planning and stop-signal reaction time all indicated enhanced performance. These improvements were complemented by a slowing in latency on delayed matching to sample, a decision-making task and the spatial planning task. Effects were not clearly dose dependent, except for those seen with the stop-signal paradigm.</td>
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<tr>
<td>Marchant <em>et al</em> 2008 (132)</td>
<td>Double blind study. 24 adults (17 female, 7 male – possible bias). 200mg Modafinil or placebo. Modafinil improved accuracy of attention shifting tasks without a reaction time trade off.</td>
</tr>
<tr>
<td>Muller <em>et al</em> 2004 (133)</td>
<td>Double blind crossover study. 16 adults. 200mg of Modafinil or placebo. Reduced errors in difficult manipulation conditions of a numeric task and in the long delay condition of a visuospatial maintenance task. Drug related rather than a trade off for delayed reaction time.</td>
</tr>
<tr>
<td>Ghahremani <em>et al</em> 2011(134)</td>
<td>Randomised double blind crossover study. 35 adults. 200mg Modafinil or placebo. Modafinil improves learning performance in individuals with poor baseline scores. The study compared individuals with history of methamphetamine abuse versus healthy controls. Modafinil may have use as an adjunct in cognitive based therapies for the treatment of methamphetamine dependence</td>
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<tr>
<td>Author</td>
<td>Modafinil Use In Healthy Non-Sleep Deprived Individuals (continued – part 2 of 3)</td>
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<tr>
<td>Baranski et al 2004 (136)</td>
<td>Double blind crossover study. 18 participants. 300mg Modafinil or placebo. Modafinil was found to improve fatigue levels, motivation, reaction time and vigilance. Over confidence in performance not found. This contrasts with a previous study in the sleep-deprived state that found significant over estimates in performance (137). Hence the possibility of sleep deprivation or the dose of Modafinil influencing metacognition.</td>
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<tr>
<td>Liepert et al 2004 (139)</td>
<td>Double blind randomized crossover study. 10 adults. 200mg Modafinil or placebo. No evidence for enhanced motor performance.</td>
</tr>
<tr>
<td>Saletu et al 1989 (140)</td>
<td>Double blind study. 10 elderly participants. 100 mg and 200mg 74einforce; 10 mg and 20 mg d-amphetamine; placebo. For one night each with corresponding washout night. There was no impact on sleep quality by Modafinil.</td>
</tr>
<tr>
<td>Saletu et al 1989 (141)</td>
<td>Double blind study. 10 ‘young’ adults. No impact on sleep quality. 100 mg and 200mg 74einforce; 10 mg and 20 mg d-amphetamine; placebo. For one night each with corresponding washout night. There was no impact on sleep quality by Modafinil.</td>
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In the literature, Modafinil studies that involve healthy participants consist of relatively low numbers of individuals. One of the larger studies was a double-blind parallel group study (129) involved 60 healthy students (aged 19-22 years). They were not sleep deprived and were allocated placebo, Modafinil 100mg or 200mg. This study found no effect on reaction time and attention. However, the 200mg Modafinil group were faster at simple colour naming of dots and performed better than placebo in the Rapid Information Processing Test of sustained attention. Verbal short-term memory recall was unaffected but 100mg of Modafinil improved digit span forwards.

<table>
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<th>Author</th>
<th>Modafinil Use In Healthy Non-Sleep Deprived Individuals (continued – part 3 of 3)</th>
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<tr>
<td>Stoops et al 2005 (142)</td>
<td>Participants blinded to medication. 6 participants allocated 100mg, 200mg and 400mg of Modafinil. Abuse potential assessed. Modafinil is a cognitive reinforcer during (improved) performance but not during the resting state. Behavioural effects may overlap with methylphenidate and cocaine suggesting possible use for in stimulant dependence.</td>
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<tr>
<td>Randall et al 2004 (143)</td>
<td>Double blind parallel study. 45 adults (50-67 years). Allocated to Placebo, 100mg or 200mg of Modafinil. Limited evidence of cognitive improvement with Modafinil use in non-sleep deprived middle aged participants. It concluded that benefits might be more apparent in the fatigued or sleep deprived individual.</td>
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<tr>
<td>Taneja et al 2007 (144)</td>
<td>Randomised crossover study. 12 adults. 3 days of 400mg Modafinil or placebo with 4 day washout period between crossover. Modafinil may have mood elevating effects accompanied by anxiety.</td>
</tr>
<tr>
<td>Randall et al 2003 (145)</td>
<td>Double blind randomized parallel study. 30 adults (19 men, 11 women). Allocated placebo, 100mg or 200mg Modafinil. Anxiety present with 100mg of Modafinil but no cognitive enhancement demonstrated.</td>
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and both doses improved the pattern recognition but had an accompanying slowing of latency in the 200mg group. Modafinil was found to have no significant effects compared to placebo in tests for long-term memory, executive function, visuospatial or constructional ability or category fluency. The authors concluded that Modafinil had limited effects that were not clearly dose related and at 100mg, effects were limited to the span of immediate verbal recall and short-term visual recognition memory (129). Non-sleep deprived individuals may display task specific effects for results obtained with Modafinil.

A study involving 18 healthy non sleep deprived volunteers focussed on visual attention capacity (130). This was a counterbalanced double-blind crossover study involving the administration of 400mg of Modafinil, 40mg Methylphenidate or placebo. The study found that both Modafinil and Methylphenidate enhanced perceptual processing speed in participants with a low baseline (placebo) performance. It is hypothesized that this is due to low base line levels of dopamine and noradrenaline. With methylphenidate, plasma concentrations corresponded to improvements in processing speed, however, this was not found to be the case for Modafinil. These results agree with Randall et al (2005) that indicate effects are not clearly dose related.

To investigate the nootropic (cognitive enhancing) properties of Modafinil, sixty adult male volunteers were recruited (131). These were allocated placebo, Modafinil 100mg or 200mg. This was a double blind randomized between subjects design. Unlike Randall et al (2005) (146) tests of digit span, visual pattern recognition memory, spatial planning and stop- signal reaction time all indicated enhanced performance. These improvements were complemented by a slowing in latency on
delayed matching to sample, a decision-making task and the spatial planning task. Randall et al (2005) (146) also demonstrated latency but with the digit span task. Participants subjectively reported feeling more alert, attentive and energetic on drug. Effects were not clearly dose dependent, except for those seen with the stop-signal paradigm.

A further study involving 24 healthy volunteers (administered 200mg Modafinil or placebo) specifically looked at distinct components of attention (132). It used tasks that focus on components of attention switching. One of the tests involved rapid switching of attention between stimuli and the second contained an embedded working memory component that also assessed attentional shift. Participants were matched for age, intelligence and baseline cognitive ability, however, there were 17 female and 7 male participants. In both conditions of attention shifting tasks, participants who received Modafinil were found to have improved accuracy without a reaction time trade off. This was found to occur only in the most challenging aspects of the task. This study found that there was no benefit from Modafinil in scenarios where unpredictable and infrequent disengagement of attention were required between two tasks.

Muller et al (133) studied 16 healthy volunteers in a double-blind crossover study aimed at investigating the effect of Modafinil on working memory. This study focused on how the observed effects on working memory were related to the effect of Noradrenaline stimulation on the prefrontal cortex. The group found that 200mg of Modafinil had fewer errors in the difficult manipulation condition of a numeric task and in the long delay condition of a visuospatial maintenance task. It was not found to influence attentional control tasks or mood ratings. This study found reduced errors
were accompanied by faster or unchanged reaction times. It was concluded that the improvements were consistent with being drug related rather than due to the trade-off in a delayed reaction time.

The impact of Modafinil on emotion has also been studied in healthy volunteers (147). A daily dose of 100mg of Modafinil was supplied for a one-week period. Emotion and cognitive information processing was assessed using Blood-oxygen-level dependent contrast imaging (BOLD) fMRI whilst participants performed tasks reliable in activating the limbic system. This form of MRI allows for activated areas of the brain to be imaged in real-time whilst performing the task. Modafinil was found to decrease amygdala reactivity to fearful stimuli, which is in contrast to other cognitive enhancing psychostimulants (148). Modafinil was found to decrease BOLD signal in the prefrontal cortex and anterior cingulate when compared with placebo for working memory and variable attention control tasks. This is consistent with a study by Thomas and Kwong (2006) after healthy volunteers were administered a single dose of 200mg of Modafinil (149).

Previous studies have suggested that the impact of Modafinil on learning performance in healthy individuals is more significant in individuals who perform poorly in cognitive tasks compared to those who have a better performance. A study involving individuals with a history of Methamphetamine (MA) abuse versus healthy individuals demonstrated a greater impact of Modafinil on learning performance in the MA-dependent group (134). Performance levels became equivalent to that of the control group. The healthy individual group that received Modafinil were initially not found to have an increase in learning performance. However, subgroup analysis of low and high performing control subjects found a bigger effect of Modafinil on the
low performing group. It was therefore postulated that the lack of Modafinil effect seen in the control group was driven by the high performance of subjects who were already performing at near-ceiling levels with minimal room for improvement.

In a separate double-blind placebo controlled study (135), 400mg of Modafinil was administered over three consecutive days following a 3 day placebo administration. This was administered to 11 methamphetamine dependent subjects. Results were consistent with the previous study in that individuals with poor baseline performance improved on Modafinil. However, high performance baseline scores in methamphetamine dependent individuals did not improve on Modafinil administration. Tests were of working memory. Measurements of episodic memory or information processing speed did not show significant improvement in either group.

A double blind crossover study by Baranski et al (136) assessed Modafinil induced over-confidence in 18 healthy non-sleep deprived individuals. This study analysed serial reaction time, logical reasoning, visual comparison, mental addition and vigilance. Trial-by-trial confidence judgments were obtained for two of the cognitive tasks and a more global, task level assessment of performance was obtained for four of the cognitive tasks. Subjective assessments on mood, fatigue, affect, vigor and motivation were also performed. Results suggested participants did not feel over or under confident when administered Modafinil for cognitive performance self-assessment. Relative to placebo, Modafinil was found to improve fatigue levels, motivation, reaction time and vigilance. This evidence contrasts with Baranski’s earlier paper (137) that suggested that sleep deprived individuals administered 300mg of Modafinil subjectively overestimated their performance. There may therefore be a difference in metacognitive abilities (i.e. the ability to accurately self-assess one’s
own cognitive performance) if one is administered Modafinil in the sleep or non-sleep deprived state. Yet in a further study by Baranski et al (150), administration of Modafinil in divided doses of 100mg three times a day found no over estimation of performance in sleep deprived individuals. Baranski therefore questions whether higher dosages of Modafinil can decrease the meta-cognitive abilities in sleep deprived individuals.

A double blind randomized controlled trial involving 11 healthy individuals tested placebo (5 times), Modafinil (1.75mg/kg, 3.5mg/kg, 7mg/kg) and d-amphetamine (0.035mg/kg, 0.07mg/kg, 0.14mg/kg) over 11 sessions(138). Modafinil was found to enhance performance on the Digit Symbol Substitution task, and increased response rate on the Repeated Acquisition of Response Sequences Task. It was found to significantly decrease Visual Analogue Score ratings of feeling sleepy and decreased ratings on the Addiction Research Center Inventory (ARCI) Pentobarbital-Chlorpromazine-Alcohol Group scale. There were increased ratings on the Amphetamine and Morphine Benzedrine Group scales of the ARCI and increased ratings on the Vigor and Total Positive scales of the Profile of Mood States. Unlike d-Amphetamine, Modafinil was not found to increase the VAS rating for feeling stimulated and liking the drug. Modafinil was found to sustain performance that deteriorated over time for the memory test - Sternberg Number Recognition Test.

A double blind randomized crossover study involving Modafinil assessed the excitatory and inhibitory properties in the motor cortex (139). It involved ten patients administered a single dose of placebo or 200mg Modafinil. Responses were measured using Transcranial Magnetic Stimulation. Results suggested there was no statistical difference between placebo and Modafinil for motor excitability and motor behavior.
This is in contrast to studies involving other CNS stimulants, for example, intracortical facilitation and stimulus response curves are enhanced by Dextroamphetamine (151). It was concluded that Modafinil did not have a significant improvement on motor performance in normal healthy subjects. This conclusion was from a small sample size but it was argued that TMS studies previously had demonstrated drug effects with similar size cohorts (152,153).

In ten healthy, elderly volunteers, Modafinil has not been found to impact upon sleep quality compared to placebo over a twelve night assessment period (140). Whereas other cognitive stimulants, such as d-amphetamine, have been shown to give a dose dependent impairment of sleep maintenance and architecture. Saletu et al (140) found a significant reduction in total sleep time, REM sleep and stage 2 sleep. Subjective sleep assessment found impairment of sleep quality only with 20mg d-amphetamine compared to Modafinil and placebo. In an experiment following the same design, this time involving 10 young and healthy individuals, Saletu et al (141) again found sleep maintenance to be impaired in a dose dependent fashion for d-amphetamine, unlike Modafinil

Six young healthy volunteers were assessed for the abuse potential of 100mg, 200mg and 400mg of Modafinil (142). The reinforcing effects of oral Modafinil were assessed under performance and relaxing conditions. Modafinil was found to act as a reinforcer during performance, but not relaxation. This may be related to the individual’s performance enhancement or perceived enhancement during the performance condition. It was found that the volunteers reported that they had an improved performance on the set arithmetic tasks, which is consistent with this observation. Drug misuse can still occur under these circumstances. This can be
shown in sports competitors who deliberately administer enhancing drugs in an attempt to improve their performance. Modafinil could therefore be abused under similar circumstances. Stoop et al (142) suggest that the behavioral effects observed in their study overlap to some extent with methylphenidate (154) and cocaine (155). Based on the behavioral effects of Modafinil, it may have a clinical application as an agonist for stimulant dependence (156).

A parallel double blind randomized study involving 45 healthy middle aged (50-67yr old) volunteers randomly allocated individuals to receive Placebo, 100mg or 200mg of Modafinil (15 participants per arm of study) (143). This study assessed if Modafinil would improve age-related degraded performance or if it would only improve temporary fatigue-related degradation of performance. Therefore, if the former group gained significant benefit from Modafinil, then they would expect positive results from the study. If Modafinil only worked for the latter type of individuals, then no significant results would be obtained. The study found no significant differences between placebo and Modafinil groups for executive function, tested by Trail-Making Test B (tests of speed of attention, sequencing, mental flexibility and visual search and motor function), letter fluency (part of the Controlled Oral Word Association Test – COWAT, using letters ‘F’, ‘A’ and ‘S’) and Stockings of Cambridge test (Spatial Planning). There were statistically significant differences in the Stroop test (perceptual shift test) for colour naming (of coloured dots) between the 200mg Modafinil group and placebo but this was not found for naming the text colour of a different colour word. Constructional ability was also found to be significantly different between the 200mg Modafinil and placebo group for the clock drawing task (visuospatial and constructional ability test).
In the 200mg Modafinil group, a decrement in performance was found in the Intra/Extra-dimensional shift task (attentional set shifting task). There was an increase in the total number of errors, total number of errors adjusted for the number of stages successfully completed, and the number of errors made at the extra dimensional shift stage (p=0.05 for each) when compared to the 100mg Modafinil and placebo group. This study found limited evidence of cognitive improvement with Modafinil use in non-sleep deprived middle-aged participants. It concluded that benefits might be more apparent in the fatigued or sleep deprived individual.

4.5 Mood

The effect of Modafinil on mood appears to be mild in healthy volunteers. A randomized crossover study involving 12 healthy volunteers (10 men, 2 women) suggests that Modafinil may have general mood elevating effects but it is accompanied by increased anxiety. Taneja et al (144) postulated that the elevated sympathetic activity may be interpreted by some individuals as signs of anxious arousal. The elevated Mood effect may be via mechanisms that are similar to stimulants. This was a 3 day counterbalanced study with a four day washout period between treatments (400mg Modafinil versus Placebo). Mood assessments were performed using Positive and Negative Affect Schedule and General Mood Scale Questionnaires.

In a double blind study also assessing mood in healthy non sleep deprived subjects, thirty individuals (19 men, 11 women) were randomly allocated to placebo, 100mg or 200mg Modafinil in a parallel designed study (145). A significant increase in Somatic
anxiety was found in the 100mg Modafinil group with individual ratings of ‘shaking’, ‘palpitations’, ‘dizziness’, ‘restlessness’, ‘muscular tension’, ‘physical tiredness’ and ‘irritability’ found to be increased. Increases in psychological anxiety and aggressive mood were also found in the 100mg Modafinil group after performing cognitive tests. It is interesting to note that this study did not find any significant cognitive enhancement in the individuals studied. Although admittedly this study was relatively small, it is argued that other pharmaceutical effects such as from lorazepam, temazepam and glycine have shown effects in groups of similar size. Modafinil effects in non-sleep deprived, healthy individuals are more evident under conditions of a higher cognitive load and this offers one explanation for the results.

4.6 ‘Off Label’ Use

The effects on the Central Nervous System by these medications can result in these pharmaceuticals being used ‘off label’ by individuals to gain an advantage. This has been documented in professional sport, where small gains can make a significant difference (157), and in students who attempt to have longer periods of concentration and reduced tiredness (158). The use of performance enhancers in sport has been band by the World Anti Doping Agency. It deemed that pharmaceuticals, such as Modafinil, could provide an unfair advantage over other competitors. This decision was made after Kelli White won Gold medals for 100m and 200m at the World Track and Field Championships in 2003 (157). It was later revealed that she did not suffer from Narcolepsy, which was initially claimed at the time.
The potential uses of these enhancers have also been considered by the military, with the wake promoting properties of Modafinil being used in troops during combat situations (159,160). This raises ethical issues as once a medication is being used for means separate to its license, then where should its applications end? Should surgeons, for altruistic means, be allowed to self-administer the medication for protracted and complex operations, especially if they occur at night?

The wake promoting properties of Modafinil have allowed for ‘sleep’ to be used as a ‘commodity of war’ (160). This concept allows for the determination of the amount of sleep required by individuals for set tasks and attempts to modify the amount of sleep with pharmaceuticals as determined by the situation on the ground. Although the UK military denies the use of Modafinil in the Iraq war, the Guardian (29 July, 2004) reported the purchase of:

‘more than 24,000 Provigil pills, which are licensed in Britain only to help people with rare sleeping disorders shrug off daytime sleepiness. Experts say the new drug could be used ‘off license’ to keep pilots and Special Forces troops awake on little sleep.’
4.7 Conclusion

The evidence for cognitive enhancement by Modafinil in the non-sleep deprived state predominantly involves studies with low participant numbers (130,143). The enhancement of the components of working memory is also variable (136,137). However, several studies demonstrate improvement in verbal working memory (129) and attention (131) (132). Animal studies have also indicated improved responses to information cues (161). With the focus of this thesis being on the recall of clinical information in the fatigued non-sleep deprived state, this information has influenced the design of the neuroenhancement study (Chapter 9).

Fatigue can reduce the cognitive performance of an individual. In the work place, this is usually acute mental fatigue and by definition, should improve if the individual is given sufficient time to rest. Admittedly this should be the first avenue of recuperation, along with access to adequate nutrition and basic stimulants of caffeine or chocolate. Yet in circumstances where this is deemed unfeasible, cognitive enhancement could be considered. To legislate this process one must first have evidence.

As Modafinil is used for chronic fatigue (162) and sleep deprived cognitive deterioration (163), there is a possibility that it would improve acute mental fatigue in the non-sleep deprived state. It may also attenuate these effects. Thus if an individual was going to be exposed to a prolonged cognitive fatiguing task and was required to continue to work without an appropriate rest opportunity, how would Modafinil influence the performance? In the medical work place this scenario could relate to a prolonged operation and patient assessments. Would verbal working memory and
recall of information be improved compared to placebo? Does Modafinil improve responses to information cues in a similar manner to animal models?

Publicity of neurocognitive enhancement has led to the self-administration of Modafinil by academics (164) and members of the medical profession (165). It is interesting to note that these individuals fluent in the interpretation of research are using Modafinil outside of current evidence. There is sufficient evidence to demonstrate cognitive enhancement or reversal of fatigue in the sleep deprived state (136,161,163). Yet evidence suggests enhancement may be restricted to individuals with lower levels of IQ (134). This is especially true for the non-sleep deprived state.

With information recall an essential element in handover, alternative interventions should be considered. There is already evidence to suggest use of Modafinil by the medical profession (41). Although some studies do show cognitive improvement, these are restricted to laboratory tasks. Cognitive enhancement is usually in lower IQ groups. It is essential for an evidenced based approach to assess the influence of Modafinil on the medical profession performing clinical tasks in-order to protect patients and users.
Chapter 5  Hypothesis

Previous chapters have discussed memory theory, the impact of acute mental fatigue and the current non-pharmaceutical and pharmaceutical fatigue management strategies.

The EWTD legislation was implemented to limit the maximum length of a shift and introduce minimum break durations. Due to the fluid environment of healthcare, fixed sessions and breaks are not easy to implement for medical staff. The intensity of the task (at any time point) and the physiological determinants of fatigue (e.g. night shift work and the influence on the circadian rhythm) are also not taken into account by this directive. It is for these reasons that FRMS were introduced within the aviation industry.

In summary, workers who are in a state of acute mental fatigue are at increased risk of making errors, placing their safety, that of their colleagues, and in the medical profession, patients, at risk(106). Fatigue and sleep deprivation are sometimes considered (inaccurately) synonymous. From the Levels of Processing theory, cognitive errors will occur the more superficial the level of information processing due to weaker encoding to long-term memory. It is my opinion that encoding, consolidation and memory retrieval are worsened when fatigued and that cognitive error is increased. In healthcare workers, this situation is likely to be worse with less experience (less related memory traces) and reduced understanding (less processing) of a clinical situation. These situations can occur at any time.

Handover of clinical information has been highlighted as an error prone procedure that is at high risk from fatigue with related patient safety concerns. It is a procedure
that is currently reliant on the accurate, concise recall of essential clinical information. To improve recall and reduce cognitive error one must therefore either improve fatigue, or implement an FRMS to reduce the depth of cognitive processing or improve understanding (to increase pathways for the memory trace to be linked and retrieved).

Checklists have been introduced to circumvent fatigue or the requirement of deep processing through presenting recognition prompts (i.e. a yes or no response to information provided) to reduce error and improve patient safety. However, in a dynamic environment such as handover, recognition prompts have limited application. Cue based recall is a generic association to the desired point of information compared to recognition memory and is also suitable for implementation within a handover document.

Acute mental fatigue is a phenomenon that occurs independently of sleep deprivation. With acute mental fatigue being persistently highlighted as a risk to patient safety despite implementation of the EWTD, additional fatigue risk management strategies should be considered to improve situations at high risk from fatigue related error. I hypothesise that:

- After implementation of the European Working Time Directive, fatigue is still a problem for doctors within the NHS.
- Recall of Clinical information is worse in the cognitively fatigued non-sleep deprived state.
• Cue based recall of clinical information will improve recall of clinical information in the cognitively fatigued non-sleep deprived state.

• The cognitive enhancer, Modafinil, will improve recall of clinical information compared to memory cues in the cognitively fatigued non-sleep deprived state.

Pre–EWTD, overall general fatigue was significantly higher (p<0.001) in the NHS workforce compared to the UK general population(48) with medical professionals reporting the highest levels of general fatigue. The following chapter investigates current fatigue in NHS doctors compared to pre-EWTD findings in the literature.
Chapter 6  Fatigue Survey

6.1  Abstract

6.1.1  Purpose
To identify current levels of fatigue in NHS doctors post implementation of the European Working Time Directive (EWTD).

6.1.2  Methods
A 49-question survey was electronically sent to hospital doctors whom were requested to complete the survey during a normal shift.

6.1.3  Results
68 hospital doctors responded to the regional survey. At the time of completion, greater than 91.2% were below optimum levels of alertness, with only 6.9% of respondents achieving recommended levels of sleep over the preceding week. 61.8% were subjectively fatigued at the time of completion of the survey, with 86.8% experiencing fatigue on at least a weekly basis. 70.7% were experiencing difficulty in recalling information when fatigued, subjectively reporting increased time required to complete a task.

Lack of Energy scored highly on the Swedish Occupational Fatigue Index, however, general fatigue scores were improved compared to 1997 levels. Despite this 43% do
not always feel safe performing their work due to fatigue with 36.2 % still attributing a near miss incident to fatigue.

6.1.4 Conclusions

There is evidence to suggest that fatigue is still a significant problem within the NHS. In this survey group, work hour limitation strategies may have improved fatigue levels compared to 1997 levels, yet there are still a high amounts of fatigue within medical staff and patient safety concerns.
6.2 Materials and Methods

A 49 question survey was created encompassing the Swedish Occupational Fatigue Index, fatigue questions from the short SF36 and a modified Visual Analogue Scale. Information on fatigue related errors, mood and measures taken to resist the effects of fatigue were also acquired. Participants were requested to fill in the questionnaire during a normal work shift. Quality of work-life balance and job satisfaction were also assessed.

6.2.1 Subjects

Questionnaires were administered electronically using Survey Monkey to hospital doctors within Northwest and southwest London deaneries in Accident & Emergency, Medicine and Surgical Specialities. 68 responses to the survey were obtained with 85.7% of respondents completing the questionnaire.

6.2.2 Demographics

Respondents to the questionnaire were requested to provide details of age, sex, time of questionnaire completion, job position and grade.
6.2.3 Questionnaire

General fatigue based information was requested regarding frequency of perceived fatigue and subjective fatigued at the time of the questionnaire. Subjects were asked what factors contributed towards their fatigued state and whether they expected this as part of their work. Attitudes towards work, sleepiness and concentration were assessed. Perceived Fatigue was measured using three separate scales.

6.2.3.1 Swedish Occupational Fatigue Inventory

This consists of 25 items divided into five dimensions of fatigue (166) (Table 6-1):-
Table 6-1: Swedish Occupational Fatigue Inventory

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Items Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of energy</td>
<td>1. Worn Out,</td>
</tr>
<tr>
<td></td>
<td>2. Exhausted,</td>
</tr>
<tr>
<td></td>
<td>3. Spent,</td>
</tr>
<tr>
<td></td>
<td>4. Drained,</td>
</tr>
<tr>
<td></td>
<td>5. Overworked</td>
</tr>
<tr>
<td>Physical exertion</td>
<td>1. Palpitations</td>
</tr>
<tr>
<td></td>
<td>2. Sweaty,</td>
</tr>
<tr>
<td></td>
<td>3. Warm,</td>
</tr>
<tr>
<td></td>
<td>4. Out of breath,</td>
</tr>
<tr>
<td></td>
<td>5. Breathing heavily</td>
</tr>
<tr>
<td>Physical discomfort</td>
<td>1. Tense Muscles</td>
</tr>
<tr>
<td></td>
<td>2. Numbness,</td>
</tr>
<tr>
<td></td>
<td>3. Stiff Joints,</td>
</tr>
<tr>
<td></td>
<td>4. Hurting,</td>
</tr>
<tr>
<td></td>
<td>5. Aching</td>
</tr>
<tr>
<td>Lack of motivation</td>
<td>1. Lack of Concern</td>
</tr>
<tr>
<td></td>
<td>2. Listless,</td>
</tr>
<tr>
<td></td>
<td>3. Passive,</td>
</tr>
<tr>
<td></td>
<td>4. Indifferent,</td>
</tr>
<tr>
<td></td>
<td>5. Uninterested</td>
</tr>
<tr>
<td>Sleepiness</td>
<td>1. Lazy,</td>
</tr>
<tr>
<td></td>
<td>2. Falling Asleep</td>
</tr>
<tr>
<td></td>
<td>3. Drowsy,</td>
</tr>
<tr>
<td></td>
<td>4. Yawning,</td>
</tr>
<tr>
<td></td>
<td>5. Sleepy</td>
</tr>
</tbody>
</table>
6.2.3.2 Fatigue measurement

To provide a comparison to fatigue levels in the NHS, a survey of 7720 NHS staff (927 doctors) was used as a direct comparison. Identical questions were used to provide one of the fatigue assessments within the survey. This comprised of two parts (Table 6-2). The first comprised of questions from the Short SF36(167). These questions were from the energy vitality scale. This consisted of three items that had identical wording as the previous paper. These were scored on a six-point scale from 'none of the time' to 'all of the time'.

Table 6-2: Fatigue Measurement

<table>
<thead>
<tr>
<th>Part 1 - Fatigue Questions SF36 – Energy Vitality Scale</th>
<th>Part 2 - Fatigability Questions Population Based Fatigue Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>How much time during the last month...</td>
<td></td>
</tr>
<tr>
<td>1. Did you have a lot of energy?</td>
<td>1. Did your muscles hurt at rest?</td>
</tr>
<tr>
<td>2. Did you feel worn out?</td>
<td>2. Did your muscles hurt after exercise?</td>
</tr>
<tr>
<td>3. Did you feel tired?</td>
<td></td>
</tr>
</tbody>
</table>

The second part consisted of two questions and were used from a population based fatigue study(48) to assess fatigability. Answers were rescored using protocol from Hardy et al (87), with two sets of outcomes scores measured:
1. 'yes' for answers of 'all of the time', 'most of the time' and good bit of the time' or 'no' for 'some of the time', 'a little of the time' and 'none of the time'.

2. 'yes' for answers of 'all of the time', 'most of the time', good bit of the time' and 'some of the time' or no for 'a little of the time' and 'none of the time'.

6.2.3.3 Modified VAS

Due to the inability to access a Visual Analogue Scale using the online survey package, an 11-point (un-numbered) scale was used. Feelings were described at each end of the scale, with the mid-point indicating no preference to the stated feelings (example shown in Figure 6-1). Sixteen different sets of opposing terms were used (Table 6-3).

Figure 6-1: Example of Scale
Table 6-3: Modified VAS - Opposing Terms

<table>
<thead>
<tr>
<th>Opposing Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Alert - Drowsy</td>
</tr>
<tr>
<td>2. Calm - Excited</td>
</tr>
<tr>
<td>3. Strong - Feeble</td>
</tr>
<tr>
<td>4. Muzzy - Clearheaded</td>
</tr>
<tr>
<td>5. Well-co-ordinated - Clumsy</td>
</tr>
<tr>
<td>6. Lethargic - Energetic</td>
</tr>
<tr>
<td>7. Contented - Discontented</td>
</tr>
<tr>
<td>8. Troubled - Tranquil</td>
</tr>
<tr>
<td>9. Mentally Slow - Quick-witted</td>
</tr>
<tr>
<td>10. Tense - Relaxed</td>
</tr>
<tr>
<td>11. Incompetent - Proficient</td>
</tr>
<tr>
<td>12. Happy - Sad</td>
</tr>
<tr>
<td>13. Antagonistic - Amicable</td>
</tr>
<tr>
<td>14. Interested - Bored</td>
</tr>
<tr>
<td>15. Withdrawn - Gregarious</td>
</tr>
<tr>
<td>16. Attentive - Dreamy</td>
</tr>
</tbody>
</table>

6.2.4 Stimulant use

General and specific use of caffeine based drinks, stimulant drinks, pro plus and Modafinil administration was assessed.
6.3 Results

6.3.1 Demographics

There were 68 participants in the NHS survey of whom 22.06% were aged between 21-29yrs, 67.65% were between 30-39yrs, 8.82% were between 40-49yrs and 1.47% aged between 50-59yrs.

57.35% were male (42.65% were female). The time of survey completion was divided into 06:00-12:00hrs, 12:00-18:00hrs, 18:00-24:00hrs and 24:00-06:00hrs. 22.06% of respondents completed the survey between 06:00-12:00hrs, 47.06% between 12:00-18:00hrs, 26.47% between 18:00-24:00hrs, and 4.41% completing between 24:00-06:00hrs. 11 (FY1’s), 10 (FY2-CT2), 45 (ST3-ST8/equivalent) and 2 consultants responded to the questionnaire.

6.3.2 Degree of Sleepiness – Stanford Sleepiness Scale (Appendix 1)

At the time of completing the questionnaire (Of 68 respondents), only 8.82% were subjectively wide-awake, with 41.18% subjectively feeling that they were functioning at a high, but not optimum level. The remaining 50% of respondents were functioning in a state of decreased alertness, with 17.65% reporting they subjectively felt ‘not fully alert’, 22.06% felt ‘somewhat foggy and let down’, 7.35% feeling sleepy/woozy and 2.94% (2) having ‘dream like thoughts’ (Mean values shown Table 6-4).
Table 6-4: Stanford Sleepiness Scale

<table>
<thead>
<tr>
<th></th>
<th>Mean Score (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK All</td>
<td>2.87 (1.25)</td>
</tr>
<tr>
<td>Male</td>
<td>2.92 (1.37)</td>
</tr>
<tr>
<td>Female</td>
<td>2.79 (1.08)</td>
</tr>
</tbody>
</table>

Table 6-5: Stanford Scale Scores

1. Feel active, vital, alert, or wide awake
2. Functioning at a high level but not at peak; able to concentrate
3. Awake but relaxed, not fully alert
4. Somewhat foggy, let down
5. Foggy, losing interest in staying awake; let down
6. Sleepy, woozy, fighting sleep; prefer to lie down
7. No longer fighting sleep, onset soon; having dream like thoughts

Only 6.90% of respondents achieved the average recommended amount of sleep (8hrs/day) over the preceding week. Most (46.55%) were averaging 6 hours of sleep, with 24.14% reporting 7 hours. 22.41% of respondents were having less than 6 hours of sleep in a 24 hour period. The mean (sd) hours sleep over the preceding week for males was 6.05 hours (1.07) and 6.5 hours (1.14) for females (Table 6-5). 75.86% of respondents felt tasks took longer to complete when fatigued, with 60.35% reporting a reduced confidence when fatigued. Situations
were subjectively more confusing for 48.28% of respondents with 65.52% having a greater reliance on documentation, and 70.69% subjectively reporting increased difficulty in recall of information (Fig. 6-2). Mean Likert score values are shown in Table 6-6.

Table 6-5: Average Hours Sleep, Concentration and Ability To Learn A New Task.

<table>
<thead>
<tr>
<th></th>
<th>Average Hours Sleep hrs</th>
<th>Ability to concentrate?</th>
<th>Ability to learn a new task?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UK (sd)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>6.05 (1.07)</td>
<td>3.47 (0.80)</td>
<td>3.40 (0.82)</td>
</tr>
<tr>
<td>Male</td>
<td>5.78 (0.93)</td>
<td>3.56 (0.88)</td>
<td>3.39 (0.93)</td>
</tr>
<tr>
<td>Female</td>
<td>6.50 (1.14)</td>
<td>3.32 (0.65)</td>
<td>3.41 (0.59)</td>
</tr>
</tbody>
</table>

Likert Scale

The above table indicates the average hours sleep/night over the preceding week. The subjective ‘ability to concentrate’ and the ‘ability to learn a new task’ in the fatigued state were assessed using the displayed Likert Scale (‘not at all’ = 1 and ‘extremely well’ = 5, example above)
Figure 6-2: Cluster Column Chart Depicting The Subjective Recall Of Clinical Information And The Use Of Documentation To Aid Recall (When Fatigued).
Table 6-6: Recall Of Information, Use Of Documentation, Confusion And Subjective Performance Times To Complete A Task

<table>
<thead>
<tr>
<th></th>
<th>Do you have any difficulty remembering information</th>
<th>Do you rely on your documentation to remember information</th>
<th>Do you find situations more confusing</th>
<th>Does it take longer to complete a task</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UK</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>3.72 (0.64)</td>
<td>3.83 (0.63)</td>
<td>3.47 (0.63)</td>
<td>3.88 (0.60)</td>
</tr>
<tr>
<td>Male</td>
<td>3.61 (0.65)</td>
<td>3.67 (0.54)</td>
<td>3.42 (0.65)</td>
<td>3.75 (0.50)</td>
</tr>
<tr>
<td>Female</td>
<td>3.91 (0.61)</td>
<td>4.09 (0.68)</td>
<td>3.55 (0.60)</td>
<td>4.09 (0.68)</td>
</tr>
</tbody>
</table>

Ratings were obtained using a Likert scale, where ‘A lot less than usual’ = 1 and ‘A lot more than usual’ = 5. Mean results shown with standard deviation in brackets.
6.3.3 Fatigue

61.77% felt fatigued at the time of completion of the survey [mean (sd) values for subjective fatigue (Yes=1, No=2) in the group were 1.52 (0.89), 1.56 (0.91) for males and 1.45 (0.87) for females]. 67.65% experienced fatigue at work more than once per week with 19.12% reporting weekly symptoms. The remaining 13.24% experienced fatigue every 2 weeks or less (mean values of Likert Scale displayed in Table 6-7).

Table 6-7: Frequency of Fatigue

<table>
<thead>
<tr>
<th>Groups</th>
<th>UK - mean (sd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>1.52 (0.89)</td>
</tr>
<tr>
<td>Male</td>
<td>1.56 (0.91)</td>
</tr>
<tr>
<td>Female</td>
<td>1.45 (0.87)</td>
</tr>
</tbody>
</table>

‘How often do you feel fatigued at work?
More than once a week = 1, Once a week = 2, Once every 2 weeks =3, Once a month = 4, Less than once a month = 5, Never = 6

Attitudes towards fatigue were assessed using a Likert scale. 72.41% of respondents expressed the view that the fatigue experienced was expected for the job they performed (agreed/strongly agreed), with 84.48% reporting that they expect to get fatigued at work. 60.35% feel that they are unable to avoid becoming fatigued at work, whilst 68.97% did not believe their employer (the
NHS) was implementing sufficient measures to reduce fatigue (see Table 6-8). 65.52% feel the NHS could do more to prevent fatigue at work. The most worrying subjective response is that 43.10% do not always feel safe performing their work due to fatigue (Fig.6-3). A total of 72.41% of respondents felt that patients were placed at risk when they were fatigued (Fig.6-4). Finally, 36.21% of respondents have attributed a ‘near miss’ to fatigue (mean values shown Table 6-9).
### Table 6-8: Work Related Fatigue

Participants rated their subjective feelings related to six statements using a likert scale:

<table>
<thead>
<tr>
<th>Statement</th>
<th>UK</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>I expect to get fatigued by my job</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The fatigue I experience is expected for the job I perform</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The fatigue I experience is comparable to similar salary jobs.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>There is no way to avoid the fatigue from my job</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My employer is trying to implement measures to improve fatigue</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My employer could do more to prevent fatigue</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>I expect to get fatigued by my job</td>
<td>3.95 (0.63)</td>
<td>3.86 (0.59)</td>
<td>4.09 (0.68)</td>
</tr>
<tr>
<td>The fatigue I experience is expected for the job I perform</td>
<td>3.74 (0.85)</td>
<td>3.83 (0.66)</td>
<td>3.59 (1.10)</td>
</tr>
<tr>
<td>The fatigue I experience is comparable to similar salary jobs.</td>
<td>2.36 (1.21)</td>
<td>2.28 (1.09)</td>
<td>2.50 (1.41)</td>
</tr>
<tr>
<td>There is no way to avoid the fatigue from my job</td>
<td>3.46 (1.06)</td>
<td>3.39 (1.05)</td>
<td>3.59 (1.10)</td>
</tr>
<tr>
<td>My employer is trying to implement measures to improve fatigue</td>
<td>1.90 (0.97)</td>
<td>1.81 (0.951)</td>
<td>2.05 (1.00)</td>
</tr>
<tr>
<td>My employer could do more to prevent fatigue</td>
<td>3.71 (1.09)</td>
<td>3.61 (1.15)</td>
<td>3.86 (0.99)</td>
</tr>
</tbody>
</table>

where ‘strongly disagree’ =1 and ‘strongly agree’ = 5.
Figure 6-3: Ability To Perform Work When Fatigued

I do not always feel that I am safe performing my work due to fatigue

Subjective Risk When Fatigued At Work

<table>
<thead>
<tr>
<th>Percentage (%)</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither Agree or Disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>15</td>
</tr>
</tbody>
</table>
Figure 6-4: Response To The Safety of Patients When Fatigued At Work

Do you feel the safety of your patients is at risk when you are fatigued?

<table>
<thead>
<tr>
<th>Subjective Risk To Patient Safety</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All the time</td>
<td>0</td>
</tr>
<tr>
<td>A large amount of the time</td>
<td>10</td>
</tr>
<tr>
<td>A small amount of the time</td>
<td>60</td>
</tr>
<tr>
<td>Not at all</td>
<td>20</td>
</tr>
</tbody>
</table>
Participants were questioned on patient safety, near miss incidents and subjective competence when fatigued. For the question of patient safety when fatigue, a likert scale was used: where ‘all the time’ =1 and ‘not at all’ = 4

Near Miss incidents were rated as Yes=1, No=2

For the statement ‘I do not always feel safe to perform my job due to fatigue’ the response was rated on the likert scale:

where ‘strongly disagree’ =1 and ‘strongly agree’ = 5
6.3.4 Attitude Towards Work

63.79% of respondents expressed the view that the level of fatigue was not similar to other jobs of similar pay scales. 18.97% were dissatisfied or very dissatisfied with their jobs and 24.14% suggested they would leave their job if offered a different job with a similar salary (mean values are shown in Table 6-10). Half of respondents found it ‘not at all easy’ to balance work with their personnel life. However, only 8.62% rated their quality of life as being poor or very poor.

Table 6-10: Job Satisfaction and Work/Life Balance

<table>
<thead>
<tr>
<th></th>
<th>How satisfied are you with your job?</th>
<th>Would you choose an alternative Career?</th>
<th>How easy is it to balance your work life and personal life?</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK (sd)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>3.55 (0.99)</td>
<td>1.24 (0.43)</td>
<td>4.31 (0.80)</td>
</tr>
<tr>
<td>Male</td>
<td>3.61 (1.08)</td>
<td>1.28 (0.45)</td>
<td>4.28 (0.82)</td>
</tr>
<tr>
<td>Female</td>
<td>3.46 (0.86)</td>
<td>1.18 (0.40)</td>
<td>4.36 (0.79)</td>
</tr>
</tbody>
</table>

Job satisfaction was rated on the likert scale:

<table>
<thead>
<tr>
<th>Very dissatisfied</th>
<th>Dissatisfied</th>
<th>Neither dissatisfied or satisfied</th>
<th>Satisfied</th>
<th>Very Satisfied</th>
</tr>
</thead>
</table>

with ‘Very Dissatisfied’ = 1 and ‘Very Satisfied’=5

If offered an alternative career for the same pay, participants answered Yes=1, No=2,

With work –life balance rated from ‘extremely easy’(1), ‘very easy’(2), ‘moderately easy’(3), ‘slightly easy’(4) and ‘not easy at all’(5)
6.3.5 Causation

‘Lack of Sleep’ was the commonest cause of fatigue with a mean (sd) score of 4.37 (1.29) with clinical work, 3.99 (1.28), and Stress, 3.81 (1.44), also scoring highly (Table 6.11).

<table>
<thead>
<tr>
<th>Clinical Work (sd)</th>
<th>Non-Clinical Work (sd)</th>
<th>Family (sd)</th>
<th>Stress (sd)</th>
<th>Lack of Sleep (sd)</th>
<th>Recent Illness (sd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>3.99 (1.28)</td>
<td>3.53 (1.49)</td>
<td>2.59 (1.64)</td>
<td>3.81 (1.44)</td>
<td>4.37 (1.29)</td>
</tr>
<tr>
<td>Male</td>
<td>3.87 (1.15)</td>
<td>3.54 (1.30)</td>
<td>2.64 (1.58)</td>
<td>3.64 (1.51)</td>
<td>4.44 (1.14)</td>
</tr>
<tr>
<td>Female</td>
<td>4.14 (1.43)</td>
<td>3.52 (1.75)</td>
<td>2.52 (1.75)</td>
<td>4.03 (1.32)</td>
<td>4.28 (1.49)</td>
</tr>
</tbody>
</table>

Questions were rated from ‘Not at all’ = 1 to ‘To a very high degree’ = 6
6.3.6 Levels of fatigue

The overall mean (sd) fatigue score was 54.03 (18.46), with males (n= 36) scoring 59.57 (17.37) and females (n=22) scoring 45.46 (17.09). Fatigability results are shown in Table 6-12. Overall, the percentage of respondents scoring "yes" to having muscle pain at rest were 20.69% and 48.28%, respectively; and scoring "yes" to having muscle pain after exercise were 39.66% and 67.24%, respectively.

Table 6-12: Fatigability

<table>
<thead>
<tr>
<th></th>
<th>Over the last month....</th>
<th>Did your muscles hurt at rest? (%)</th>
<th>Did your muscles hurt after exercise? (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>UK Score 1</td>
<td>Score 2</td>
</tr>
<tr>
<td>UK All</td>
<td></td>
<td>20.69</td>
<td>48.28</td>
</tr>
<tr>
<td>All Male</td>
<td></td>
<td>10.35</td>
<td>24.14</td>
</tr>
<tr>
<td>All Female</td>
<td></td>
<td>10.35</td>
<td>24.14</td>
</tr>
</tbody>
</table>
6.3.7 Swedish Occupational Fatigue Inventory

The highest scoring dimensions were Lack of Energy and Sleepiness with mean (sd) values of 5.17 (2.68) and 3.45 (3.02) respectively. Females scored higher in the dimensions ‘Lack of Energy’, ‘Physical discomfort’, ‘Lack of Motivation’ and ‘Sleepiness’ compared to male counterparts (Table 6-13).

Table 6-13: Swedish Occupational Fatigue Inventory

<table>
<thead>
<tr>
<th></th>
<th>Lack of Energy (sd)</th>
<th>Physical Exertion (sd)</th>
<th>Physical Discomfort (sd)</th>
<th>Lack of Motivation (sd)</th>
<th>Sleepiness (sd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>5.17 (2.68)</td>
<td>1.08 (2.17)</td>
<td>2.01 (2.84)</td>
<td>2.58 (2.42)</td>
<td>3.45 (3.02)</td>
</tr>
<tr>
<td>Male</td>
<td>4.81 (2.75)</td>
<td>1.10 (2.17)</td>
<td>1.91 (2.78)</td>
<td>2.33 (2.44)</td>
<td>2.84 (2.88)</td>
</tr>
<tr>
<td>Female</td>
<td>5.79 (2.45)</td>
<td>1.05 (2.19)</td>
<td>2.18 (2.93)</td>
<td>2.97 (2.34)</td>
<td>4.50 (2.99)</td>
</tr>
</tbody>
</table>

6.3.8 Mood

The average mood of participants was rated between ‘neither happy or sad’ and ‘happy’ for the survey group and for male and female sub-groups. This rating persisted for subjective mood over the preceding month (mean values shown in Table 6-14). Only 18.3% of participants surveyed rated their mood as ‘sad’ or ‘very sad’.
6.3.9 Modified VAS

The mean scores for the modified VAS are shown in Table 6-15.

All mean ratings except Lethargic-Energetic are shifted towards the positive, less fatigued rating. Lethargic-Energetic scored a mean (sd) result of 4.80 (2.36) with 46.03% of respondents subjectively lethargic whilst working. However, although the remaining mean values are shifted away from fatigue, a large proportion of doctors who completed the survey were rated as being impaired. 36.51% of respondents were drowsy and feeling tense, 31.75% were feeling mentally slow,
23.81% incompetent and antagonistic. At the time of survey completion, a large proportion of the workforce was functioning in a physical state that would be considered unacceptable for the delivery of high quality care.
Table 6-15: Modified Visual Analogue Scale (UK Group)

<table>
<thead>
<tr>
<th>Alert-Drowsy</th>
<th>Calm-Excited</th>
<th>Strong-Clumsy</th>
<th>Muzzy-Clearheaded</th>
<th>Well co-ordinated-Clumsy</th>
<th>Lethargic-Energetic</th>
<th>Contented-Discontented</th>
<th>Troubled-Tranquil</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UK</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>4.22 (2.45)</td>
<td>3.28 (1.64)</td>
<td>4.36 (2.03)</td>
<td>5.75 (2.24)</td>
<td>3.38 (2.19)</td>
<td>4.80 (2.36)</td>
<td>4.03 (2.05)</td>
</tr>
<tr>
<td>Male</td>
<td>3.95 (2.48)</td>
<td>3.03 (1.68)</td>
<td>4.15 (2.22)</td>
<td>6.03 (2.21)</td>
<td>3.26 (2.14)</td>
<td>5.21 (2.48)</td>
<td>4.18 (2.13)</td>
</tr>
<tr>
<td>Female</td>
<td>4.64 (2.38)</td>
<td>3.68 (1.52)</td>
<td>4.68 (1.70)</td>
<td>5.32 (2.27)</td>
<td>3.56 (2.31)</td>
<td>4.16 (2.04)</td>
<td>3.80 (1.94)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UK</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>5.75 (2.25)</td>
<td>5.20 (2.04)</td>
<td>6.22 (2.15)</td>
<td>3.76 (2.08)</td>
<td>6.16 (2.23)</td>
<td>4.38 (2.29)</td>
<td>5.28 (1.77)</td>
</tr>
<tr>
<td>Male</td>
<td>5.92 (2.26)</td>
<td>5.36 (2.21)</td>
<td>6.33 (2.19)</td>
<td>3.58 (2.21)</td>
<td>6.26 (2.28)</td>
<td>4.64 (2.23)</td>
<td>5.21 (1.79)</td>
</tr>
<tr>
<td>Female</td>
<td>5.48 (2.24)</td>
<td>4.96 (1.77)</td>
<td>6.04 (2.11)</td>
<td>4.04 (1.86)</td>
<td>6.00 (2.18)</td>
<td>3.96 (2.37)</td>
<td>5.40 (1.76)</td>
</tr>
</tbody>
</table>

Sixteen different sets of opposing terms were used to describe different aspects of the participants affect. An 11 point scale was used, with opposing feelings described at each end of the scale with the mid-point rating as no preference to the stated feelings. Mean values are displayed depicting position on the scale.
6.3.10 Stimulant Usage

Caffeine usage during an average working day is low. 38.24% do not drink tea, 23.53% do not drink coffee and 86.77% deny consuming drinks containing stimulants. When subjectively fatigued 80.88% have tried to use coffee, 57.35% have tried to use tea, 54.41% chocolate and 33.82% have tried stimulant drinks to improve their symptoms. 4.41% have used Pro-Plus and 1.47% have used Modafinil, a cognitive enhancer with wake promoting properties (mean values displayed Table 6-16).

<table>
<thead>
<tr>
<th>Use of Stimulants to improve fatigue:</th>
<th>Coffee</th>
<th>Tea</th>
<th>Stimulant Drinks</th>
<th>Pro-plus</th>
<th>Chocolate</th>
<th>Modafinil</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UK</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>1.81 (0.40)</td>
<td>1.57 (0.50)</td>
<td>1.34 (0.48)</td>
<td>1.04 (0.21)</td>
<td>1.54 (0.50)</td>
<td>1.02 (0.12)</td>
</tr>
<tr>
<td>Male</td>
<td>1.85 (0.37)</td>
<td>1.56 (0.50)</td>
<td>1.36 (0.49)</td>
<td>1.03 (0.16)</td>
<td>1.44 (0.50)</td>
<td>1.03 (0.16)</td>
</tr>
<tr>
<td>Female</td>
<td>1.76 (0.44)</td>
<td>1.59 (0.50)</td>
<td>1.31 (0.47)</td>
<td>1.07 (0.26)</td>
<td>1.69 (0.47)</td>
<td>1.0 (0)</td>
</tr>
</tbody>
</table>

Participants responded to a Yes =2, No=1 question for ‘Stimulant use to improve subjective fatigue’.
6.4 Discussion

Despite the introduction of the EWTD and resultant work hour restrictions, the current survey suggests that doctors still experience significant levels of fatigue. At the time of the survey, 61.77% of respondents were subjectively fatigued with 67.65% reporting fatigue more than once a week. The majority of surveys were completed during daylight hours. Almost three quarters of the respondents (72.41%) felt patients were being placed at risk through staff fatigue and 36.21% had attributed a ‘near miss’ due to fatigue. These findings suggest concerning levels of fatigue and potential exposure of patients to clinicians who are at increased risk of error (106).

Fatigue scores from the short SF36 were found to be similar to pre-EWTD findings (87). Hardy et al (87) found male doctor fatigue levels of 53.67 and 46.95 in females (lower scores indicate worse fatigue). Data from the current survey suggest that there has been little change in fatigue scores despite the introduction of EWTD legislation [mean scores (sd): male=59.57 (17.37) and females= 45.46 (17.09)].

The impact of fatigue on ‘muscle pain’ was found to be worse compared to those in 1997, i.e. prior to the introduction of working time directives. Whereas previous levels of muscle pain at rest were 22.9% and 7.5% (score 1 and 2), respectively; and scoring “yes” to having muscle pain after exercise were 37.1% and 12.6% (87), this has increased to 48.28% and 20.69% at rest; and 67.24 and 39.66% after exercise.
The SOFI indicates high mean (sd) scores in the dimensions of ‘Lack of Energy’ of 5.17 (2.68) [male=4.81 (2.75), female=5.79 (2.45)], and that of ‘Sleepiness’ of 3.45 (3.02) [male=2.84 (2.88), f=4.50 (2.99)]. It is interesting to note that Swedish medical personnel also scored highly (166) for ‘Lack of Energy’, mean=4.99, and 2.72 for ‘Sleepiness’. These again were the highest scoring dimensions. Scores suggest comparative, if not worse SOFI scores than Swedish medical staff in 1997.

The modified VAS scale similarly indicated that respondents were subjectively sleepy. However, the mean is not necessarily the best indicator on this scale. One would hope that staff would feel subjectively alert rather than drowsy, whilst at work, indicating a left sided shift graphically.

The current survey suggests that despite implementation of the EWTD, clinicians still do not obtain sufficient sleep. With only 6.9% of respondents found to average the recommended amount of sleep over the week preceding the survey, fatigue could still be a result of sleep deprivation. Indeed, the average amount of sleep obtained by female doctors during the week preceding the survey was 6.5hrs compared to 6.05hrs for men. This questions whether the legislation is effective in increasing rest or whether it is insufficient as a standalone intervention to manage workplace fatigue? Other factors not addressed by the EWTD may also influence fatigue e.g. task intensity, circadian effects, family life or gender susceptibility as although men rated less fatigued they also had less sleep.
In the survey, recall of clinical information was subjectively worse (in 70.69% of respondents) when fatigued. Individual coping strategies suggested an increased reliance on documentation (by 65.52%) and stimulant use, including Modafinil (by 1.47%). When fatigued, 48.28% of respondents found situations more confusing and took longer to complete tasks (75.86%). This would suggest that further fatigue risk management strategies should be considered to support situations where healthcare professionals experience increased cognitive load. Handover has been highlighted as being at increased risk of error especially when fatigued (4) and would be suitable for FRMS. Potential strategies are the use of documentation with memory cues to aid recall of clinical information. This cognitive aid may also reduce confusion improving handover. The use of the cognitive enhancer and wake promoting agent, Modafinil could also be used to improve focus, attention (136) and recall (129) of clinical information, especially as 35.94% of respondents were subjectively drowsy at work.

6.5 Conclusion

With 84.48% of respondents expecting to feel fatigued by their job and 60% indicating fatigue from work as unavoidable, it is not surprising that the survey found 43.1% of respondents reporting an episode where they felt unsafe to perform their work. One should always be cautious extrapolating results from a small study, however, good clinical practice would suggest that further research to provide fatigue management strategies could only be advantageous to clinical practice. To that end, the following chapters investigate the influence of fatigue
on the recall of clinical information and attempts to develop cued recall and
Modafinil as fatigue management strategies.
Chapter 7  The Preservation of Cued Recall in the Acute Mentally Fatigued State - A Randomised Crossover Study

7.1  Abstract

7.1.1  Purpose
To investigate the impact of acute mental fatigue on the recall of clinical information in the non-sleep deprived state.

Acute Mental Fatigue in the non-sleep deprived subject is rarely studied in the medical workforce. Patient handover has been highlighted as an area of high risk especially in fatigued subjects. This study evaluates the deterioration in recall of clinical information over a 2 hour time period with cognitively demanding work in non-sleep deprived subjects.

7.1.2  Method
A randomised crossover study involving twenty medical students assessed free (presentation) and cued (MCQ) recall of clinical case histories at 0 and 2 hours under low and high cognitive load settings using the N-Back task. Acute Mental Fatigue was assessed through the Visual Analogue Scale (Appendix 2), Stanford Scale and NASA-TLX Mental Workload Rating Scale (Appendix 3).
7.1.3 Results
Free recall is significantly impaired by increased cognitive load (p<0.05) with subjects demonstrating perceived mental fatigue during the high cognitive load assessment. There was no significant difference in the amount of information retrieved by cued recall under high and low cognitive load conditions (p =1).

7.1.4 Discussion
This study demonstrates the loss of clinical information over a short time period involving a mentally fatiguing, high cognitive load task. Free recall for the handover of clinical information is unreliable. Memory cues maintain recall of clinical information. This study provides evidence towards the requirement for standardisation of a structured patient handover. The use of memory cues (involving recognition memory and cued recall methodology) would be beneficial in a handover checklist to aid recall of clinical information and supports evidence for their adoption into clinical practice.
7.2 Introduction

In 2004, the World Health Organisation identified fatigue as a leading factor in medical error and injury in healthcare (112). Current fatigue management comprises work hour’s reduction with interspersed breaks. The Accreditation Council for Graduate Medical Education (ACGME) has twice recommended reductions in work time for medical trainees due to concerns regarding fatigue (86). In the UK, the working hours legislation was principally introduced as part of the European Working Time Directive (EWTD) (7) with work hours expected to average 48 hours by August 2009. Despite these restrictions, fatigue has still been highlighted as a concern within the medical profession with the Joint Commission Patient Safety Advisory Group issuing a Sentinel Event Alert in December 2011 (168).

As healthcare worker fatigue is linked to patient safety, it has been recommended that healthcare organisations examine processes where patients are “handed off” or transitioned from one caregiver to another. This is an area of risk that is compounded by fatigue (114). However, there are no reports of studies specifically investigating the impact of acute mental fatigue on the recall of clinical information in the non-sleep deprived state.

Rather, the majority of fatigue literature focuses on cognitive assessment in the sleep deprived state. Examples have included word recollection tasks in Emergency department doctors (95), and assessments on vigilance and reaction times as part of a battery of cognitive tests in year 1 qualified doctors (169). These demonstrate impaired performance with post shift reduced word recall and reaction times that declines with increased loss of sleep during vigilance assessment. Fatigue studies frequently imply sleep deprivation studies that are typically lab-based or performed
around shift work. However, acute mental fatigue produced through high mental workload can also cause impairment in working memory (170), but is less recognised or addressed by the medical profession. Hence, one does not necessarily need to be sleep-deprived to be fatigued, and the impact of fatigue on clinical performance in the non-sleep deprived state remains unknown.

I hypothesise that memory cues (cued recall and recognition memory) can improve the recall of clinical information in the of acute mentally fatigued, non-sleep deprived state.

This study aims to investigate whether acute mental fatigue in non-sleep deprived state influences free- and cued-recall/ recognition memory of clinical data. Using a reproducible fatigue-inducing task and clinical case histories, it is the first step in creating an evidence-based handover process that may have potential in offsetting fatigue induced performance decline and clinical errors.
7.3 Material and Methods

The study followed a randomized crossover design. Ethical approval was granted by Cambridgeshire Research Ethics Committee1 (Ref:09/H0304/24). Site-specific approval, sponsorship, and funding were provided by Imperial College London.

20 medical students familiar with case history presentation skills were recruited.

Prior to commencing the study, participants completed a National Adult Reading Test (NART – Appendix 4) (171), baseline demographics and health questionnaire (Appendix 5). A Confidence questionnaire, Stanford Sleepiness Scale (172) investigating subjective fatigue and Visual Analogue Score(VAS) (173) assessing sixteen dimensions of opposing conditions, that include alert-drowsy, attentive-dreamy and incompetent-proficient, were completed before each session.

7.3.1 Study Design

Participants were recruited to a two day randomized crossover study between February and August 2012 (Figure 7-1 & 7-2). Randomisation was by a blinded sealed brown envelope allocation to one of four groups (to counterbalance the study) Groups were defined by order of cognitive load, questionnaire assessment and set of case histories used (illustrated in Figure 7-1).

The study was performed in an empty quiet, room. All participants were required to be healthy individuals taking no regular medications, and free from stimulants (caffeine) from midnight prior to the study. Any past medical history or illness that could impair cognition excluded participation in the study.
Participants completed baseline questionnaires at 0930 hours. A 20-minute memorisation task followed where candidates were allocated 4 minutes per case history. Candidates were provided 1 case at a time in a specific order. Each case was removed after 4 minutes to allow for 5 cases to be read in the allocated time period. Time Point 1 Baseline assessments of Free recall of clinical information, Multiple Choice Questions and the non-clinical Verbal Recognition Memory task (CANTAB) were then performed. The cognitive loading task (N-Back) – level dependent on randomisation, immediately followed, with the VAS and NASA-TLX questionnaires subsequently performed pre and post Time Point 2 assessments.
A crossover design study involving 20 participants. Participants were randomised to 1 of 4 Groups at session 1 (S1) that had been allocated to high (HCL) or low (LCL) cognitive loads. Order of MCQ’s were counterbalanced between groups. At the end of the study, 1 candidate was excluded from Group 3 and Group 4.
Participants completed baseline questionnaires prior to reading 5 Case Histories for a 20-minute time period. Free and Cued recalls were observed consecutively for clinical and non-clinical information at ‘Assessment 1’. Easy or hard 90-minute cognitive loading was performed according to allocation. Once completed, participants repeated a Free and Cued Recall assessment task in an identical order to previous at ‘Assessment 2’. The timings indicated on the left of the diagram represent the average time for participants to complete one session.
7.3.2 Case Histories

Ten case histories with similar diagnoses were generated (example Appendix 6). Participants were allocated a set of five cases to memorise (Set 1 or 2), different for each study session. Case histories were designed using a structured approach, for example – pain would be described in a standard manner – initial site of pain, current site, rapidity of onset, type of pain, exacerbating and relieving factors, prior to describing other symptoms. This format allowed point allocation for each statement, with no distractors (information not assessed).

7.3.3 Multiple Choice Questionnaire (MCQ)

Ten sets of two 20 question, multiple choice questionnaires were developed corresponding to the Case History Information sheets (Appendix 7). Answers could consist of wrong information (confabulated/information from a different history), correct information or the answer ‘other’- enabling questions to be asked that contained two wrong answers and ‘other’ being the correct answer.

7.3.4 Time point one - Immediate Assessment

Participants were provided with five case histories. Subjects were allocated 4 minutes to memorise each case in consecutive order. Each case history was removed at the end of this allocated time.
7.3.5 Assessments

7.3.5.1 Clinical
Free (verbal) recall was assessed by recording and marking the presentation of all five case histories separately by 2 individuals on a predetermined proforma. Cued recall – the provision of information memory cues to aid recall of information, was assessed using MCQ’s and were presented in a different case order to the memorisation task at each assessment time point and session (identical for all participants).

7.3.5.2 Non-Clinical Information
Recall of non-clinical information was assessed using the validated Verbal Recognition Memory test (VRM - CANTAB-Cambridge Cognition Limited, Cambridge, United Kingdom) (174). Candidates memorised a set of eighteen words presented on a monitor prior to their immediate free recall. Cued recall comprised of thirty-six words individually displayed (18 correct/incorrect words to act as cues to recall). Two sets of the VRM task were used to increase the amount of information and thus difficulty of recall.

7.3.6 Cognitive Loading and Fatigue-Inducing Interventions
The N-Back task (175) is a continuous performance task. A white square on a grey background randomly appears at one of eight positions on the computer screen every 2.5 seconds, that is visible for 0.5 seconds. The participant must indicate when the current stimulus matches that from \( n \) steps back in the sequence.
Depending on randomisation the task was delivered at a high/low cognitive load setting. The low cognitive loading task involved the recall of the square in the position of 1 step back. Subjects performed this task for 15 minutes alternating with 15 minutes rest time for 90 minutes. The high cognitive loading (Dual-2-Back) task involved the presentation of two independent sequences simultaneously (audio of letters & visual squares) matching each stimulus from 2 steps back. This task was performed in 15 minute blocks for 90 minutes with no rest.

7.3.7 Time point 2 – post intervention recall assessment
Identical methodology was followed (as that in Time Point 1) for the assessment of clinical and non-clinical free and cued recall information.

7.3.8 Statistics
Statistical analysis was performed using Stata/SE 12 (StataCorp) (176). Normality was assessed using the Shapiro-Wilk test. The Wilcoxon Sign Rank test was used to analyse data between the High and Low Cognitive load groups for subjective questionnaires, free and cued recall (for related data). Results were displayed using means and standard error (se).
7.4 Results

20 medical students were recruited. One withdrew after one session and was therefore excluded from the study. One subject was excluded due to failure of the N-Back program for low cognitive loading (High-Low Randomisation group). Remaining participants were matched on all measured baseline parameters. There was no significant difference in age or clinical year of study between groups who started with the low (LH) or high (HL) cognitive load task [Mean Age (years) LH 22.68 se 0.26, HL 23.33 se 0.57, p=0.26], [Mean Clinical Year (years) LH 4.11 se 0.26, (HL) 4.11 se 0.26] (Table 7-1). Attitude and confidence scores performed prior to low and high cognitive load tasks were similar (LH 55.06 se= 2.55, HL 54.67, se= 2.33, p= 0.65). The mean NART result was 116.19 (se 0.60). One subject omitted the NART during the study and subsequently could not be contacted. As each candidate is their own control this did not impact on analysis of the results.

7.4.1 Stanford Sleepiness Scale

Pre-intervention there was no significant difference in sleepiness between loading sessions, with participants rating themselves between ‘Functioning at a high level but not at peak; able to concentrate’ and ‘Awake but relaxed, responsive but not fully alert’ (Table 7-2). Following the high cognitive load intervention, subjects were significantly fatigued compared with low cognitive loading (p<0.001) scoring between ‘Somewhat foggy, let down’ and ‘Foggy, losing interest in staying awake; let down’. Low cognitive load sessions scores remained unchanged up to the 2 hour recall task (Fig. 7-3). The high cognitive load group remained significantly fatigued during the 2-hour recall task (p<0.05).
### Table 7-1: Demographics

<table>
<thead>
<tr>
<th>Randomisation Group (Cognitive Loading)</th>
<th>Age (yrs)</th>
<th>Clinical Year (yr)</th>
<th>Attitude &amp; Confidence Score (a.u.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low to High (LH)</td>
<td>22.68 (0.26)</td>
<td>4.11 (0.26)</td>
<td>55.06 (2.55)</td>
</tr>
<tr>
<td>High to Low (HL)</td>
<td>23.33 (0.572)</td>
<td>4.11 (0.26)</td>
<td>54.67 (2.33)</td>
</tr>
</tbody>
</table>

Mean baseline demographics with standard deviation (se) shown in brackets.

### Table 7-2: Stanford Sleepiness Scale

<table>
<thead>
<tr>
<th>Stanford Scale Score</th>
<th>Pre-Cognitive Load</th>
<th>Post Cognitive Load</th>
<th>2 hour Free Recall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LCL</td>
<td>HCL</td>
<td>p</td>
</tr>
<tr>
<td>Stanford Scale Score</td>
<td>2.50 (0.2)</td>
<td>2.17 (0.18)</td>
<td>0.25</td>
</tr>
</tbody>
</table>

**Stanford Scale Scores**

1. Feel active, vital, alert, or wide awake
2. Functioning at a high level but not at peak; able to concentrate
3. Awake but relaxed, not fully alert
4. Somewhat foggy, let down
5. Foggy, losing interest in staying awake; let down
6. Sleepy, woozy, fighting sleep; prefer to lie down
7. No longer fighting sleep, onset soon; having dream like thoughts
Figure 7-3: Stanford Sleepiness Scale

The Figure displays subjective levels of sleepiness at baseline, intervention with the N-Back task (High or Low Load) and after Assessment, with error bars displaying standard error.
7.4.2 Visual Analogue Scale

Pre-testing, there was no significant difference in VAS scores between High and Low Load sessions. Post N-back, as highlighted in Table 7-3, participants subjectively reported feeling mentally slower (illustrated in Fig. 7-4) \( (p<0.001) \) and less attentive \( (p<0.01) \]. Attention had improved by the two-hour free recall assessment \( (p=0.09) \), but participants were still subjectively mentally slow \( (p<0.05) \). Cognitive loading also significantly influenced mood and emotion (Table 7-3).

7.4.3 NASA Task Load Index

As illustrated in Table 7-3, the Dual-2-Back task evoked greater mental demand compared with the 1-back task \( (p<0.001) \). This was also reflected in subjective ratings for temporal demand \( (p<0.01) \), effort \( (p<0.01) \), performance \( (p<0.001) \) and frustration \( (p<0.001 \text{ (Fig. 7-5)}) \]. Following the Dual-2-Back task, frustration persisted \( (p<0.05) \). Mental demand \( (p=0.28) \), temporal demand \( (p=0.39) \), effort \( (p=0.57) \) and performance \( (p=24) \) were insignificant. Although subjectively fatigued, participants did not express higher cognitive demand during the recall of the clinical information task compared to the non-fatigued state.
Table 7-3: Visual Analogue Score and NASA-TLX. Results for LCL and HCL at time points “Post Cognitive Load” and “2 hour Free Recall”.

<table>
<thead>
<tr>
<th>VAS (a.u.)</th>
<th>Post Cognitive Load</th>
<th>2 hour Free Recall Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LCL (se)</td>
<td>HCL (se)</td>
</tr>
<tr>
<td>Mentally slow-Quick Witted</td>
<td>55.82 (4.52)</td>
<td>33.47 (5.12)</td>
</tr>
<tr>
<td>Attentive-Dreamy</td>
<td>48.23 (5.23)</td>
<td>64.86 (6.09)</td>
</tr>
<tr>
<td>Incompetent-Proficient</td>
<td>58.70 (4.51)</td>
<td>37.75 (4.84)</td>
</tr>
<tr>
<td>Withdrawn-Gregarious</td>
<td>52.54 (4.24)</td>
<td>33.33 (4.15)</td>
</tr>
<tr>
<td>Alert-Drowsy</td>
<td>44.11 (4.82)</td>
<td>67.00 (5.79)</td>
</tr>
<tr>
<td>Happy-Sad</td>
<td>33.80 (4.89)</td>
<td>55.09 (6.11)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NASA-TLX (a.u.)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental Demand</td>
<td>8.22 (1.20)</td>
<td>17.06 (0.82)</td>
<td>p&lt;0.001</td>
<td>14.00 (1.07)</td>
<td>14.78 (1.11)</td>
<td>p=0.282</td>
</tr>
<tr>
<td>Temporal Demand</td>
<td>5.89 (1.13)</td>
<td>11.78 (1.45)</td>
<td>p&lt;0.010</td>
<td>9.06 (1.21)</td>
<td>9.67 (1.62)</td>
<td>p=0.392</td>
</tr>
<tr>
<td>Frustration</td>
<td>6.28 (1.11)</td>
<td>14.56 (1.30)</td>
<td>p&lt;0.001</td>
<td>9.28 (1.32)</td>
<td>12.50 (1.42)</td>
<td>p&lt;0.050</td>
</tr>
<tr>
<td>Physical Demand</td>
<td>3.56 (1.00)</td>
<td>5.83 (1.33)</td>
<td>p&lt;0.010</td>
<td>2.61 (0.89)</td>
<td>3.72 (1.37)</td>
<td>p=0.289</td>
</tr>
<tr>
<td>Performance</td>
<td>12.22 (1.01)</td>
<td>4.89 (0.70)</td>
<td>p&lt;0.001</td>
<td>7.28 (1.05)</td>
<td>5.78 (0.79)</td>
<td>p=0.238</td>
</tr>
<tr>
<td>Effort</td>
<td>6.61 (1.14)</td>
<td>14.28 (1.08)</td>
<td>p&lt;0.010</td>
<td>11.50 (1.03)</td>
<td>11.78 (1.36)</td>
<td>p=0.570</td>
</tr>
</tbody>
</table>
Subjective rating of level of mentally slow (0) to Quick Witted (100). Error bars = standard error.
Figure 7-5: NASA Task Load Index

7.4.4 Free Recall – Clinical & Non Clinical Information

The change in the amount of information that is freely recalled is significantly reduced by increased cognitive load [mean decrease in information (a.u.) following LCL = 1.33, se 2.81, following HCL = 10, se 2.33, p<0.05]. The pair plot depicted in (Fig. 7-6) demonstrates a subgroup of individuals who have poor recollection of information when acutely fatigued. Participants identified in this group could deliberately incorporate the use of mental aids at work to aid in the recollect of information if this was demonstrated to them. There was no significant difference in the change of freely recalled non-clinical information between sessions (mean change (a.u.) post LCL = 4.44 se 0.94, HCL = 6.11 se 1.01, p=0.39).

7.4.5 Cued Recall - Clinical & Non Clinical Information

There was no significant change in amount of information recalled under low and high cognitive load conditions for the cued recall of clinical information [mean change in cued clinical information recall (a.u.) LCL = -2.56, se 1.76, HCL = -2.44, se 1.61, p= 1]. The mean amount of correct cued recall pre cognitive loading was 61.28% (se 1.98) for the low load session, and 60.17% (se 2.73) for the high load session. Following the N-Back task recall was 58.72% (LCL se 2.69) and 57.72% (HCL se 2.79) of the correct information.
The pairplot displays the difference in information recalled per subject under high and low cognitive load. Value for each condition was the difference in amount of information recalled pre and post N-Back task.
There was no significant change in amount of information recalled between sessions for low and high cognitive load conditions for the cued recall of non-clinical information [mean change in cued non-clinical information recall (a.u): LCL = 2.78 se 0.87, HCL = 3.89 se 1.05, p= 0.08].

7.4.6 Confidence
There was no significant difference in confidence when presenting case histories prior to the cognitive loading task (mean low cognitive load 12.22 se 0.65, mean high cognitive load 12.67 se 0.63, p=0.63). Following the N-back task, there was a significant difference between sessions for the change in the confidence in the accuracy of the free recalled clinical information. Specifically, subjects were observed to be less confident following the high load condition i.e. when mentally fatigued [mean change -low load 0.44 se 0.55, high load = -2.67 se 0.45, p<0.05]. The confidence of a subgroup of participants is particularly effected by any cognitive loading (Fig. 7-7). This does not necessarily reflect a decrement in knowledge, when compared to Fig. 7-6.

There was no significant difference between sessions for the change in confidence for cued recall (mean decrease in confidence score – low load 16.11 se 11.53, high load 14.06 se 14.40, p=1).
‘Change in Confidence’ after the N-Back task (top = High Load, Bottom = Low Load). A subgroup of six subjects display a possible susceptibility to reduced confidence when under cognitive demand. Six of the lowest nine ranked subjects display reduced confidence after high or low cognitive loading.
7.5 Discussion

With patient handover being highlighted as a key area for error and patient safety (4,177), that is heightened in the fatigued state, the creation of an intervention to improve information recall is essential (178). This study found deterioration in free recall of information with increased, fatigue inducing cognitive load, but displayed relative sparing of recognition memory and cue-induced recall multiple choice questions. Confidence in the accuracy of recalled information was maintained with the latter assessment. Currently, there is no standardised documentation for handover. The preservation of cued recall and recognition memory creates the opportunity to design an evidence based handover proforma to reduce error whilst maintaining confidence to facilitate decision-making.

Evidence from cognitive psychology demonstrates that memory cues aid in information retrieval (179,180). The current study is consistent with the literature indicating that recognition memory and cued recall are superior to the free recall of information (181). This study is the conscious application of cognitive psychology to improved dissemination of medical information during handover.

Recall of information relies on the strength of the memory pathway that was formed when encoding the memory. The weaker the link, the more difficult the retrieval of the required information. Cued Recall occurs when the brain receives a clue to accessing the desired answer. To be an effective stimulus the cue must relate to the way the subject interpreted the information at the time of consolidation. An example of this is if the interpretation of the word ‘foot’ were anatomical, one would not immediately associate the word to the cue ‘distance’. If the interpretation of ‘foot’ was that of a measurement, then it would be a helpful cue. Recognition memory has
increased specificity where the response to a presented item of information would be a yes or no response.

Cues can be subtle. What is inferred at the time of encoding can significantly affect recall of information at a later time point (34). Thus the experience of the medical practitioner at the consultation will effect what is recalled. Hence a proforma using memory cues is more likely to aid the less experienced clinician. This is beneficial as in my opinion it is the less experienced doctor who is involved in dissemination of information at handover, and the proforma would be designed to produce information that an experienced clinician would want.

However, one should still view the results in context. This was a study of medical students fatigued by a non-medical cognitive task for ninety minutes and assessed on their recall of five patients case history information. It has positive findings that need further investigation. It is likely that memory retrieval of clinical information is less robust in medical students who have less clinical understanding (Levels of Processing theory) (22). The study would need further validation within clinicians to confirm current findings. Equally different experience levels may reveal different findings, thus it should be targeted at the appropriate level of doctors (i.e. if designing a handover proforma – the doctors involved in producing the handover document).

A non-clinical cognitive fatiguing task may not develop similar levels of cognitive fatigue to that experienced in a clinical setting. Whether the fatigue is task specific is also unknown. A translational study comparing the effects of the N-back to an on call session would be of benefit to establish a baseline comparison for future studies.
Checklists use recognition memory and cued recall to stimulate actions or information retrieval. They can prevent deliberate omission of information or aspects of a procedure - ‘cutting corners’ due to over familiarity or fatigue. The safety conscious airline industry uses checklists for this purpose. A benefit of this type of fatigue resistant process is that less experienced staff can produce an identical output of critical information by following the checklist format. This cognitive process has been applied to the WHO pre-operative checklist (111).

Cues can trigger information recall of the required and related information. Within medicine, we sub-consciously use serial recall (the recall of related information in a memorised order) as a cue to presenting patient information. If a surgeon was to recall a patient with small bowel obstruction, the free recall of the diagnosis should trigger serial recall of classical symptoms, e.g. feculent vomiting with burping and absolute constipation, that would act as cues for specific patient information. However, as shown in this study, this process is susceptible to cognitive fatigue. Medical handover has the potential to generate evidence based written cues to aid recall of information beyond the current written format. A handover system could be developed to use cues to improve dissemination of required information by less experienced staff (example of a cue based handover system Fig. 7-8).

Free recall of clinical information is significantly reduced by a cognitively demanding 90-minute task. It is conceivable that errors in patient handover may be made in a short time between clerking a patient and presenting the history, even in the non-sleep deprived state. Extrapolating upon these findings, any cognitively demanding clinic or operative procedure could result in impaired recall.
The quantity of information desired at handover is a defining factor to the accuracy and safety of the process. The use of high volume data over a short time period could create information displacement from memory (as described by the Model of Working Memory) (19), a problem likely to be faced by on-coming teams during handover. The results raise interesting questions concerning how the profession should approach the dissemination of information at handover. If the volume of information is high, then it is likely that some information will be lost, however, if a minimalistic approach is taken, crucial information may be omitted. It is clearly a difficult balance. Handover requires an evidence-based, fatigue resistant process that achieves efficient, dissemination of the smallest amount of accurate patient information for a practical safe transition of care.

Checklists specifically designed to resist fatigue related errors could be beneficial in a modern healthcare system. The implementation of the WHO checklist (111) is a move in this direction. Cognitive fatigue is not restricted to information recall but broadly influences a doctor’s ability to provide quality care. Fatigue may influence any aspect of care, for example vigilance and polyp detection rates during colonoscopy (96). What time limit or number of procedures should be performed in a session before time-on-task effects significantly impair performance? Future work should address these important questions.
Figure 7-8: Cue Based Recall Intervention

<table>
<thead>
<tr>
<th>Name, DOB, Hospital Number</th>
<th>Location</th>
<th>Diagnosis</th>
<th>History</th>
<th>Imaging Results</th>
<th>Examination, Observations &amp; Blood Results</th>
<th>Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name, DOB, Hospital Number</td>
<td>Ward, Bed Number</td>
<td>Important History including surgically important PMH, Allergies or Medications</td>
<td>Scan Results</td>
<td>Examination Findings, Abnormal Observations and Blood Results</td>
<td>Management Plan with Outstanding Investigations or Scans Requiring Booking Including Urgent Pre-operative Requirements</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name, DOB, Hospital Number</th>
<th>Location</th>
<th>Diagnosis</th>
<th>History</th>
<th>Imaging Results</th>
<th>Examination, Observations &amp; Blood Results</th>
<th>Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name, DOB, Hospital Number</td>
<td>Ward, Bed Number</td>
<td>obstruction</td>
<td>Important History including surgically important PMH, Allergies or Medications</td>
<td>XVR, EOB, CT</td>
<td>examination findings, abnormal observations, T, BP, HR, Sats, NG &amp; UDI, wbc, crp, renal function, other abnormal results, Abg</td>
<td>NG, Catheter, NBM, IV fluids type and rate, Siting Scale? Outstanding Scans or Investigations Requiring Booking Including Urgent Pre-operative Requirements</td>
</tr>
</tbody>
</table>

Implementation of cue based recall in a current unpublished study. Participants are provided with memory cues based on aspects of information desired at handover dependent on input of diagnosis.

a) information displayed prior to entering diagnosis
b) the display changes on the input of the diagnosis, with information specific to condition displayed. The participant does not have to input all of the information displayed, the principle is to create a cue so that all of the information is considered.
7.6 Conclusion

This study has identified a sub-group of individuals that are significantly affected by acute mental fatigue. When fatigued, free recall of clinical information is significantly impaired. The relative preservation of recognition and cued recall allows for the design of checklists that can trigger recall of essential areas of information during a handover process. With work hour restrictions limiting but not eradicating work-based fatigue, targeted interventions need to be developed to limit fatigue related error. Patient handover has specifically been identified as an area of concern (4). Implementation of a generalised checklist that uses memory cues could create a baseline standard from which improvement in patient care can be developed. The next chapter explores this concept.
Chapter 8  Cognitive Aids For Recall of Clinical Information - A Randomised Crossover Study

8.1 Background

In 2007, the Royal College of Surgeons issued guidance on handover in response to changes in working hours. The increased frequency of handover highlighted patient safety concerns and the requirements for an effective handover process (182). Its aim was to describe the main features of a successful surgical handover and good practice principles in a single document. It also acknowledged that a ‘one size fits all’ approach might not be feasible in the fluid and variable handover process of a hospital environment. Common difficulties were the concise presentation of the essential information of patients, with accurate location and patient identification demographics. The report acknowledged that handover checklists for common conditions might be appropriate to aid this process.

In the United States, a review of the handover process recommended a standardised approach to patient handover (to improve accuracy and reduce errors) in requirement 2E of the 2006 National Patient Safety Goals (issued by the Joint Commission) (183). By 2010, in response to duty hour restrictions, the Accreditation Council for Graduate Medical Education also required the monitoring of patient handover to ensure doctor competence in the communication process (177).

The importance of the handover process and the risks to patient safety are a worldwide phenomenon. Yet, despite multiple quality improvement projects conducted on patient handover, a standardised and reliable measurement tool remains
elusive (184). A high quality handover process is critical in the provision of safe and effective patient care. This was emphasized by major documents issued by the World Health Organisation (12), the ACGME (185), RCS England (182) and the Joint Commission (184) (186) the latter of which produced a ‘2006 National Patient Safety goal’ that required a ‘standardised approach to handover communications’. Currently, education on the risks to patient safety is the basis for developing skills and creating a standardised approach to the handover process. The use of checklists have also demonstrated increased dissemination and retention of critical information at handover (187).

With evidence of varying quality of the handover process despite quality improvement projects, one must question the reasons for the inability to produce a standardised reliable measurement tool. Whilst the RCS of England states that a one size fits all approach is not feasible, there is a fundamental disagreement in the literature as to the purpose of handover. A suggested conceptual framework was published where seven alternative functions of handover were defined (184) with quality measures for each function. A multifaceted approach to the management of handover could therefore be considered a prerequisite for standardisation.

The principle function of handover is the dissemination of essential information between two working groups: ‘shift work starters’ and ‘shift work finishers’. This can involve a multidisciplinary team or a single doctor, but the underlying principle remains. Inadequacies in this process predispose to adverse events (188).

The focus of this chapter is on information transfer at handover. Evidence suggests that handover is a learnt process, where information transfer is influenced by
experience (189). Fewer omissions of information have also been associated with the ‘use of electronic support tools’ (190). The use of documentation can aid the transfer and recall of information’ compared to verbal information transfer (191) and is recommended at handover (186). Evidence from the literature suggests that a well designed handover document can improve patient safety (192). This is a recurrent theme. However, with no conformity between institutions, it would be reasonable to presume that there is variation in the level of improvement to patient safety outcomes. There is currently no ability to assess this process.

Thus to create an evidenced based document, one must question what aspects of a document are effective and why? Is it the use of any written aid or is there a defined structure for document design that can improve it? This chapter attempts to explore the mechanism of handover and identify what aspects of documentation are important to reduce error i.e. without an accepted format; one must create an evidence-based process to identify inclusion criteria to provide standardisation.

Standardisation of handover can occur through a compulsory system assigned by a governing body. Such an approach is generally resisted with varying clinical requirements for each speciality, along with high IT implementation costs for a system that may not be evidence based. Yet, a standardised approach may be influenced through educational based programs during training. Thus the ACGME requires residency programs to provide formal instruction on handover.

Most handover interventions do not specifically assess documentation structure or design but the overall process by which patient handover occurs. In a review of the literature it was concluded that there was little research done to identify ‘best
practices’ (193). Research on the effectiveness of structured protocols and interventions is still required. It is interesting to note that only 44.3% of the articles reviewed suggested strategies for standardisation, with 16.4% discussing technological solutions (computerized handover). Only 11.4% discussed improvements in communication skills to improve the handover process. The diversity in handover needs typifies the process. With varying and conflicting requirements (194) it is difficult to produce documentation that can fulfil these needs. However 50% of staff report important care information is lost during shift change (195), emphasising the need for continued improvement strategies.

Compartmentalisation of handover into four phases allows for targeted interventions within the handover process (196):

1) Pre-work (anticipating and preparing for handover)
2) Actual Handover
3) Acknowledgment of information received
4) Acknowledgment of transfer of responsibility

This PhD has focussed on recall of information through the provision of memory cues that aid information recall. Its advantage is that it stimulates memory at the pre-work stage to allow for preparation of the required information if the physician deems it necessary. This information is then available during the ‘Actual Handover’ and can act as a memory cue during the verbal recall of a patient.
It is interesting to note that of the four comprehensive reviews of handover literature identified (197), the handover process found research to have many flaws with anecdotal recommendations (193), with verbal and written sign out being a recommended requirement of the handover process (198). Education into how to conduct handover was also recommended (199) along with a systematic analysis of all stages of the handover process (200). Current evidence has focussed on the actual handover without identifying where and why communication failures have occurred.

It is difficult to design a gold standard for handover with varying requirements even within specialities. This is reflected by 24 distinct handover pneumonics being identified in the literature (201), none of which appear to be in wide use. Checklists are the commonest method of attempts at standardisation with evidence to show improvements in data between day and night teams. This form of standardisation is maximised through the increasingly prevalent use of electronic medical records (EMR’s). These systems are gaining wider acceptance with increased satisfaction reported with EMR use (202,203).

A significant proportion of computerised handover tools use electronic medical records to produce the handover document. Explanations for this approach state the reduced manual input of data by the handover team, providing significant time saving steps, increased accuracy during handover and decreased clinical errors.

However, most of the reported positive effects of patient safety are perceptions of the medical staff without objective measurements to support this opinion. This is due to high numbers of participants required to statistically assess this aspect of care, with most studies being small and involving a single department.
A review of computerized handover found limited evidence for the improvement of patient outcomes. Only 6 studies that assessed the impact of a computerized handover system were found between 1960 and 2011 (204). It reported only 1 randomised control trial and 5 controlled before and after studies. Two studies demonstrated reduced adverse events and missed patients whilst 3 demonstrated increased quality in handover. It concluded computerized handover packages might improve work efficiency, increase the completeness of handovers whilst reducing adverse events. It emphasised the need for more rigorous study designs.

A review of the literature found 11 papers that describe computerised handover tools (Table 8-1). There was a subjective improvement in satisfaction of the handover system with reported increased data quality. Considering the increasing use of the EMR and handover systems, this is of low numbers with subjective reports and possibly underpowered results (i.e. a decrease in adverse events from 1.7 to 1.2 p<0.1). None identify specific aspects of information that will improve the handover process. Improvement may be produced through increased volume of data generated from the EMR or handover tools thus allowing for increased interpretation of patient data at handover.

This observation is reflected in a two-year review of an EMR system in two hospitals. It is interesting to note it highlighted the lack of clarity in benefits from the system with trade offs in ‘individual workloads and organisational benefits’ with staff reporting no significant time savings and new unanticipated risks produced by the new system (205).

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Standardisation of key content was a recommendation from an assessment of sign-out practices (206). This chapter has designed key elements into a computerised handover tool to improve written and verbal handover procedures. Currently it is independent of an EMR system but its methodology could feasibly be integrated into one at a future date.
<table>
<thead>
<tr>
<th>Paper</th>
<th>Type</th>
<th>Study Size</th>
<th>Summary of Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kochendorfer et al 2010 (203)</td>
<td>EMR report</td>
<td>Single Department</td>
<td>Reported trends of increased accuracy in handover information and decreased clinically relevant error. Significantly reduced time inputting data and improved satisfaction</td>
</tr>
<tr>
<td>Palma et al 2011 (207)</td>
<td>EMR report</td>
<td>Single department</td>
<td>Significant increase in perceived information accuracy and reduced inputting of information for handover.</td>
</tr>
<tr>
<td>Ram et al 1993 (202)</td>
<td>Handover system</td>
<td>2 Family practice residency programs</td>
<td>Demonstrated increased satisfaction and use of computerised the handover sheet. Percentages only</td>
</tr>
<tr>
<td>Choudhury et al 2014 (208)</td>
<td>Handover system /outstanding tasks</td>
<td>1 NHS Trust</td>
<td>No comparison data. 89.4% of handover tasks completed on computerised system. Three times the volume of e-handover work tasked for weekends and bank holidays</td>
</tr>
<tr>
<td>Kannry et al 1999 (209)</td>
<td>Handover system (MediSign)</td>
<td>4 teams</td>
<td>Patient tracking for handover. Data presented in percentages only</td>
</tr>
<tr>
<td>Petersen et al, 1998 (210)</td>
<td>Handover system</td>
<td>1 hospital</td>
<td>Adverse events decreased from 1.7% to 1.2% (p&lt;0.10)</td>
</tr>
<tr>
<td>Starmer et al 2013 (185)</td>
<td>Handover system</td>
<td>1 hospital</td>
<td>Computerised package used as part of a bundle of interventions (with only part of the group using the computerised package). A significant reduction in the omission of important information was found.</td>
</tr>
<tr>
<td>Campion et al 2007 (211)</td>
<td>EMR report - incorporated ‘WizOrder’ handover tool</td>
<td>2 Hospitals</td>
<td>No comparison data for pre IT handover system. Despite IT, system ambiguities regarding tasks can still occur. Recommendations on how to improve Handover design</td>
</tr>
<tr>
<td>Raptis et al 2009 (212)</td>
<td>Handover system</td>
<td>1 hospital</td>
<td>Significant increase in quality of information using computerised system</td>
</tr>
<tr>
<td>Van Eaton et al 2005 (213)</td>
<td>Handover system (UWCores)</td>
<td>2 hospitals</td>
<td>Missed encounters were halved (p=0.0001), shortened rounds (p=0.0006). The system reduced pre handover time preparation p&lt;0.0001. Residents subjectively reported better quality of handover and improved continuity of care.</td>
</tr>
</tbody>
</table>
8.2 Introduction

Handover is the communication and transfer of patient care between individuals in a clinical setting. This process has been highlighted as an area at significant risk from error (214), especially if performed in an unstructured manner (189). To improve patient safety, recent studies have assessed the handover process with the aim to reduce medical errors, adverse events and omissions of key information in written and verbal handover procedures (42). Importantly these studies address the lack of clear handover pathways through use of a structured multifaceted approach to improving care, one aspect of this being a computerised handover tool, that has been demonstrated to reduce omissions of key data points (42).

This is a positive step to improve patient safety yet the analysis of why certain aspects of an approach produce an improvement is rarely considered. The fact that it is a provision of a structured approach to a regularly unstructured process is true. Yet, such processes need to be evidence based and rigorous in improving patient safety, optimised against the effects from antisocial hours when the tendency for fatigue induced error is increased (215).

Cognitive fatigue can result in lapses in attention with the inability to remain focused on a given task. Individuals have impaired communication, memory lapses and reduced motivation. This is a worrisome combination when a physician is obliged to produce a handover document towards the end of a shift. Therefore, it would be beneficial if a structured handover system could aid in the reduction of fatigue-induced error through the conscious application of cognitive science. Inbuilt error prevention mechanisms could aid in patient safety through reduced omission of key
facts by the forced consideration of aspects of a patient’s history, investigation or management plan. This process is similar to the Fatigue risk management strategies instigated by the airline industry (216). An example of which is the pre-flight checklist where the individual is forced to consider all aspects of the plane, assuring that it is safe and ready for take-off.

The underlying mechanism for such a process involves the application of memory ‘cues’ that stimulate the recall of information (and possible action by the individual). This is a simple but advantageous process by which an individual is able to improve recall of information. The more generic the cue, the less likely that it will stimulate the recall of information. It is therefore the specificity of the stimulus in an intervention package that is of importance.

For a clinical handover procedure to be efficient, a checklist would need to be a more fluent and malleable process, requiring little effort from the operator to construct the handover document. This study aims to improve written and verbal handover procedures through the use of a cue based computerized handover system compared to standard computerized handover documentation. With careful consideration, this underlying process could be consciously applied to improve patient safety in multiple care pathways
8.3 Materials and Methods

The study followed a randomized counterbalanced crossover design (Fig. 8-1). Ethical approval was granted by Cambridgeshire Research Ethics Committee 1 as part of the ethics application (Ref: 09/H0304/24). Site-specific approval, sponsorship, and funding for the study were provided by Imperial College London.

8.3.1 Study Design

20 non-sleep deprived doctors (including F1, F2-CT2 and Registrar levels) were recruited to participate in a randomized counterbalanced crossover study (Fig. 8-2) (over two separate days) from August 2013 to February 2014. Randomisation was to one of four groups by a blinded sealed brown envelope allocation. Participants were required to be working a normal day shift free from on call commitments.

The study was performed in a quiet, room containing the participant and assessor. All participants were well rested, healthy individuals taking no regular medications, and free from stimulants (caffeine) from midnight prior to the study that commenced between 09:30 and 10:00 hours (for baseline questionnaires completion) – Figure 8-2. Any past medical history or illness that could impair cognition excluded participation. At 10:00 hour’s participants were allocated the case history memorisation task.

8.3.2 Case Histories

Using experience gained from earlier studies, ten case histories with similar diagnoses were generated (example Appendix 8). Participants were allocated five cases to
A crossover design study involving 20 participants. Participants were randomised to 1 of 4 Groups at session 1 (S1), to receive Case Histories 1 or 2 (CH1 or CH2) that had been allocated to receive an intervention (INT), to improve recall at handover or no intervention (No INT). Session 2 (S2) allocated the remaining case history and intervention/no intervention strategy.
Participants completed baseline questionnaires between 09:30 and 10:00hrs for each session, prior to memorisation of 5 Case Histories over a 20 minute time period. Immediately post memorisation task, Verbal recall was assessed. (Time point 1). Once completed, participants performed a full clinical days work returning at 17:00hrs (Time point 2) to create a handover sheet (with/without intervention) to aid verbal recall as per their standard clinical practice.
memorise over a 20-minute time period (with a 4 minute allocation per case), with different cases chosen for each study session. Each case history was removed at the end of this allocated time to prevent comparison and cross-referencing between histories.

Case histories were designed using a structured approach, for example – pain would be described in a standard manner – initial site of pain, current site, rapidity of onset, type of pain, exacerbating and relieving factors, prior to describing other symptoms. This format allowed for point allocation for each statement, with no distractors (information not assessed).

8.3.3 Time Point 1 - Immediate Assessment

Participants were requested to provide a detailed history of all five cases that was recorded and blind marked by a third party using a mark sheet provided.

8.3.4 Time Point 2 – Handover

Participants were requested to create a detailed handover document for the five cases. They were provided with a basic excel handover proforma (Fig. 8-3), similar to current use (for the control session). The Intervention session consisted of a similar proforma with one extra line of ‘cues’ that could be referenced by the participant upon documentation of a diagnosis (Fig. 8-4). Cues were generic such that they could be used for any case with the same diagnosis. The line of ‘cues’ was removed for blind marking of results by a third party. Time was not restricted for data input.
Participants are provided with a basic handover proforma. Structure was similar to one in current use by participants.
Figure 8-4: Cue Based Recall Handover Intervention

Below is a checklist for the creation of the handover document. It aims to prompt recall of clinical information. Currently, it is listing ‘default’ information for an uncommon diagnosis. Please type your diagnosis into the grey box. Common diagnoses will produce unique information requirements in associated cells. Use the cells for reference when creating handover sheets.

<table>
<thead>
<tr>
<th>Name, DOB, Hospital Number</th>
<th>Location</th>
<th>Diagnosis</th>
<th>History</th>
<th>Imaging Results</th>
<th>Examination, Observations &amp; Blood Results</th>
<th>Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ward, Bed Number</td>
<td>Important History including surgically important PMH Allergies or Medications</td>
<td>Scan Results</td>
<td>Examination Findings, Abnormal Observations and Blood Results</td>
<td>Management Plan with Outstanding Investigations or Scans Requiring Booking Including Urgent Pre-operative Requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ward, Bed Number</td>
<td>Important History including surgically important PMH Allergies or Medications</td>
<td>AXR, ECHK, USS/CT</td>
<td>Examination Findings, abnormal observations (T, BP, HR, Sats, UO), ABG, SCORE, WBC, CRP, renal function, LFT, amylase, glucose, other abnormal results</td>
<td>Catheter, IV fluids inst rate, Scan booked? Outstanding Investigations</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Participants are provided with memory cues based on aspects of information desired at handover dependent on input of diagnosis.

a) represents information displayed prior to entering diagnosis

b) change in display with diagnosis input with information specific to condition.
The handover document was printed and used to aid the presentation of the case histories, following the Time Point 1 format.

8.3.5 Questionnaires

8.3.5.1 Demographics
Participants were asked for their gender, age and date of birth and were free from stimulants (caffeine & chocolate) from midnight on the day of study.

8.3.5.2 Medical history
Participants were required to take no regular medication or have any significant past medical history as defined by the exclusion criteria.

8.3.5.3 Stanford Sleepiness Questionnaire
Subjects rated themselves on a scale of one to seven where one is feeling active and alert and seven is having dream like thoughts.

8.3.5.4 Visual Analogue Scale
Subjects rated how they were feeling on an analogue scale (between two opposing conditions). Sixteen dimensions were assessed. Measurements were recorded at baseline prior to the memorization task and at time point 2 prior to construction of the handover document.
8.3.6 Handover Proforma

The Intervention handover proforma was designed for the presentation of ‘cues’ of information to aid recall of a case history (Fig. 8-4). During medical training, doctors are taught ‘classical’ histories to aid in diagnosis. An example is that of migration of pain from the central abdomen to the right iliac fossa, classical of appendicitis. This symptom supports the clinical sign of tenderness at McBerney’s point. Serial recall of information can be triggered from a key information point; for example, the word ‘pain’ can trigger this descriptive information on classical symptoms if discussing a case of appendicitis.

It is common that a diagnostic impression is recalled concerning a patient, and it can be argued that this is sufficient when discussing a patient at handover. However, for pancreatitis it is useful to know of a history of gallstones or their Glasgow/Ranson score. Thus the cue of ‘Score’ during the creation of a list may trigger the individual to obtain this information. This computerised handover proforma provides ‘cues’ for a clinical condition. It is dependent on the diagnosis to provide this, however in instances of rare or uncertain diagnosis there was a standard set of cues presented (case 5 in each set).

The specificity of a cue can range from broadly generic to extremely specific - with a question for each symptom of a patient’s condition, but it is the author’s impression that a handover list must remain fluid, malleable and for an individual clinician to have control over the level of detail they wish to have. It should also be quick to produce.
Ultimately, a cue is aimed at triggering the recall of information, not necessarily its documentation or presentation. This can be explained by the example cue ‘Warfarin’. Most surgical patients would not be taking this medication, so the recall of the negative is relevant, but does not usually need to be documented or vocalized. This important cue is present for the small proportion of cases that are currently or have previously received the drug, due to the serious consequences if this information is missed. Thus the current aim is to prove that recall has taken place even if it would not actually be documented during a ‘working/live proforma’. It is essential to know that the cue document can demonstrate this.

8.3.7 Statistics
Using a previous study and the items of information assessed, for a power of 0.9 needed to be enrolled in the study. Each case contained approximately 50 to 80 items of assessable data. Thus for each session at least 336 points of information were assessed for written and verbal handover. Normality was assessed using the Shapiro-Wilk test. For assessment of information between paired samples the paired t-test was used. Independent samples were assessed using the unpaired t-test. e.g. the paired t-test was used to assess written and verbal recall of information. Results were displayed using means with standard deviations (sd).
8.3.8 Results
20 doctors (mean age 29.63yrs) participated in the study. One withdrew after one session and was therefore excluded. There was no significant difference between experience levels between groups (4 HO, 12 SHO and 3 Registrar grade doctors). At baseline, there was no significant difference in the percentage information recalled by each candidate for each session. The mean time between sessions was 32.26 days (sd 19.27).

8.3.9 Stanford Sleepiness Scale (SSS)
There was no significant difference between Intervention and no Intervention groups for level of sleepiness at baseline (Intervention SSS 2 sd 0.82, No Intervention 2.32 sd 1.20, p=0.35) or at Time point 2[Intervention SSS Timepoint2 2.68 sd 1.20, No Intervention 2.90 sd 1.29, p=0.61 (Stanford performed pre intervention)]. Participant’s mean Stanford scores rated alertness between ‘Functioning at a high level not peak; able to concentrate;(score=2)’ and ‘Awake but relaxed, responsive but not fully alert (score=3)’.

8.3.10 Visual Analogue Scale
There was no significant difference between sessions [Intervention (Int) v no intervention (no int)] for all questions at baseline or at time point 2. However there was a significant change in the VAS from baseline to time point 2 over each session (Table 8-2a & b) suggesting fatigue. The ‘Intervention’ group subjectively was more drowsy (p=0.01), less attentive (p<0.05) and had increased boredom (p=0.001) whilst
the ‘no intervention’ group was subjectively more discontented \((p<0.01)\), sad \((p<0.05)\) and subjectively less proficient during the task \((p<0.01)\).
### Table 8-2 a: Visual Analogue Scale

<table>
<thead>
<tr>
<th>Visual Analogue Score (mm)</th>
<th>Alert-Drowsy</th>
<th>Calm-Excited</th>
<th>Strong-Feeble</th>
<th>Muzzy-Clearheaded</th>
<th>Well coordinated - Clumsy</th>
<th>Lethargic - Energetic</th>
<th>Contented - Discontented</th>
<th>Troubled - Tranquil</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline (Time Point 1 - TP1)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention (Int)</td>
<td>25.63 (14.60)</td>
<td>30.58 (13.75)</td>
<td>34.16 (17.33)</td>
<td>69.05 (18.36)</td>
<td>26.90 (16.12)</td>
<td>59.47 (20.56)</td>
<td>23.21 (12.92)</td>
<td>71.47 (14.12)</td>
</tr>
<tr>
<td>No Intervention (No Int)</td>
<td>28.05 (18.20)</td>
<td>29.79 (22.86)</td>
<td>28.42 (13.86)</td>
<td>66.11 (19.77)</td>
<td>26.37 (15.70)</td>
<td>62.05 (24.03)</td>
<td>22.63 (15.77)</td>
<td>69.58 (22.36)</td>
</tr>
<tr>
<td>p value Int. vs. No Int</td>
<td>0.61</td>
<td>0.87</td>
<td>0.22</td>
<td>0.51</td>
<td>0.86</td>
<td>0.65</td>
<td>0.90</td>
<td>0.66</td>
</tr>
</tbody>
</table>

| **Time Point 2 - TP2**                     |              |              |               |                   |                           |                       |                         |                     |
| Intervention                               | 40.80 (17.43)| 39.53 (13.38)| 44.68 (15.16) | 56.47 (20.30)     | 42.26 (20.07)            | 52.11 (20.16)         | 27.74 (11.64)          | 67.21 (12.34)        |
| No Intervention                            | 36.68 (20.11)| 37.58 (22.31)| 40.79 (19.59) | 55.90 (23.09)     | 35.74 (20.03)            | 53.47 (27.24)         | 30.84 (18.63)          | 65.05 (22.70)        |
| p value Int. vs. No Int                   | 0.24         | 0.72         | 0.35          | 0.91              | 0.09                      | 0.77                  | 0.41                    | 0.66                |
| p value Int T1 vs. T2                      | 0.01         | 0.05         | <0.05         | <0.05             | <0.05                     | 0.23                  | 0.17                    | 0.17                |
| p value No Int T1 vs. T2                   | 0.09         | 0.12         | <0.01         | 0.09              | <0.01                     | 0.16                  | <0.01                   | 0.15                |

**Visual Analogue Scale (part 1 of 2)**

Eight of Sixteen different sets of opposing terms were used to describe different aspects of the participants affect. Standard deviation in brackets.
**Table 8-2 b: Visual Analogue Score**

<table>
<thead>
<tr>
<th></th>
<th>Visual Analogue Score (mm)</th>
<th>Baseline - Time Point 1 (TP1)</th>
<th>Time Point 2 (TP2)</th>
<th>p value Int. vs. No Int</th>
<th>p value Int. T1 vs. T2</th>
<th>p value No Int T1 vs. T2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mentally Slow – Quick Witted</td>
<td>Tense - Relaxed</td>
<td>Incompetent - Proficient</td>
<td>Happy - Sad</td>
<td>Antagonistic - Amicable</td>
<td>Interested - Bored</td>
</tr>
<tr>
<td><strong>Intervention</strong></td>
<td>64.42 (19.69)</td>
<td>68.79 (17.81)</td>
<td>70.37 (14.14)</td>
<td>22.00 (12.27)</td>
<td>73.74 (13.30)</td>
<td>27.00 (17.24)</td>
</tr>
<tr>
<td><strong>No Intervention</strong></td>
<td>61.79 (15.72)</td>
<td>70.16 (22.07)</td>
<td>69.90 (11.92)</td>
<td>20.74 (12.69)</td>
<td>79.63 (12.48)</td>
<td>30.00 (18.85)</td>
</tr>
<tr>
<td><strong>p value Int. vs. No Int</strong></td>
<td>0.59</td>
<td>0.81</td>
<td>0.87</td>
<td>0.76</td>
<td>0.06</td>
<td>0.54</td>
</tr>
</tbody>
</table>

**Visual Analogue Scale (part 2 of 2)**

Eight of Sixteen different sets of opposing terms were used to describe different aspects of the participants affect. Standard deviation in brackets.
8.3.11 Handover Documentation

There was a significant difference in the percentage recall of information for each case between the ‘intervention’ and ‘no intervention’ assessments (Intervention 32.11% sd 3.60, No intervention 27.36% sd 3.75, p<0.01). There was no significant difference in the amount of incorrect information documented by each participant for each case series (Intervention 8.02% sd 4.07, No Intervention 6.09% sd 2.49, p=0.09).

8.3.12 Recall of Clinical Information

There was a significant difference between the percentage changes in correct information recalled for each case by the intervention compared to the non-intervention group for the assessment of verbal recall (Intervention 2.42% sd 1.02, No Intervention 0.29% sd 1.20, p<0.05) (Fig. 8-5). There was no significant difference for the change in incorrect information recalled for each case between the ‘intervention’ and ‘non-intervention’ assessment of verbal recall (Intervention 1.44% sd 4.11, No Intervention 0.54 sd 3.78, p=0.13).
Graph displaying all five case histories presented during intervention/no intervention assessment – Change in Percentage of Information Recalled (%). Error bars = standard deviation.
8.4 Discussion

This study demonstrated that memory cues can improve the recall of clinical information during a handover process. It improves handover documentation whilst also increasing the subsequent information that is verbally presented, without an increase in error. It is a quick tool to improve the handover process. This study is the first step in creating evidence-based cues that improve information delivery.

With handover documentation being a necessary requirement, this ‘cue’ based system requires little change in the current approach to the handover process, with little extra time required for completion. It is also adaptable with the possibility of cues being refined by individual consultant’s, who can stipulate which cues they require on their proforma. This flexible system could be acceptable to a larger consultant body as a result.

A possible criticism of this approach is that all items of information are not of equal relevance. An increase in volume of the information presented is not necessarily what is required. This is certainly true and it is not the aim of this research group to promote an inefficient process. Yet the first step to delivering a refined, focused and specific handover proforma is the demonstration of what clinical information can be recalled from a cued stimulus and that it is superior to current methods. Despite cues only 35% of a patient history was recalled. This is a percentage of all the information that was presented, with a large amount of this information being irrelevant. The current study was not designed or powered to perform sub-case history analysis.

All systems have limitations. This system is not EMR based and it demonstrates the fallibility in recall with time and worker fatigue. It is a strong argument that
documentation should be gathered from the original data entry to prevent error in recall. With only 35% of information recalled there is still a risk of omission of key information. At this point in time an EMR system may not present the information or be in the format that is desired for an effective handover process. This is due to program design rather than information recall, although it is likely that future systems will be derived from this form of information delivery system. Currently there is insufficient evidence in the literature to define a gold standard EMR/handover program.

Despite the possibility of EMR based systems, this research still has significant relevance to the process of information delivery. It highlights how memory cues can influence data entry, to create a more informative document. Standard documentation does not provide the cue-based stimulus that will improve information dissemination, especially in the fatigued or less experienced professional. Cued memory can be used at any point of data entry. The clinical impression can be used to provide cues for recommended information that should be documented along with baseline tests that should be considered. This could also be the link through which an EMR program can acquire data to generate a handover document. Currently, some EMR systems use a cue based approach to achieve government objectives, for example DVT prophylaxis.

The results from this study are encouraging, but due to the limited numbers involved require further investigation. The development of further case models are required before a prospective 3 month study in a clinical setting. The aim would be to demonstrate a significant difference in information provision during handover
(written and oral), ultimately looking into documentation error and patient outcome measures. This system can be applied to multiple areas of patient care.

‘Do no harm’ is a founding principle of the medical profession. By ignoring documented concerns of inefficiencies and errors present in the current handover process (217,218), one must question whether we are continuing to abide by this principle. We have the capability to improve fatigue and the handover process, ignorance or reluctance to change can no longer be an accepted argument when patient safety is of concern.

8.5 Conclusion

Cue based documentation has multiple possibilities for improving patient safety. It is a simple method that could easily be implemented across hospitals whilst the search for an acceptable EMR handover delivery system continues.

The next chapter investigates if pharmacological aids to cognition are better than cued based fatigue management strategies.
9.1 Abstract

A double-blind, parallel, randomised controlled trial assessing the impact of Modafinil on “free” and “cued” recall of clinical information in fatigued, non-sleep deprived clinicians. Modafinil attenuates fatigue, improving free but not cue-based recall. Memory cues to aid information retrieval may reduce fatigue related error without adverse effects of neuropharmacology.
9.1.1 Purpose
To evaluate the impact of Modafinil on “free” and “cued” recall of clinical information in fatigued but non-sleep deprived clinicians.

Despite attempts to minimize sleep deprivation through roster redesign, evidence suggests that fatigue remains prevalent. The wake-promoting agent Modafinil improves cognition in the sleep-deprived fatigued state and may improve information recall in fatigued non-sleep deprived clinicians.

9.1.2 Methods
Twenty-four medical undergraduates participated in a double-blind, parallel, randomised controlled trial (Modafinil-200mg: placebo) involving one hundred and forty-four manpower hours. Medication was allocated two hours before a 90-minute fatigue inducing continuous performance task (dual 2-back task). A case history memorization task was then performed. Clinical information recall was assessed as “free” (no cognitive aids) and “cued” (using aid memoirs). Open and closed cues represent information of increasing specificity to aid the recall of clinical information. Fatigue was measured objectively using the psychomotor vigilance task (PVT) at induction, before and following the dual 2-back task.
9.1.3 Results
Modafinil significantly reduced false starts and lapses (Modafinil= 0.50, placebo = 9.83, p<0.05) and improved PVT performance (Decreased Performance, Modafinil= 0.006, placebo= 0.098, p<0.05). Modafinil improved free information recall (Modafinil= 137.8, placebo= 106.0, p<0.01). There was no significant difference between groups in the amount of information recalled with open (Modafinil= 62.3, placebo= 52.8, p=0.1) and closed cues (Modafinil =80.1, placebo=75.9, p=0.3).

9.1.4 Discussion
Modafinil attenuates fatigue and improves free recall of clinical information without improving cue-based recall. Memory cues to aid clinical information retrieval are convenient interventions that may reduce fatigue related error without adverse effects of neuropharmacology.
9.2 Introduction

Fatigue induced decrements in cognitive performance can impair decision-making (219), produce attentional failures (100,219), reduce vigilance (94) and impair recall(95,219); ultimately leading to error (49,100,219) with consequent risks to both patients and clinicians (94,99). Despite strategies to redesign rostas in an attempt to curtail working hours and minimize sleep-deprivation (220), persistent fatigue amongst healthcare workers remains a cause for concern (7,86,106). Data acquired subsequent to the introduction of the Accreditation Council for Graduate Medical Education (ACGME) 16-hour duty hour restrictions in July 2011 paradoxically suggests greater burnout, fatigue and lower quality of life amongst residents (221-223). Therefore, it is conceivable that clinicians’ experience the effects of fatigue without necessarily being sleep-deprived per se.

Fatigue can occur in the non-sleep deprived state as a result of the cumulative time-on-task effects (219,224) or from circadian misalignment (100,219,225,226), and yet fatigue induced performance decline in non-sleep deprived clinicians has not been systematically evaluated to date. Of all human cognitive facets, memory is especially sensitive to the effects of cumulative fatigue (94,227) which for clinicians may result in critical clinical information loss during the “hand-over” or “hand-off” process. Importantly, there is evidence to support a correlation between inadequate communication, information loss and adverse outcomes (30,95,168,228) making the hand-off process a risk window for fatigue-related medical errors and a priority area for the ACGME. Moreover, whilst working-hour restrictions have been an important step in fatigue amelioration; as an isolated strategy is insufficient to prevent fatigue-induced errors in information transfer between clinicians (49,229).
Approaches to improve clinical information management include checklists, mnemonics and electronic handover packages. Systems that standardize information exchange at hand-offs may improve patient care (99,230-232) but have not been studied in non-sleep deprived fatigued clinicians. Additionally, whilst electronic packages seek to standardize the ‘fields’ of information entry (220,233,234) they do not necessarily provide clinicians with focused cues to prompt information recall. Checklists on the other hand use evidence from cognitive psychology where a cued response will have an increased correct recollection compared to reliance on the free recall of information (7,34,86,106) and thereby force the provider to acknowledge specific elements of care provision, thus improving safety (221-223,235).

As some clinicians are known to utilize legal stimulants such as caffeine to offset fatigue (236) there has been growing interest in the effects of neuro-pharmaceuticals such as wake-promoting drugs that improve attention, concentration and working memory. The use of ‘off label’ wake-enhancing medication, for example, Modafinil, which increases dopamine concentrations in the brain through dopamine transporter blockade (124) has been demonstrated to improve performance in the sleep-deprived (fatigued) state (237) and has been used for fatigue management by the military (117) and professional groups (including doctors) (238,239). In fatigued (sleep-deprived) doctors performing non-clinical cognitive tasks, Modafinil led to improved attentional performance (41) and decision making (165). However, Modafinil has not been studied in non-sleep deprived fatigued clinicians and its effects on the recall of clinical information are unknown. To this end, the current study aims to assess the influence of neuropharmological enhancement in performance amongst non-sleep deprived fatigued doctors. Specifically, we investigate the impact of Modafinil on the
amount of clinical information freely recalled and recalled following cue-based memory improvement interventions.
9.3 Materials and Methods

Ethical approval was granted by Cambridgeshire Research Ethics Committee-11 (Ref: Version8/09-H0304-24). Site-specific approval, sponsorship, and funding for the study were provided by Imperial College London. The research trial was registered with University hospital Medical Information Network (UMIN) registration number UMIN000013822 (http://www.umin.ac.jp/ctr).

Twenty-four undergraduate medical students participated in the double-blind, parallel, randomised placebo-controlled third party allocated 1:1 placebo: 200mg Modafinil study (Fig.9-1). Randomisation was performed using excel and was stored by hospital pharmacy to ensure investigators were blinded to pharmaceutical allocation. Prescriptions were dispensed in identical capsules. A single researcher enrolled participants more than 24 hours after provision of study documentation.

Participants were eligible if they were over eighteen years of age and were not taking regular medication(s). They were required to be well rested. Modafinil reduces the effectiveness of the oral contraceptive through interaction with cytochrome P450 isoenzymes (240), thus female candidates required a negative pregnancy test on commencing the study and were required to use barrier contraception for one month post study completion (n=5). Subjects were excluded if any medical history was detected that would impair cognitive or motor function; they consumed more than twenty-one units of alcohol/week; scored more than one on the CAGE questionnaire (241); had a history of illicit drug use; scored more than nine on the Epworth Scale (242) or consumed greater than three cups of coffee/day.
Figure 9-1: Consort Diagram

N=24 recruited
(19 male, 5 female)

24 Randomised by
external person using
excel

N=0 Exclusion or Withdrawal

Modafinil Group
N=12
(9 male, 3 female)

Completed Study
N=12

Side Effects
N=1 Headache & poor sleep
N=1 Headache

Placebo
N=12
(10 male, 2 female)

Completed Study
N=12

N=0 Exclusion or Withdrawal

Side Effects
N=1 Headache & poor sleep
From the information provided, no participant was excluded. The study was performed in an allocated quiet room at St Mary’s Hospital, Imperial College London, United Kingdom.

9.3.1 Baseline Questionnaires

9.3.1.1 a) Demographics
Participants gender, age and date of birth, year of study and clinical year of study were recorded. No stimulants were ingested (caffeine & chocolate) from midnight on the day of study. IQ was assessed using the National Adult Reading Test (NART) (171).

b) Stanford Sleepiness Questionnaire (SSS) (172)

The SSS is a validated assessment of sleepiness and introspective fatigue. Participants were requested to rate themselves on a sleepiness scale from 1 (feeling active and alert) to 7 (having dream like thoughts).

c) NASA Task Load Index (243)

The NASA-TLX is a validated multi-dimensional rating score that assesses the subject workload of a given task on an individual was used to assess cognitive demands of the N-Back task can be assessed. It derives an overall score based on
weighted average ratings on six subscales, namely: Mental Demands, Physical Demands, Temporal Demands, Performance, Effort and Frustration.

d) Visual Analogue Scale of Affect (244)

Sixteen dimensions of affect were assessed. The subjective scale was converted to a computerized eleven-point (0-10) Likert scale, an accepted alternative method of assessment (245). It provides a subjective measure of the cognitive workload experienced by the participant during the study.

e) Epworth Score (246)

Chronic sleepiness is assessed by the participant rating their likelihood of falling asleep in a range of scenarios (Appendix 9).

9.3.2 Tasks

9.3.2.1 a) N-Back Task
The N-back task is a continuous performance task where the participant indicates whether the presented stimulus is identical to ‘n’ steps back. Stimuli can consist of auditory (letters), visual (squares appearing in one of eight designated points on a screen) or both, thus increasing task complexity. To induce fatigue, this study used a
90 minute dual-2-back assessment where the participant recalled visual and auditory stimuli from two steps back (247).

b) Psychomotor Vigilance Task (PVT) (248)

The PVT is a sustained-attention, reaction-timed task used to measure the speed of response to a visual stimulus. Participants responded to a counter that randomly appeared between two and ten seconds with the reaction time displayed in milliseconds for one-second after the response. PVT is an objective assessment of behavioral alertness and sleep deprivation with the ‘Total Number of Lapses and False Starts’ (TFL) being most sensitive to acute sleep deprivation (249). Reaction times less than 200ms were defined as false starts and those more than 500ms as lapses respectively.

9.3.3 Case Histories

Five written and two video case histories were generated. All case histories were designed using a structured approach to symptom description; for example, pain would be described in a standardised manner – initial site, current site, rapidity of onset, frequency, exacerbating and relieving factors. This allowed for a point allocation for each statement, such that there were no distractors (information not assessed). Candidates were allocated four minutes per written case. They were requested to be able to recall all information provided.
9.3.4 Protocol
Participants completed baseline questionnaires, subjective and objective fatigue measurements at 10:00 hours on the day of study (Fig. 9-2). Allocated medication was administered and the participant was observed for two hours (for peak plasma levels) prior to repeat PVT measurements pre and post N-Back task. Participants were provided with written case histories followed by two video presentations. Candidates were allowed to take notes but they were removed prior to the free recall task. Subjective fatigue measurements were recorded at set time points as indicated in Figure 9-2.

9.3.5 Outcome Measures
Each information point recalled is allocated 1 mark.

9.3.6 Clinical
9.3.6.1 Free Recall
Upon completion of the memorisation task, free recall (verbal) was immediately assessed by presentation of all case histories. Responses were recorded for subsequent marking.
Protocol:
The Study commenced at 10am. Time points for subjective assessments (VAS, Stanford Sleepiness Scale and NASA-TLX) and objective assessment (PVT) are shown.
9.3.7  Open and Multiple Choice Questions

9.3.7.1  Cued recall
The provision of memory cues to aid recall of information was assessed using questionnaires developed for each case history. Open questions and MCQ prompts (which also influenced recognition memory) (Appendix 7 & 10) were developed for each question towards a graded level of information cue. Open questions were allocated a blank space for an answer. MCQ’s provided three possible responses and could consist of wrong information (i.e. confabulated or information from a different case history), correct information or the answer ‘other’. Thus questions could contain two incorrect responses with ‘other’ being the correct answer. Questionnaires were provided in a different case order to the memorisation task.

9.3.8  c) Confidence
Lack of awareness of fatigue can impair judgement (250). Confidence was assessed to ascertain insight into the accuracy of recalled information. Assessments occurred after each case for free recall and each question for cued recall. Participants rated confidence between one (low) and six (high).

9.3.9  Statistical Analysis
For free recall and a power of 0.9, nine candidates were required for each arm of the study (each participant had the possibility of recalling 333 individual points of information). The Shapiro-Wilk test was used to assess the normal distribution of
data. Statistical Analysis was performed using STATA (Version12). Baseline information, Free, Cued Recall, Confidence, Objective fatigue (PVT) and NASA-TLX were analysed using the unpaired t-test. Data from fatigue questionnaires was analysed using the Wilcoxon-Mann-Whitney test. Data was displayed with means and standard error (se).

9.3.10 Harms

No candidate withdrew from the study due to side effects of the medication. There were no significant differences between groups in observed harms. One participant reported a headache in the Modafinil group whilst one reported headache and trouble sleeping in both groups.

9.3.11 Safety

All participants were provided with information on the side effects of Modafinil with instructions regarding how to proceed in the eventuality of symptoms. Participants were observed for medication side effects throughout and had a follow up telephone call following the study.
9.4 Results

9.4.1 Baseline
There was no significant difference in age, year of study, clinical year or Epworth score (Table 9-1). Based on the National Adult Reading test scores the placebo group comprised subjects with significantly higher IQ scores than the Modafinil group [(p<0.01) Table 9-1].

9.4.2 Free Recall
As illustrated in Figure 9-3, the Modafinil group recalled significantly more points of clinical information compared to the Placebo group (Free Recall (au): Modafinil 137.83 se7.12, placebo 106.00 se8.38, p<0.01). Sub-group analysis found increased recall for written case information in the Modafinil group (Written: Modafinil 100.00 se4.12, placebo 79.42 se5.84, p<0.01) but no significant difference between groups for video case information (Video: Modafinil 37.83 se3.55, placebo 26.58 se4.22, p=0.05).

There was no significant difference between groups in the total incorrect (Incorrect Free Recall (au): Modafinil 50.33 se4.36, placebo 44.42 se6.02, p=0.44), written (Incorrect Written (au): Modafinil 38.17 se2.82, placebo 37.25 se5.40, p=0.88) or video free recall of information (Incorrect Video (au): Modafinil 12.17 se1.98, placebo 7.17 se1.68, p=0.07).

There was no significant difference in the time taken to recall the total clinical information (Time(s): Modafinil 796.50 se55.03, placebo 649.33 se56.47, p=0.75).
### Table 9-1: Baseline Values

<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>Year of Study</th>
<th>Clinical Year</th>
<th>Epworth Score</th>
<th>NART IQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Placebo</td>
<td>22.33</td>
<td>4.17</td>
<td>1.75</td>
<td>4.00</td>
<td>121.23</td>
</tr>
<tr>
<td></td>
<td>(0.28)</td>
<td>(0.21)</td>
<td>(0.39)</td>
<td>(0.73)</td>
<td>(0.49)</td>
</tr>
<tr>
<td>Modafinil</td>
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<td>3.92</td>
<td>1.58</td>
<td>3.25</td>
<td>118.13</td>
</tr>
<tr>
<td></td>
<td>(0.69)</td>
<td>(0.19)</td>
<td>(0.34)</td>
<td>(0.57)</td>
<td>(0.74)</td>
</tr>
<tr>
<td>p</td>
<td>0.58</td>
<td>0.39</td>
<td>0.75</td>
<td>0.43</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

Mean baseline values with standard error (se) shown in brackets.
Figure 9-3: Free Recall - Total amount of correct points of information recalled per case (%).

Error bars = standard error
Sub-group analysis found no significance in free recall time of written information (Time–Written: Modafinil 564.75 se41.70, placebo 473.08 se48.27, p=0.16). Time taken for free recall of video case information was significantly longer in the Modafinil group (Time–Video: Modafinil 231.75 se18.90, placebo 176.25 se14.22, p<0.05) (Fig. 9-4).

9.4.3 Cued Recall

9.4.3.1 Open Question
There was no significant difference in the total cued recall between Modafinil and Placebo groups for open questions (Open Cued (au): Modafinil 62.33 se4.39, Placebo 52.75 se3.27, p=0.09). Sub-analysis found open question cued recall was increased for written information in the Modafinil group (Written Cued: Modafinil 45.00 se2.94, placebo 34.75 se2.76, p<0.05). There was no significance between groups for open cued recall for the video cases (Video Cued: Modafinil 17.33 se2.09, placebo 18.00 se1.66, p=0.81).

9.4.3.2 Closed Questions-MCQ’s
There was no significant difference in memory cues (recognition and cued recall) between groups for MCQs (MCQ (au): Modafinil 80.08 se2.30, placebo 75.92 se3.47, p=0.33). Sub-analysis found no difference between MCQ cues for written (MCQ written: Modafinil 56.08 se1.87, placebo 52.50 se2.74, p=0.29) or video cases (MCQ video: Modafinil 24.00 se1.02, placebo 23.42 se1.35, p=0.73).
Cases 1-5 are written histories. Cases 6 & 7 are verbal histories. Error bars = standard error.

9.4.4 Objective Fatigue Detection

9.4.4.1 PVT

Figure 9-5 illustrates that the placebo group demonstrated a significant deterioration in PVT performance versus the Modafinil group. (Reduction in Performance:
Modafinil 0.006, se0.010, placebo 0.098, se0.036, p<0.05, with an increased Total False starts and Lapses (TFL) (Fig. 9-6 - Increase in TFL (n): Modafinil 0.50, se0.90, placebo 9.83, se3.62, p<0.05). The mean change in reaction times from ‘induction’ to ‘post cognitive loading task’ was significantly inferior in the placebo group (Mean Increase in Reaction Time (ms): Modafinil 2.42, se6.38, placebo 43.75, se18.53, p<0.05).

9.4.5 Subjective Fatigue

9.4.5.1 Stanford Scale

Pre-intervention there was no significant difference in sleepiness between groups [Stanford Scale (a.u): Modafinil 1.83 se0.17, placebo 1.67 se0.19, p=0.47], with participants rating themselves between ‘Feeling active, vital, alert or wide awake’ and ‘Functioning at a high level but not at peak; able to concentrate’. There was no significant difference observed post N-Back or post recall task in introspective fatigue [Stanford Scale(a.u), N-Back: Modafinil 3.08 se0.51, placebo 4.08 se0.40, p=0.13, Recall: Modafinil 3.58 se0.42, placebo 4.50 se0.36, p=0.12].
Figure 9-5: Objective Fatigue Measurements. The Psychomotor Vigilance Task - Performance
Figure 9-6: Objective Fatigue Measurements. The Psychomotor Vigilance Task - Lapse & False Starts
9.4.5.2 b) VAS
Pre-testing, there was no significant difference in VAS scores between groups. As illustrated in Figure 9-7, the placebo group was significantly less alert (Alert-Drowsy (au) Modafinil 4.67 se0.64, placebo 6.42 se0.50, p<0.05). They also displayed a decrease in mood (Happy-Sad (au): Modafinil 3.75 se0.46, placebo 5.17 se0.53, p<0.05) with loss of interest (Interested-Bored (au): Modafinil 5.17 se0.79, placebo 7.42 se0.61, p<0.05) on completion of the recall task.

9.4.5.3 NASA-TLX
There was no significant difference between groups for each subscale at baseline and pre-cognitive loading task. Following the N-Back task, frustration was significantly increased in the placebo group (Frustration (au): Modafinil 4.75 se0.57, placebo 6.58 se0.61, p<0.05). The placebo group experienced a significant increase in temporal demand on completion of the recall task (Temporal Demand (au): Modafinil 4.54 se0.48, placebo 5.92 se0.46, p<0.05).
Figure 9-7: Subjective Fatigue Measurement. Visual Analogue Score – Alert-Drowsy

Alert-Drowsy scale ratings between 0 and 10. The higher the score, the less attentive or alert the participant.
9.5 Discussion

This study was specifically designed to induce cognitive fatigue in non-sleep deprived clinicians, to assess the attenuating effect of Modafinil on the recall of clinical information following a fatigue-inducing task. The results demonstrate that Modafinil attenuates decrements in vigilance in the non-sleep deprived fatigued state and improves free recall of clinically relevant information after a cognitive fatiguing task. Although free recall of clinical information is improved compared to placebo, questions that employ specific cues or prompts produce equivalent clinical information recall. Clinician confidence was appropriate to the response, thus significantly higher for free recall in the Modafinil group but for specific cue based recall no difference was observed between experimental groups.

The PVT was used to objectively assess cognitive fatigue induced by the N-Back task. Compared to the group randomised to Modafinil there were significantly more lapses and false starts committed by the placebo group following N-Back task completion. These results both confirm the fatiguing nature of the N-Back task and provide more evidence to support the capacity of Modafinil to ameliorate the effects of fatigue-induced changes in operator vigilance. These results are commensurate with literature which demonstrates improved working memory (reduced impulsivity, flexible cognition and decision making) in sleep deprived clinicians medicated with Modafinil (251).

However, unlike prior randomised studies which failed to demonstrate significant improvements in clinical performance despite significant improvements in cognitive efficiency following Modafinil administration (251), here improved vigilance is
observed alongside improved free recall of clinical information. Specifically, following cognitive loading, free recall of clinical information was significantly improved in clinicians randomised to Modafinil. In real terms, Modafinil led to an average thirty-one more points of freely recalled information versus placebo, and whilst it is accepted that not all points of clinical information are of equal relevance and indeed that information was not weighted, it follows that the anticipated quality of free information transfer at hand-off would be superior following Modafinil administration. This notwithstanding, the current study was not designed to determine causality and although plausible, it remains uncertain whether improved attention as a result of Modafinil administration directly led to enhanced memorisation of clinical case histories which subsequently manifest as superior free recall.

Instead of depending on free recall of clinical data, checklist systems reduce error related effects through recognition of specific aspects of care provision, thus improving safety (235). This study identifies specific cue based recall as a method of improving recollection of clinical information. Critically, compared to placebo, neuropharmacology offered no significant advantage with respect to the amount of clinical information recalled as long as participants received cues. The implications are that cues can be developed in pre-existing systems, for example during creation of the handover list that can stimulate information recall (example Chapter 8, Fig. 8-4), thereby obviating the medical side effects (252,253) and ethical implications associated with pharmaceutical administration (254). Cues can be designed to provoke thought rather than produce an automated response, the latter a legitimate concern amongst senior physicians. However, a system has to be designed for the weakest component (i.e. a fatigued inexperienced doctor), and cues do not necessitate
use of the information recalled, just the subconscious recognition of the retrieved information.

It is acknowledged that there are number of important limitations with the current study. Firstly, the N-Back task was chosen as a surrogate of fatigue in a clinical setting but it is not known how N-Back evoked fatigue translates to that induced by real patient care. However, for a preliminary investigation it allows for a standardised assessment in a controlled environment. Secondly, whilst Modafinil was observed to preserve vigilance and reduce lapses in attention as indexed by PVT results, the translational impact of this result is arguably best reflected in a clinical paradigm that requires both sustained attention and yet a rapid behavioural responses to discrete stimuli (i.e. less than 500ms). Recall of clinical information does require sustained attention but rapid responses were not required. Theoretically, future work should focus on operative tasks sensitive to longitudinal variation in vigilance such as for instance colonoscopy polyp detection rates time (255,256). Finally, the NART (crystallized intelligence) results demonstrated a significantly elevated IQ level in the placebo group. However, in real terms this was 3 IQ points reflecting a small ‘real’ difference between two groups with generally high IQ scores. In our opinion the difference in IQ did not influence the results in this study.

9.6 Conclusion

In Summary, Modafinil may attenuate fatigue induced by performance decline, and improve subsequent free recall of clinical information. However, evidence for improved recall with Modafinil during cue based recall is lacking. In an era in which
clinicians remain fatigued even if not sleep deprived, cue based information retrieval represents a simple intervention suitable for implementation as part of a healthcare Fatigue Risk Management System to reduce fatigue related error and improve patient safety especially during hand offs.
Chapter 10 Limitations, Lessons and Further Work

10.1 General Conclusions

Acute Mental Fatigue is continuing to produce significant detrimental cognitive impairment to the medical workforce. Survey data suggests that although inroads into fatigue have conscientiously been made through work hour limitation strategies, a multi-faceted approach targeting other fatigue inducing factors is required. Without broad ranging fatigue interventions, the work-force will continue to experience excessive fatigue. Thus patient safety is still of concern through fatigue induced errors. Compensatory mechanisms to reduce fatigue through the use of legal stimulants are repeatedly used by staff who subjectively recognise that they are fatigued, yet these measures are time limited and ultimately will fail.

Handover is a highlighted area for concern due to the requirements for accurate, concise patient information delivered over a short time period. Patient safety is frequently placed at risk through omitted or inaccurate information transfer, heightened by the fatigued state. This recognised problem has not been effectively resolved despite 10 years of publicity and recommendations by medical governing bodies.

Evidence behind the handover process is sparse. It is recognised that verbal transfer of information is less effective without hard copies of information to aid information transfer. Yet the required content is not easily defined lacking supporting evidence. Electronic medical records have started to improve documentation through obtaining
information from the original source document or through creating structure for the handover process. These systems can improve handover. However, what information should be included is not defined.

This thesis explored cognitive cues that can be used to improve recall and medical documentation. It is evidenced based and can improve cognitive recall in the acute mental fatigue state. This process still requires refinement. However, it does highlight possibilities for use in software packages for cues during initial clerking or during the creation of a handover document. This thesis provides an evidenced based approach for creating information delivery systems for the dissemination of patient information that can be extrapolated to other checklists or proformas.

Cue induced recall has been demonstrated to improve recall of clinical information. This is equivalent to the currently publicised pharmaceuticals used by academics to improve performance during cognitively fatiguing tasks. Modafinil has been publicised by the media due to its use by students, academics and the military to improve cognitive performance. Yet, evidence in the non-sleep deprived state is limited. This thesis has demonstrated that non-sleep deprived healthy individuals have improved recall if cognitively fatigued, but this is only of similar levels to cue induced recall. This finding suggests that there are avenues available to improve fatigue related error without pharmacological use.
10.2 Limitations and Further Work

Cue based recall requires further investigations for an effective handover intervention. Key principles have been demonstrated by studies within this thesis but further analysis is required. This could enable in-depth analysis of the recall of an individual case history and could potentially highlight areas of information repeatedly forgotten. The current studies were insufficiently powered to perform this sub-analysis. How primacy and recency are effected by cues is not clear but may create interesting avenues of research for cue based development. Cues focussed on information within the middle of a case history may improve recall due to these effects (described Chapter 2.8.2.1). The following areas demonstrate the limitations of this thesis:

10.2.1 Case Histories

Items of information within a case history are not of equal relevance. The presentation of significant quantities of information could also be distracting. In this thesis each information point was equally weighted (1 point allocation). This was deliberate as it was considered that this information would be presented to the doctor when taking a detailed history. One may also state that this study is attempting to identify information less experienced individuals recall and what information cues would be required to obtain the optimum handover information for a specific diagnosis. With experience, doctors may encapsulate key information, and it is the designs of the intervention to mimic this process in aiding, less experienced doctors achieve high quality, concise, information dissemination during handover.
10.2.2 Non-Clinical Tasks

A common criticism of the research is the use of non-clinical tasks to induce fatigue. Unfortunately there was no translational study performed to allow categorisation of fatigue within clinical practice compared to the N-Back task, although it has certainly been considered for future work. The level of cognitive load may differ to clinical practice and could potentially have different effects on recall in the context of clinical handover. However, the benefits were that of a quantifiable, reproducible fatigue level in a lab-based environment that could be standardized for the study.

Subjective fatigue measurements were used throughout the study. However, for quantifiable results that can be reproduced in other hospital settings, it is important that objective scales are developed. The PVT is a ten-minute vigilance assessment that has limited applications due to time requirements within the time pressured clinical environment. However there is evidence of use of this task when investigating fatigue (249). Shorter versions are now available and are increasingly being validated (257), thus may prove to be appropriate for a translational study of fatigue between clinical and non-clinical environments.

10.2.3 Participants

Further limitations are that of the use of medical students for recall assessments. From the levels of processing theory, individuals with greater processing and understanding would find recall of information easier. For an initial investigative study, the ease of recruitment balanced with initial uncertainty of intervention effectiveness deemed their recruitment appropriate for the preliminary study phase. A result was more likely
to be demonstrated using an inexperienced group, hence allowing for the clarification and refinement of essential cues prior to use with clinical personnel.

The second study did move the focus of the research into a clinical environment with assumed fatigue from work-based practice. This was done knowing how individuals respond to cues when cognitively fatigued. One must also consider that the intervention must be designed towards the less experienced doctor who inputs the information for distribution at handover, (hence limited effects of the levels of processing theory [22]).

10.2.4 Interventions
10.2.4.1 Modafinil
When new interventions arise they need to be scientifically, ethically and economically evaluated to provide sufficient knowledge to the medical community. The ethical debate concerning neurocognitive enhancement is an emotive subject. With increasing information on ‘smart drugs’, one must consider patient safety and physician well being. Coercive pressures from employers, patients and altruistic desires may occur, alongside risks of addiction. Although there is freedom of choice in a libertarian society, the potential benefits of cognitive enhancement must be carefully considered while minimising risk to all. Whilst it is not the author’s recommendation to administer neurocognitive enhancement, an ethical framework needs to be developed within which forthcoming developments can be addressed. Currently pharmaceutical enhancement is separated from clinical work, yet these limitations will be repeatedly challenged over the coming years. For safe
development of neurocognitive enhancement, clear ethical guidelines need to be produced by the medical governing bodies.

10.2.5 Non-Pharmacological Intervention

10.2.5.1 Multiple Choice And Open Questions
Multiple choice questions and open questions stimulated recall of information using cued recall and recognition memory. With increasing question specificity (MCQ vs Open questions) the greater the focus on recognition memory. One must also question how applicable this method of questioning is when attempting to create an intervention in the fluid environment of handover. Doctors are very familiar with this method of questioning due to assessments performed throughout medical training. One could also state that it is a key word that is of importance rather than the sentence within which it is displayed, providing it is within the correct context. Hence the word “score?” has significant meaning to a doctor when placed within a handover cue for pancreatitis. Outside of the medical profession this would have limited meaning. It would prompt a doctor to check or recall the severity classification score of pancreatitis for a patient as this has a predictive value towards patient outcome and complications. “What was the pancreatitis score?” imparts very little extra information and was the reasoning behind the refinement of the questions in the handover intervention.

10.2.5.2 Handover Intervention
A significant limiting factor for further development of the cue-based handover intervention was the Excel package. It was initially used due to the familiarity of
participants with the package and its current use in the handover process (at the participating hospital). Unfortunately the spread sheet code for an individual cell was limited preventing more than five diagnoses being detected during the study. The ‘diagnosis’ function is a key aspect of the cue based handover program. For the study to be extrapolated to a clinical environment, an alternate program would need to be developed.

10.3 Further Work

The conscious implementation of cognitive science is an important step towards evidence based improvements in patient safety. Unfortunately, current use of cognitive psychology in fatigue management is limited. For support in the application of memory cues in clinical practice, the clinical relevance for its application in fatigue related error and patient safety must be apparent. A translational study demonstrating the levels of clinical fatigue at handover compared with non-clinical tasks should be undertaken. This will provide direct comparisons to this thesis and future fatigue work.

Further work should focus on junior doctors and the recall of clinical information within a clinical environment. This thesis has demonstrated that improvements can be made to the current handover process using cue based interventional strategies. An alternative software package would need to be developed to continue this pathway of investigation.
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Chapter 12 Appendix
Appendix 1

IMPERIAL COLLEGE LONDON
Department of Surgery and Cancer
St Mary’s Hospital, Praed Street, London, W2 1NY

Participant number:
Date:

**Stanford sleepiness questionnaire**

Please rate how alert you are feeling using the following scale.

<table>
<thead>
<tr>
<th>Degree of sleepiness</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Feeling active, vital, alert, or wide awake</td>
<td>1</td>
</tr>
<tr>
<td>2. Functioning at a high level but not at peak; able to concentrate.</td>
<td>2</td>
</tr>
<tr>
<td>3. Awake but relaxed, responsive but not fully alert.</td>
<td>3</td>
</tr>
<tr>
<td>4. Somewhat foggy, let down.</td>
<td>4</td>
</tr>
<tr>
<td>5. Foggy, losing interest in staying awake; let down.</td>
<td>5</td>
</tr>
<tr>
<td>6. Sleepy, woozy, fighting sleep; prefer to lie down.</td>
<td>6</td>
</tr>
<tr>
<td>7. No longer fighting sleep, onset soon; having dream like thoughts.</td>
<td>7</td>
</tr>
<tr>
<td>8. Asleep</td>
<td>X</td>
</tr>
</tbody>
</table>
## Appendix 2

**Visual Analogue Scale**

<table>
<thead>
<tr>
<th>Trait</th>
<th>Opposite Trait</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alert</td>
<td>Drowsy</td>
</tr>
<tr>
<td>Calm</td>
<td>Excited</td>
</tr>
<tr>
<td>Strong</td>
<td>Tired</td>
</tr>
<tr>
<td>Mazy</td>
<td>Clear Headed</td>
</tr>
<tr>
<td>Well Co-ordinated</td>
<td>Grumpy</td>
</tr>
<tr>
<td>Energetic</td>
<td>Lethargic</td>
</tr>
<tr>
<td>Contented</td>
<td>Discontented</td>
</tr>
<tr>
<td>Troubled</td>
<td>Tranquil</td>
</tr>
<tr>
<td>Mentally Slow</td>
<td>Quick Witted</td>
</tr>
<tr>
<td>Tense</td>
<td>Relaxed</td>
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<tr>
<td>Incompetent</td>
<td>Proficient</td>
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<tr>
<td>Happy</td>
<td>Sad</td>
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<tr>
<td>Antagonistic</td>
<td>Amicable</td>
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<tr>
<td>Interested</td>
<td>Bored</td>
</tr>
<tr>
<td>Withdrawn</td>
<td>Gregarious</td>
</tr>
<tr>
<td>Attentive</td>
<td>Dreamy</td>
</tr>
</tbody>
</table>
Appendix 3

IMPERIAL COLLEGE LONDON
Department of Surgery and Cancer
St Mary’s Hospital, Praed Street, London, W2 1NY

NASA-TLX Mental Workload Rating Scale

Please place an “X” along each scale at the point that best indicates your experience with the display configuration.

**Mental Demand:** How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc)? Was the mission easy or demanding, simple or complex, exacting or forgiving?

Low | | | | | | | | | | | | | High

**Physical Demand:** How much physical activity was required (e.g., pushing, pulling, turning, controlling, activating, etc)? Was the mission easy or demanding, slow or brisk, slack or strenuous, restful or laborious?

Low | | | | | | | | | | | | | High

**Temporal Demand:** How much time pressure did you feel due to the rate or pace at which the mission occurred? Was the pace slow and leisurely or rapid and frantic?

Low | | | | | | | | | | | | | High

**Performance:** How successful do you think you were in accomplishing the goals of the mission? How satisfied were you with your performance in accomplishing these goals?

Low | | | | | | | | | | | | | High

**Effort:** How hard did you have to work (mentally and physically) to accomplish your level of performance?

Low | | | | | | | | | | | | | High

**Frustration:** How discouraged, stressed, irritated, and annoyed versus gratified, relaxed, content, and complacent did you feel during your mission?

Low | | | | | | | | | | | | | High
<table>
<thead>
<tr>
<th>Chord</th>
<th>Ache</th>
<th>Depot</th>
<th>Aisle</th>
<th>Bouquet</th>
<th>Psalm</th>
<th>Capon</th>
<th>Deny</th>
<th>Nausea</th>
<th>Debt</th>
<th>Courteous</th>
<th>Rarefy</th>
<th>Equivocal</th>
<th>Naïve</th>
<th>Catacomb</th>
<th>Gaoléd</th>
<th>Thyme</th>
<th>Heir</th>
<th>Radix</th>
<th>Assignate</th>
<th>Hiatus</th>
<th>Subtle</th>
<th>Procreate</th>
<th>Gist</th>
<th>Gouge</th>
<th>Superfluous</th>
<th>Simile</th>
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<tbody>
<tr>
<td>Banal</td>
<td>Quadruped</td>
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</tbody>
</table>
Health Questionnaire:

Participant Number: ____________

Are you currently taking any medication? Yes/No
If yes, please state: ____________

Do you have a history of any psychiatric illness? Yes/No

Have you ever been referred to a psychiatric service? Yes/No

Have you ever received medication for depression? Yes/No

Have you ever had any serious problems with anxiety/agitation/tension? Yes/No

Have you ever used alcohol or drugs heavily? Yes/No

Have you ever been treated for alcohol/drug problems? Yes/No

How much alcohol do you drink per week? Yes/No

1. Never
2. 0-7 units
3. 8-14 units
4. 15-20 units
5. > 21 units
(exclusion if 21 units or more/week)

When did you last have an alcoholic drink? ____________
(exclusion if any in last 24 hours)

When did you last have a drink with caffeine? ____________
(exclusion if any in last 24 hours)
Have you ever had any other serious medical problems*? Yes/No

**Have you ever had:-**
- Heart problems (eg: angina, arrhythmia) Yes/No
- Hypertension (high blood pressure) Yes/No
- A Serious head injury Yes/No
- Injury resulting in loss of consciousness Yes/No
- Surgery* Yes/No
- Problems with hearing* Yes/No
- Problems with vision* (including colour vision impairment) Yes/No
- Problems with movement* (motor impairment) Yes/No

I confirm that all information provided is accurate

Date: ______________ Signed: ______________ (Participant)

Is the participant suitable for inclusion in study (refer to inclusion/ exclusion criteria) Yes/No

Date: ______________ Signed: ______________ (Researcher)
Appendix 6: Example of Case History provided to participant.

IMPERIAL COLLEGE LONDON
Department of Surgery and Cancer
St Mary’s Hospital, Praed Street, London, W2 1NY

Ian Davis
SM542189
07/05/78

PC
33yr old male, GP referral with 1/7 history of abdominal pain
Initially generalised abdominal pain that is now currently in right iliac fossa
Gradual onset
Constant pain
Exacerbated by coughing. Relieved by flexing right hip.
Bowels normal. Nauseated, no vomiting
Complained of urinary frequency. No dysuria
No fevers
No family history of inflammatory bowel disease or malignancy
No weight loss

PMH
Asthma

Allergies - Amoxicillin
Medications - Salbutamol

SH Lives alone. Smoker – 20 per day

O/E
HR 92 BP 125/76 Sats 98% OA T 37.7
Mild guarding and rebound in the RIF over McBurney’s point
PR normal
Urine dip was normal (negative for leukocytes and nitrites)

Blood Results
Fbc Hb 14.2 Wbc 11
Plt 255
CRP 25
Amy 35

U&E Na 141 LFTs ALT 32
K 4.2  
Ur 5 Bil 3
Cr 73 Alb 38
Clotting N/A G&S done

Imp
Appendicitis

Plan
NBM, IV fluids. N.Saline 6 hourly
Not for antibiotics yet. Laparoscopic Appendicectomy mane?
Appendix 7

IMPERIAL COLLEGE LONDON
Department of Surgery and Cancer
St Mary’s Hospital, Praed Street, London,
W2 1NY

Participant number:
Date:

Immediately Minutes Post Verbal presentation.

Please indicate if you agree with these statements by circling True or False and indicate your certainty of answer on the scale of 1 to 6 (1 = relatively low confidence, i.e. basically guessing, 6 = relatively high confidence, i.e. relatively sure).

The male diagnosed with appendicitis:

<table>
<thead>
<tr>
<th>His name was</th>
<th>James Elm / Ian Richards / Other</th>
<th>1 2 3 4 5 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>His age was</td>
<td>31 / 33 / Other</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>The patient described a history of pain lasting</td>
<td>1/7 / 2/7 / Other</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>He was referred in by</td>
<td>A&amp;E / GP / Other</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>He initially had</td>
<td>Generalised pain / Central pain / Other</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>He</td>
<td>Vomited / was nauseated / Other</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>The patient experienced</td>
<td>A single loose bowel motion / constipation / other</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>He complained of</td>
<td>Dysuria / urinary frequency / other</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>The patient had a family history of</td>
<td>Crohn’s disease / Ulcerative colitis / Other</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>The patient was prescribed</td>
<td>Hartman’s 6 hourly / N. Saline 6 hourly / Other</td>
<td>1 2 3 4 5 6</td>
</tr>
</tbody>
</table>
### Appendix 7

<table>
<thead>
<tr>
<th>He felt</th>
<th>Feverish today / feverish yesterday / other</th>
<th>1 2 3 4 5 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>He was allergic to</td>
<td>Penicillin / no known drug allergies / other</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>He lived</td>
<td>With his long-term partner / with friends / other</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>He</td>
<td>Smoked 20 per day / 10 per day / other</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>He had a temperature of</td>
<td>37.7 / 37.8 / other</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>He was for</td>
<td>Open appendicectomy / laparoscopic appendicectomy / other</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>PR was</td>
<td>Tender on right side / refused / other</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>His urine dip was</td>
<td>Normal / positive for leukocytes / other</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>He had a past medical history of</td>
<td>Laparotomy for stabbing / asthma / other</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>He was</td>
<td>Not for antibiotics / for oral antibiotics / other</td>
<td>1 2 3 4 5 6</td>
</tr>
</tbody>
</table>
Appendix 8

IMPERIAL COLLEGE LONDON
Department of Surgery and Cancer
St Mary’s Hospital, Praed Street, London, W2 1NY

Edward James
SM423675
11/03/45
Bed A2 Falcon Ward

PC
55yr old male, GP referral with 6/7 history of abdominal pain
Started in central abdomen. Now worse in right iliac fossa
Gradual onset
Colicky pain.
Nauseated. Faeculent vomiting
No exacerbating factors.
Bowels not open for 2/7. No flatus today. Burping.
c/o bloating and distended abdomen
No urinary frequency or dysuria
Feverish today
No weight loss. No family history of inflammatory bowel disease or bowel cancer

PMH
Right inguinal hernia repair 2007
MI 2012

Allergies - Penicillin

Medications - Aspirin
Propanolol

SH Lives alone. Non-smoker
 Doesn’t drink
 Good exercise tolerance. Performs all ADLs.

O/E
HR 115 BP 100/50 Sats 93% OA T 37.9
Tense & Distended. Rebound & Guarding right iliac fossa with a tender reducible recurrent right inguinal hernia.
PR found a loaded rectum. Urine dip normal

AXR – dilated small bowel loops. Faecally loaded rectum
Erect Chest – no free air. Consolidation Right base

Blood Results
Fbc Hb 14.2 U&E Na 127
Wbc 21 K 3.3
Plt 450 Ur 22
CRP 95   Cr 231
Clotting N/A   G&S not done

D/W On call consultant re: theatre/scan – needs resuscitation then CT

CT Result
In the right iliac fossa there is a 10cm thickened blind ending luminal structure that tracks from the caecum to lie within a right inguinal hernia. There is significant inflammatory stranding tracking towards the base of the caecum where there is a 5x5cm gas containing collection containing a higher density component consistent with a faecolith. The small bowel is significantly distended almost to the caecum where it appears to be involved in the inflammatory mass surrounding the collection and is the site of obstruction. The colon is faecally loaded but relatively collapsed.

Conclusion
Perforated Appendicitis with the appendix tip situated in the sac of the Right inguinal hernia. There is a 5x5 cm collection at the base of the appendix containing a faecolith suggesting this is the site of the perforation. The distal ileum is involved in the inflammatory process surrounding the abscess and is the site of obstruction. On call registrar for surgery has been informed.

Imp
Small Bowel Obstruction secondary to a perforated appendix
Right Basal Pneumonia

Plan
NBM, IV fluids. Hartmans at a 2 hourly rate
For Cefuroxime & Metronidazole.
Nasogastric tube and catheter.
Hourly Urine Output
Saline Nebulisers

Outstanding jobs
Needs Group and save
Consent.
Book for theatre
Inform Consultant on call
Open Questions

Please write an answer for the following questions on the clinical case of –

**THE MALE WITH APPENDICITIS**

Some answers regarding a patients symptoms may be 'none’. Please indicate the certainty of each answer you provide on the scale of 1 to 6 (see reference sheet). You should spend no more than a few seconds on each question.

If you struggle to recall an answer at all you may put a dash in the box to indicate this – and circle the lowest confidence level.

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What was the patient’s name?</td>
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<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>2. What was the patient’s age?</td>
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<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>3. How many days had the patient been in pain?</td>
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<td>1 2 3 4 5 6</td>
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<tr>
<td>4. Who was the patient referred by?</td>
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<td>1 2 3 4 5 6</td>
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<tr>
<td>5. Where was the initial abdominal pain located?</td>
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<td>1 2 3 4 5 6</td>
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<tr>
<td>6. What symptoms of nausea and vomiting did the patient experience (if any)? State ‘None’ if no symptoms</td>
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<td>1 2 3 4 5 6</td>
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<tr>
<td>7. Describe the nature of the patient’s bowel movements?</td>
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<tr>
<td>8. What were the urinary symptoms of the patient (if any)? State ‘None’ if no symptoms</td>
<td>1 2 3 4 5 6</td>
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<tr>
<td>9. Which fluids (if any) were prescribed and state the rate at which these were given? State ‘None’ if not given.</td>
<td>1 2 3 4 5 6</td>
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</tr>
<tr>
<td>10. What was the patient prescribed in the management plan? State ‘Nothing’ if not prescribed anything</td>
<td>1 2 3 4 5 6</td>
<td></td>
</tr>
<tr>
<td>11. Describe any feverish symptoms experienced, if any? State ‘None’ if no symptoms</td>
<td>1 2 3 4 5 6</td>
<td></td>
</tr>
<tr>
<td>12. Did the patient have any allergies and if so what were these? State ‘None’ if no allergies</td>
<td>1 2 3 4 5 6</td>
<td></td>
</tr>
<tr>
<td>13. Who did the patient live with?</td>
<td>1 2 3 4 5 6</td>
<td></td>
</tr>
<tr>
<td>14. Did the patient smoke and if so how much?</td>
<td>1 2 3 4 5 6</td>
<td></td>
</tr>
<tr>
<td>15. What was the patient’s temperature?</td>
<td>1 2 3 4 5 6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Options</td>
</tr>
<tr>
<td>---</td>
<td>---------------------------------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>16.</td>
<td>What procedure was planned (if any)? State ‘Nothing’ if no procedure planned</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>17.</td>
<td>Describe the PR examination findings. State ‘Normal’ if no findings.</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>18.</td>
<td>What, if anything, was found on urine dipstick? State ‘Normal’ if nothing found</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>19.</td>
<td>What was the patients past medical history (if anything)? State ‘None’ if no PMHx.</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>20.</td>
<td>Please state the antibiotics prescribed, if any, and the route by which these were administered. State ‘None’ if not given</td>
<td>1 2 3 4 5 6</td>
</tr>
</tbody>
</table>
Epworth sleepiness scale

Please rate how likely you are to fall asleep in the following situations, in contrast to just feeling tired. Please refer to your usual way of life in recent times. Even if you have not done some of these things recently, please try and work out how they would affect you. Use the following scale to choose the most appropriate number for each situation.

0 = No chance of dozing  
1 = Slight chance of dozing  
2 = Moderate chance of dozing  
3 = High chance of dozing

PARTICIPANT NO:

<table>
<thead>
<tr>
<th>Situation</th>
<th>Chance of dozing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sitting and reading</td>
<td></td>
</tr>
<tr>
<td>2. Watching TV</td>
<td></td>
</tr>
<tr>
<td>3. Sitting inactive in a public space (e.g. in a theatre or meeting)</td>
<td></td>
</tr>
<tr>
<td>4. As a passenger in a car for an hour without a break</td>
<td></td>
</tr>
<tr>
<td>5. Lying down to rest in the afternoon when circumstances permit</td>
<td></td>
</tr>
<tr>
<td>6. Sitting and talking to someone</td>
<td></td>
</tr>
<tr>
<td>6. Sitting quietly after lunch without alcohol</td>
<td></td>
</tr>
<tr>
<td>7. In a car while stopped for a few minutes in traffic</td>
<td></td>
</tr>
</tbody>
</table>

Total: