

## **Self-assessment - a useful contribution to our understanding of pilot fatigue?**

Auto-avaliação – uma contribuição útil para nosso entendimento da fadiga de pilotos?

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**ABSTRACT:** *Sleep science predicts a link between time awake and physical and psychological impairment. Responding to an on-line questionnaire pilots described their physical and psychological state after various periods of wakefulness. A syntax analysis (Gee, 2005) revealed a positive correlation between time awake and perceived symptoms of fatigue. Such data is usually garnered from instantaneous self-assessments (ISAs). These findings were derived from post-hoc accounts. Given the consistency of the findings with those based on ISAs it would seem that post-hoc accounts are not unreliable. There are questions over the accuracy of ISAs (Caldwell et al., 2009; Baron, 2009; Eurocontrol, 2012). Post-hoc accounts may be subject to anchoring. Tversky and Kahneman's (1974) work on heuristics and Kasperson and Kasperson's (1996) work on risk amplification is relevant to questions of distortion. The methodology of the ISA and post-hoc account requires further validation.*

**KEYWORDS:** *Pilots; fatigue; accounts; post-hoc; significance.*

**RESUMO:** *A ciência do sono prediz uma ligação entre o tempo passado acordado e a diminuição da capacidade física e psicológica. Respondendo a um questionário online, pilotos descreveram seu estado físico e psicológico depois de vários períodos acordados. Uma análise da sintaxe (Gee, 2005) revelou uma correlação positiva entre o tempo passado acordado e os sintomas de fadiga percebidos. Tais dados são geralmente coletados a partir de autoavaliações instantâneas (ISAs). Estas descobertas foram derivadas de descrições post-hoc. Dada a consistência das descobertas com aquelas baseadas em ISAs pareceria que as descrições post-hoc não são desprovidas de confiabilidade. Existem dúvidas sobre a precisão das ISAs (Caldwell et al., 2009; Baron, 2009; Eurocontrol, 2012). As descrições post-hoc podem estar sujeitas a ancoragem. O trabalho de Tversky e Kahneman (1974) sobre heurística e o trabalho de Kasperson e Kasperson (1996) sobre amplificação do risco são relevantes para questões de distorção. A metodologia da ISA e da descrição post-hoc requer validação adicional.*

**PALAVRAS-CHAVE:** *Pilotos; fadiga; descrições; post-hoc; importância.*

### **1 Introduction**

Perrow (1984; 1999) attributes incidents and accidents to technical factors, specifically tight-coupling and interactive complexity. Perrow's narrow focus is challenged by theorists like Turner

(1978), Cox and Tait (1991), Toft (1992), Vaughan (1996) and Challenger and Clegg (2011). Turner (1978) asserts:

It is better to think of the problem of understanding disasters as a ‘socio-technical’ problem, with social organisation and technical processes interacting to produce the phenomena to be studied.

Cox and Tait (1991) explain:

The majority of accidents are, in some measure, attributable to human as well as procedural and technological failure.

Toft (1992) notes:

[T]he majority of large-scale accidents arise from a combination of individual, group, social and organisational factors – and rarely as the result of technical factors alone.

Speaking to the importance of *holism* as a means to safe design, Challenger and Clegg (2011) write:

[P]eople, processes and procedures, goals, culture, technology, and buildings and infrastructure should all be viewed as *interdependent* and given joint consideration [my emphasis].

Accepting that incidents and accidents may have a *socio-technical* dimension draws human factors (stress, fatigue, job training, teamwork, physical fitness, psychological health, personal ambition, the desire to conform to cultural norms, etc.) into the investigator’s purview.

## **2 Fatigue as a possible contributory factor in incidents and accidents**

According to Petrie, Powell and Broadbent (2004) “... fatigue [is] a major problem for many pilots operating regional and international routes”. While there is uncertainty over the number of incidents and accidents attributable to pilot fatigue, it is safe to assume that fatigue plays a role in some.

Caldwell and Caldwell (2003) note:

Kirsch (1996) estimates that fatigue may be involved in 4-7% of civil aviation mishaps, and data from the U.S. Army suggest fatigue is involved in 4% of Army accidents.

Battelle Memorial Institute (1998) suggests that pilots may underplay the role of fatigue in adverse events:

An initial analysis of NASA’s Aviation Safety Reporting System (ASRS) in 1980 revealed that 3.8 percent (77) of the 2006 air transport crew member error reports received since 1976 were directly associated with fatigue .... This may seem like a rather small proportion, but ... fatigue is frequently a personal experience. Thus, while one crew member may attribute an error to fatigue, another may attribute it to a more directly perceived cause such as inattention or a miscommunication. When all reports which mentioned factors directly or indirectly related to fatigue are included, the percentage increases to 21.1 percent.

Pilots commonly fall asleep while in flight (Werfelman, 2009). The National Sleep Foundation’s 2012 survey of transportation workers highlights pilots’ sleep-related problems:

One in five pilots (20%) admit that they have made a serious error ... due to sleepiness .... Pilots ... are significantly more likely than non-transportation workers ... to say that they have been involved in a car accident due to sleepiness while commuting .... About one-fourth of ... pilots (23%) admit that sleepiness has affected their job performance at least once a week, compared to

about one in six non-transportation workers (17%) .... [O]ne-half of pilots (50%) say they rarely or never get a good night's sleep on work nights .... more than one-third of pilots (37%) report that their current work schedule does not allow adequate time for sleep (National Sleep Foundation, 2012).

De Vries, Michielsen and Van Heck (2003) define fatigue as:

... a general psychophysiological phenomenon that diminishes the ability of the individual to perform a particular task by altering alertness and vigilance, together with the motivational and subjective states that occur during this transition. As a consequence, there is reduced competence and willingness to develop or maintain goal-directed behaviour aimed at adequate performance.

In this paper fatigue will be defined as “a non-pathologic state resulting in a decreased ability to maintain function or workload due to mental or physical stress” (Strauss, 2010). One’s fatigue level is a corollary of “time since awake, the amount of time doing the task, sleep debt and circadian rhythm disruption” (Strauss, 2010).

There are two approaches to measuring fatigue: quantitative (objective) and qualitative (subjective) (De Vries, Michielsen and Van Heck, 2003). Each has adherents and detractors, strengths and weaknesses. Grounded in science, technology and mathematics, aviation is drawn to quantitative measures (like error-monitoring, reaction-time tests or personal motion-sensor records). Qualitative measures are less favoured.

Social science has a mixed track-record in aviation. Although social science-informed risk-management tools like crew resource management are now well established (Wiener, Kanki and Helmreich, 1993; Krause, 1996), Bor, Field and Scragg (2002) claim that pilots remain suspicious of social science-informed interventions:

[I]t has been observed that pilots generally dislike being interviewed by mental health professionals .... This is because they do not feel in control of the situation, [and] that goes against their nature. They may feel uncomfortable in a context where they are unfamiliar with the rules ...

The debate over the reliability of a participant’s assessment of her/his physiological or psychological state complicates matters. Proponents of subjective measures claim them to be as accurate as objective measures (like measures of heart rate, ocular or brain activity or respiration). Regarding subjective assessments (ISAs) of mental workload (loading) Pickup, Wilson, Sharples and Smith (2005) note:

Self report of workload is widely accepted as capturing the operator’s perception of workload or effort. Some authors believe that subjective ratings are the most sensitive and accurate reflection of mental workload (Hart and Staveland, 1988). Others suggest that they can reflect the actual effects on performance greater than measures of task demands (Jensen *et al.*, 1994) and benefit from the operator’s insight into an increase in effort prior to performance degradation (Muckler and Seven, 1992). When an individual is rating themselves they may well be considering how well they are coping, the resources they are using and the amount in reserve, previous experiences and their level of motivation (Muckler and Seven, 1992) .... The IWS [integrated workload scale] appears to provide a meaningful approach to capturing real time [railway] signaller perception of the demands and effort experienced as a consequence of their work, and has not been considered to be intrusive.

Williamson, Friswell and Feyer (2004) note of self-assessment:

Subjective experience is one tool that individuals in the workplace are likely to use to judge their own fatigue level and to make fatigue management decisions. In this sense, subjective measures are an important component of any fatigue measurement battery. There is also some evidence to suggest that subjective experience may be more sensitive to fatigue (or at least sleepiness) than performance or physiological measures because sleepiness ratings have been shown to respond to sleep deprivation before effects on other measures become evident (e.g., Akerstedt and Gillberg, 1990; Dinges *et al.*, 1997; Jewett, Dijk, Kronauer and Dinges, 1999; Williamson, Feyer, Mattick, Friswell and Finlay-Brown, 2001).

Regarding subjective assessments of fatigue Powell, Spencer, Holland, Broadbent and Petrie (2007) note of the self-administered seven-point Samn-Perelli scale: “[S]cores have been shown to follow similar trends to objective measures throughout a [flight] duty period”. Based on an evaluation of six fatigue questionnaires De Vries, Michielsen and Van Heck (2003) conclude:

... all fatigue questionnaires used in the Fatigue at Work programme measure fatigue ... in a reliable and valid way.

Dekker (2007) reminds us that when subjective measures are used it is wise to corroborate the findings:

All measurements ... are inferences. They may say something about the mental effort you are putting in to a task (but they may not). The best strategy is to use a number of different methods [triangulation]. If measurements converge they may have measured the same thing.

Detractors claim that subjects find the self-assessment of fatigue problematic. Caldwell *et al.* (2009) claim: “People cannot reliably self-judge their own level of fatigue-related impairment”. Majumdar (2011) reflects: “[H]ow about measuring fatigue reliably? If it is about feelings, then surely all we need to do is ask individuals if they are tired and to what extent. The evidence though shows that humans are not necessarily good at judging when they are fatigued”. Battelle Memorial Institute (1998) notes: “[F]atigue is frequently a personal experience”. Baron (2009) writes:

Fatigue is a very subjective phenomenon. There are tests that can accurately determine whether someone is driving under the influence of alcohol. However, there are no scientific tests that can measure whether someone is ‘working under the influence of fatigue’. To compound this issue further, people are not very good at making a self-determination that they are too fatigued to work.

Dekker (2011) makes the following observations about an incident investigation at an air navigation service provider (ANSP):

The scale on which [the air traffic control officers] could rate their fatigue was 1 to 9. Nine meant they were wide-awake, one meant that they were completely worn out .... [W]hat exactly is fatigued to the point of feeling ‘three’ on a scale of nine? Fatigue is a hugely subjective, slippery experience .... [T]he very fact that you are fatigued makes estimating ... exactly how fatigued you are very difficult.

Organisational theorists Podsakoff and Organ (1986) describe their reservations about using self-reports in organisational research:

The authors have themselves struggled over the years with the dilemma posed by the use of self-reports in organisational research. From the beginning, we were aware that the questionnaire, at best, provides ‘soft’ data, perhaps better than mere opinions with no data at all, but vastly inferior to most other kinds of data .... [W]hen using self-reports ... we are generally not asking people to report a specific fact or a finite event. We are asking persons to go well beyond that and to engage in a higher-order cognitive process – a process that involves not only recall but weighting, inference, prediction, interpretation and evaluation. Many times ... we are requiring the

respondents to work at a fairly high level of abstraction. Thus, the data we obtain are already quite a few steps removed from the level of discrete stimuli and responses.

Those pilots who completed the on-line BALPA questionnaire were asked to report more than a specific fact. Rather they were asked to recall, assess and accurately describe in prose their physical and psychological state some considerable time after the event – very much a ‘higher-order cognitive process’ (to quote Podsakoff and Organ (1986)).

Given the above it is unsurprising that qualitative measures of fatigue risk (and complementary social-science-informed investigations of pilot fatigue) are treated with scepticism by some in the aviation and wider community. Aviation is familiar ground to mathematicians, statisticians, programmers, chemists, metallurgists, engineers and sleep scientists. It is less familiar ground to anthropologists, sociologists and ethnographers (like the author).

### **3 The British Air Line Pilots’ Association report – reception and outcomes**

Concerned to improve our knowledge of the lived reality of commercial flying operations in 2010 the British Air Line Pilots’ Association (BALPA) commissioned a study of the pilot lifestyle (Bennett, 2011a). Using questionnaires, interviews and sleep logs, the study generated both qualitative and quantitative data. Interestingly, BALPA played down the study’s quantitative dimension, presenting it as a qualitative investigation. A senior human factors expert at the Civil Aviation Authority (CAA) framed the study in the same way. BALPA concluded that ‘further quantitative research is required’. It is reasonable to conclude that qualitative studies are perceived (by both regulators and regulatees) to be less credible than quantitative studies.

If we accept the view that subjects are not able to reliably self-assess their fitness for work, then the credibility of subjective accounts (including *post-hoc* accounts) is called into question. If, however, we take the opposite view (as do Pickup, Wilson, Sharples and Smith (2005), Powell, Spencer, Holland, Broadbent and Petrie (2007), De Vries, Michielsen and Van Heck (2003) and Williamson, Friswell and Feyer (2004)) then self-assessments/subjective accounts may be considered to have something to contribute to our understanding of fatigue risk (with the proviso that such accounts – whether produced concurrently or after-the-fact – cannot be anything more substantial than *perceptions/interpretations*).

### **4 Aims of the research**

First, to present pilots’ recollections of their physical state after being awake and on duty for up to 17 hours, between 18-22 hours, between 23-27 hours and for 28 hours or more. Given the nature of the research method (an on-line questionnaire survey) the data is recorded after-the-fact (*post-hoc*). Issues include pilots’ ability to reliably self-assess, memory distortion (heuristic bias) and loss.

Secondly, to evaluate sleep scientists' prediction of possible physical and psychological impairment after 12-18 hours of continuous wakefulness (Rhodes and Gil, 2002; Miller, 2005; Bor and Hubbard, 2006; Hersman, 2009; Caruso and Hitchcock, 2010; Federal Aviation Administration, 2010).

A discourse analysis (Deese, 1984; Gee, 2005) of the pilots' lexicon was used to test sleep scientists' prediction of possible physical and psychological impairment after 12-18 hours of continuous wakefulness: specifically a count was made of pilots' use of the words 'irritable', 'tetchy', 'short-tempered', 'ill-tempered', 'bad-tempered', 'drained', 'fatigued', 'exhausted' and 'knackered'. (The questionnaire survey made no suggestions as to which adjectives pilots should use to describe how they felt thereby removing the risk of anchoring). Counts are provided for those awake for up to 17 hours, and those awake for over 17 hours.

Thirdly, to evaluate the proposition that after 24 hours of continuous wakefulness a pilot would experience the same sensations as if s/he were just over the United Kingdom's present (2012) drink/drive limit (Civil Aviation Authority, 2007). To this end pilots' lexicon was analysed: specifically a count was made of pilots' use of the words 'intoxicated', 'drunk', 'dizzy', 'light-headed', 'detached', 'confused', 'spaced'/'spacey', 'disorientated' and 'numb'. (The questionnaire survey made no suggestions as to which adjectives pilots should use to describe how they felt). Counts are provided for those awake for up to 22 hours, and those awake for over 22 hours. It would be expected that the percentage of respondents using these adjectives would increase the longer the period of wakefulness. Weaknesses in this approach include the possibility that respondents either described their symptoms in other ways (perhaps by using different adjectives) or ignored them.

Fourthly to evaluate whether pilots' *post-hoc* accounts can be used to add to the large body of scientific data on pilots' physical and psychological responses to long periods of wakefulness. Sleep scientists traditionally use instantaneous self-assessment (ISA) to gather qualitative data on perceived fatigue. This paper investigates whether *post-hoc* (after-the-fact) accounts can compliment ISA-derived data.

## 5 Methodology

Pilots were offered the chance to complete an on-line questionnaire. Four hundred and thirty-three pilots responded. Respondents represented every sector (for example, full-service long-haul, low-cost short-haul, business-jet operations, helicopter operations, night-freight). One of the questions (Question 16) asked:

What is the longest period of continuous wakefulness (in hours, from waking up to setting the brakes at the end of the last sector) you have experienced at work? Please describe how you felt when you set the brakes on your final sector.

The distribution of the 433 responses was as follows:

Hours awake	Number	%
Up to 17	60	13.9
18 - 22	141	32.6
23-27	144	33.3
28 or more	88	20.3
	433	100

Passenger aircraft are being flown by pilots who have been awake for over 24 hours. Over 50% of the pilots who completed the survey had flown an aircraft after being awake for 24 hours. Miller (2005) claims: “Acute mental fatigue [is] caused by wakefulness in excess of 16 hours”. Rhodes and Gil (2002) claim:

By the 18th hour [of wakefulness the subject] will have great difficulty remembering things he has done or said a few moments ago (short-term memory) and his reaction time will have almost doubled in duration. By the 24th hour his ability to think creatively and make decisions will be dangerously low.

It is interesting to note that even with operating pilots spending such long periods awake, commercial air travel remains one of the safest forms of mass transit. Snyder (2012) notes:

2011 was an incredibly safe year for commercial air travel. In fact, there were only 373 fatalities on 18 scheduled passenger flights worldwide. Considering that there are roughly 10 million flights per year in the U.S. alone, this is a remarkable feat.

It would be interesting to know to what degree and in what ways such safety ‘buffers’ as automation, crew resource management and other protocols (like read-back, sterile cockpit and monitor-and-cross-check) help counteract the risks inherent in acute and chronic pilot fatigue.

## **6 A reflexive comment on the methodology**

As a research method the analysis of unconstrained accounts has strengths and weaknesses. On the plus side it reduces the possibility of anchoring or focalism, where suggestions made by the researcher (appropriate adjectives, for example) constrain respondents’ description. Tversky and Kahneman (1974) define anchoring as follows: “[D]ifferent starting points yield different estimates, which are biased toward the initial values”. On the minus side respondents may describe identical physiological or psychological states in different ways (by using different adjectives, for example), making syntax and trend-analysis difficult. Further, the same adjective may mean different things to different people (subjectivity).

A key question is the degree to which pilots’ awareness of sleep scientists’ predictions of a link between time awake and symptoms of physical and psychological impairment influenced participants’ recollections. Pilots are introduced to sleep science in several ways: during compulsory

fatigue risk management training; via research to inform trade union fatigue risk management campaigns (for example Bennett (2011b)); via journal articles and exchanges with colleagues in web-based aviation chat-rooms; and via conversations with colleagues on the flight-deck, in down-route hotels and in the crew room. Calculating the degree to which such interactions influence perceptions is problematic. Kasperson and Kasperson’s (1996) theory of the social amplification/attenuation of risk is relevant to this discussion:

The concept of the social amplification and attenuation of risk provides an approach that recognizes that how social institutions and structures process a risk will shape greatly [the] responses of management institutions and people.

Vasterman, Yzermans and Dirkzwager (2005) note: “The social amplification of risk framework is based on the metaphor of amplification: signals are received, interpreted, amplified and passed on ... ”.

Problems associated with memory and recall have long been recognised by social scientists. According to Fielding (1993) memory is eroded not so much by the passage of time as by new inputs (the number of which increases as time passes). The International Sociological Association (2012) notes: “Error with recall and the memory process can affect the reliability of retrospective history data”. Blumer (cited in Plummer, 1990) says: “[C]ritics charge that the authors of personal accounts can easily give free play to their imagination, choose what they want to say, slant what they wish, *say only what they happen to recall at the moment* [my emphasis] ... ”. The paper’s conclusions should be considered in light of these methodological issues.

Despite these issues and caveats, there *is* support for subjective assessments of fatigue (and stress). As mentioned above Pickup, Wilson, Sharples and Smith (2005), Powell, Spencer, Holland, Broadbent and Petrie (2007), De Vries, Michielsen and Van Heck (2003) and Williamson, Friswell and Feyer (2004) believe subjective assessments create valid indices of fatigue (and stress).

## 7 Data

The data, presented in tabular form, runs to 32 pages (Appendix 1). Pilots’ statements are reproduced verbatim. Here is a sample of the data:

<b>16. What is the longest period of continuous wakefulness (in hours, from waking up to setting the brakes at the end of the last sector) you have experienced at work?</b>	<b>16.a. Please describe how you felt when you set the brakes on your final sector.</b>
Up to 17	Completely drained.
Up to 17	Fatigued.

Up to 17	Felt drowsy but confident I could drive home safely and not much more.
Up to 17	Exhausted. Barely able to drive the 15 minutes home.
Up to 17	Ill. Found it difficult to concentrate, or engage in any meaningful conversation.
18 - 22	Dazed, numb.
18 - 22	Like a Zombie. Only worse. And probably looked like one, too!
18 - 22	Tired but alert.
18 - 22	Very tired.
18 - 22	I can't describe what I had no conscious awareness of.
23 - 27	Completely exhausted, and 'punch-drunk'.
23 - 27	Relieved.
23 - 27	Like a robot on automatic; no emotion; indifferent to anything.
23 - 27	Detached, irritable, uncomfortable, but relieved.
23 - 27	Very fatigued and struggling to stay awake. Almost in a dreamlike state.
28 or more	Punch-drunk. Utterly exhausted. Incapacitated. I checked straight into a hotel and didn't even drive home. The trouble with long-haul flying is you simply cannot predict how tired you will be at the end of a flight.
28 or more	Mildly euphoric!
28 or more	I suffered from fatigue which persisted for some time and required medical advice.
28 or more	Tired.
28 or more	Wiped-out.

## 8 Analysis and discussion

Mindful of the methodological weaknesses described above (the susceptibility of *post-hoc* recollections to bias, for example) a number of tentative conclusions can be drawn.

First, pilots may experience long periods of wakefulness in different ways. Physiological variation, as well as circadian, work-rate, ergonomic, welfare, psychological, CRM and other factors, may play a part in this (Bennett, 2010). One pilot recalled his condition after being awake for ‘up to 17 hours’ as: “Exhausted. It is a concern ... especially if you then have to drive home”. Awake for the same period, another recalled being: “Pretty sharp, but grateful that we hadn't had to divert”. (There is no way of knowing how well-rested each pilot was prior to commencing her/his duty).

One pilot recalled his condition after being awake for ‘18-22 hours’ as: “Totally shattered. Sick”. Awake for the same period, another recalled being: “Tired, slightly sick”. Caldwell and Caldwell (2003) discuss variability in human responses to fatigue:

As Dr Mark Rosekind ... points out: 1) there are wide variations in workplace demands; 2) there are considerable differences in how individuals respond to these demands; and 3) there are changes in individual responses to both job factors and the specific countermeasures that occur over time .... What helps a young ... helicopter pilot may not be effective for one of his [colleagues] simply because no two people are exactly alike. Even though both pilots are the same age and are flying the same missions in the same aircraft, *variations in their physiological and psychological make-ups will likely make them differentially responsive to their jobs* and to the effects of various coping strategies. Likewise the best fatigue countermeasure for a 45-year-old airline pilot may not do the trick for this same pilot at age 55 because of natural age-related changes in sleep architecture and/or circadian rhythms (my emphasis).

Dekker (2007) observes: “Not everybody experiences the same situation in the same way. It depends on experience, proficiency, time of day, familiarity, disposition and so on”. Majumdar (2012) warns: “[T]o ignore the subjective nature of fatigue leaves the organisation vulnerable”.

Secondly, pilots recalled a deterioration in physical condition and mood after about 17 hours of continuous wakefulness (see table below).

Adjective	Wakefulness	
	Up to 17 hours	Over 17 hours
	Usage count	
irritable	3	3
tetchy	0	1
short-tempered	0	3
ill-tempered	0	1
bad-tempered	0	0
drained	5	24
fatigued	1	10
exhausted	9	36
knackered	1	6

While many pilots used adjectives relating to their physical state, few used adjectives relating to their psychological state. Are pilots who experience long periods of wakefulness better able to control mood impacts than performance impacts? Perhaps pilots are reluctant to reflect upon mood

(note Bor, Field and Scragg’s (2002) observations above)? Perhaps sleep science over-estimates the impact of long periods of wakefulness on mood?

Adjectives suggestive of fatigue (for example, ‘exhausted’ and ‘drained’) were used more frequently by pilots recalling how they felt after being awake for more than 17 hours. This supports sleep scientists’ prediction of possible physical impairment after 12-18 hours of continuous wakefulness (Rhodes and Gil, 2002; Miller, 2005; Bor and Hubbard, 2006; Hersman, 2009; Caruso and Hitchcock, 2010; Federal Aviation Administration, 2010). The pre/post 17-hour ratio for the use of ‘exhausted’ was 1:4. For the use of ‘drained’ it was 1:5 (rounded up) and for the use of ‘fatigued’ it was 1:10.

Whether or not long periods of wakefulness impact outcomes will depend on mediators like teamwork, safety protocols, environmental factors, innate ability and experience, food and caffeine intake, length and quality of prior sleep, physiology and mission-focus. Even though a pilot may recall being ‘drained’, a safety decrement should not be assumed. Majumbar (2011) observes:

[A]cknowledging that fatigue affects performance, how can we assess if it affects safety in particular? After all, granted that fatigue may reduce performance, but will it actually compromise safety to the extent of causing incidents and accidents? Or is there an acceptable level of performance decrement due to fatigue that organisations ... can tolerate?

Pilots who believe themselves to be fatigued employ coping strategies. As one low-cost pilot explained: “[R]ather than not do them [checks], you’ll think ‘Did I do that or didn’t I?’. So you reiterate and repeat the exercise, rather than miss it” (cited in Bennett, 2003). Coping strategies may help maintain safety margins.

	<b>Wakefulness</b>	
	<b>Up to 22 hours</b>	<b>Over 22 hours</b>
<b>Adjective</b>	<b>Usage count</b>	
intoxicated	1	3
drunk	8	15
dizzy	4	5
light-headed	3	5
detached	1	7
confused	0	1
spaced/spacey	3	2
disorientated	1	4
numb	3	5

Adjectives suggestive of inebriation (for example, ‘drunk’ and ‘disorientated’) were used more frequently by pilots recalling how they felt after being awake for more than 22 hours (although the adjective ‘drunk’ was used eight times by pilots who had been awake for less than 22 hours). The pre/post 22-hour ratio for the use of ‘drunk’ was about 1:2. For the use of ‘dizzy’ it was about 1:1 and for the use of ‘detached’ it was 1:7. It is reasonable to conclude that the longer the period of wakefulness, the greater the likelihood of a pilot describing symptoms identical to those resulting

from alcohol consumption. The Civil Aviation Authority (2007) notes: “A blood alcohol concentration (BAC) level of 0.085% ... is just over the permitted level for drivers of road vehicles in the UK. This is approximately the level reached ... after 24 hours of continuous wakefulness”.

## 9 Conclusions

Respondents perceived a deterioration in physical condition and mood after about 17 hours of continuous wakefulness. This finding supports sleep scientists’ prediction of a link between wakefulness and physical and psychological impairment.

Regarding the question of a link between wakefulness and symptoms similar to those produced by alcohol consumption, adjectives suggestive of inebriation (for example, ‘drunk’ and ‘disorientated’) were used more often by pilots recalling how they felt after being awake for more than 22 hours

Do these findings tell us anything about the accuracy of *post-hoc* subjective assessments of performance? Sleep science predicts performance decrements after about 12-18 hours of continuous wakefulness. The fact that adjectives denoting fatigue were used more often by pilots recalling how they felt after seventeen hours or more of continuous wakefulness suggests that pilots are able to recall their physical state with a reasonable degree of accuracy. Subjective, after-the-fact accounts have something to contribute to our understanding of the causes, nature, prevalence, consequences and rationalisation of fatigue. However, Tversky and Kahneman’s (1974) work on heuristics and biases and Kasperson and Kasperson’s (1996) theory of risk amplification suggests we should treat this finding with caution. Awareness of sleep scientists’ findings and predictions (as well as interactions with colleagues, time spent in on-line flight-crew chatrooms, time spent watching TV news items or listening to radio broadcasts about fatigue, etc.) may act to skew recollections. It seems sensible that *post-hoc* accounts should be filed as soon as possible after the end of the duty or trip. Given the number of sleep-related problems within commercial aviation (Bennett, 2011a; National Sleep Foundation, 2012a) it also seems sensible to suggest that policymaking should draw on the growing body of quantitative and qualitative research into pilot fatigue.

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## Appendix 1

Data sourced from Bennett (2011). Pilots' statements are reproduced verbatim.

16. What is the longest period of continuous wakefulness (in hours, from waking up to setting the brakes at the end of the last sector) you have experienced at work?	16.a. Please describe how you felt when you set the brakes on your final sector.
Up to 17	Completely drained.
Up to 17	Fatigued.
Up to 17	Felt drowsy but confident I could drive home safely and not much more.
Up to 17	Exhausted. Barely able to drive the 15 minutes home.
Up to 17	Ill. Found it difficult to concentrate, or engage in any meaningful conversation.
Up to 17	Tired but not fatigued; fatigue results from longer-term excessive flying.
Up to 17	Utterly drained. Very slow to think and process information. My brain hurt (headaches) and the greatest worry was that we had minimum legal rest (10 hours in a hotel) before reporting again. Hence the worry that the clock was ticking.
Up to 17	Relieved.
Up to 17	Knackered and a very low level of attention to detail.
Up to 17	Exhausted. Ready for bed! Being switched from a late to an early with only one day in between does not allow the body to successfully adapt its circadian rhythm in that short time. I had to sit in my car in the car park for at least 10 minutes.
Up to 17	There have been occasions when I have felt very tired at the end of a final sector.
Up to 17	Very tired. However, it is not the individual

	sector/s that do the damage. Fatigue manifests in me by a feeling of having to combat lethargy, and making a myriad of small mistakes. This is induced by flying too much without sufficient rest-time in-between.
Up to 17	Like a zombie.
Up to 17	Worried about the safety of driving myself home. When I got home I couldn't remember the drive home that I'd just completed. I'd been micro-sleeping down the final approach.
Up to 17	Exhausted and error-prone.
Up to 17	Glad to be going home. It is exhausting and, as a general rule, I find the more sectors I fly the harder it gets. The actual sector length and overall time seems less relevant to me on short-haul. Every time I get to sector number four I'm not as sharp.
Up to 17	Very tired.
Up to 17	Relieved. Headache. Tired eyes. Exhausted.
Up to 17	Tired. Lacking in concentration and focus.
Up to 17	Overly-weary, and not looking forward to the drive home! (1hr). On this occasion, having extended by 1-2hrs, we had a fumes event on approach during the last sector, including using oxygen masks, and we definitely felt the effects of having had a long day.
Up to 17	Tired.
Up to 17	I had rested sufficiently but felt tired. I was able to sleep when I got home.
Up to 17	It was like the journey to that point was completed due to our reliance on 'trigger points' for our actions and calls while on the flight-deck. It was like when you are in your

	car and arrive at your destination with no recollection of the scenery, etc.
Up to 17	Totally exhausted and ready to sleep.
Up to 17	Exhausted. It is a concern ... especially if you then have to drive home.
Up to 17	Pretty sharp, but grateful that we hadn't had to divert.
Up to 17	Setting the brakes is not the end. Normally a walk through the terminal, a 10-minute wait for a bus. Then the horrendous traffic associated with working in and around London Heathrow.
Up to 17	Tired and irritable.
Up to 17	Exhausted and ... in 'auto' mode on way home. Not a nice feeling at all.
Up to 17	Tired.
Up to 17	Not able to function correctly. Just about coping with simple tasks. Would struggle with poor weather or higher workload and would probably not be able to cope with an emergency.
Up to 17	I felt very tired. The complex tasks required intense concentration and were actually achievable, but mistakes were being made on everyday, simple tasks. These included missing items from checklists and calling for a flap selection that was already actioned.
Up to 17	Blind drunk.
Up to 17	Probably not advisable to continue flying and to be extremely careful when driving home.
Up to 17	Relieved.
Up to 17	Wrecked, tired and fed up.
Up to 17	Had gone past the tired phase and just felt warm and fuzzy, and a bit 'not with it'. I was

	<p>simply reacting to the situation and tasks as they arose rather than 'projecting ahead'. Even reading a checklist was a big effort/hassle. The biggest concern was my ability.</p>
Up to 17	Tired.
Up to 17	Extremely tired, both physically and mentally. Very drained and relieved to finish the duty. Trying to order thoughts and produce a coherent sentence took immense effort.
Up to 17	DRAINED. By the nature of the job, you finish your working day with an approach and landing, which is, in the main, the most 'stressful' part of the day. After a long duty, I think you get through it on adrenalin.
Up to 17	Qualified: during these periods there is always a chance to rest on repeated occasions, usually bunk-time.
Up to 17	Totally drained, mentally and physically.
Up to 17	Relieved!
Up to 17	Very tired.
Up to 17	Felt relieved, ready for bed. But also wondering what the roster the next day would be like.
Up to 17	Relieved, tired, buzzing head, 'wired'.
Up to 17	Weak and unable to concentrate, finding the smallest thing distracting. Even difficult to input simple post-flight data into our Intranet in the crew room.
Up to 17	Very tired, but I have an hour's commute in the car from the airport to home so I was also well-aware that I had to negotiate this drive before I could think about sleeping. I often find the drive home from work to be the worst part of the day regarding fatigue.

Up to 17	Relief.
Up to 17	Tired.
Up to 17	Like you have been dug up! I wasn't aware before I did long-haul how many of the symptoms of a hangover are simply attributable to a lack of sleep.
Up to 17	'Dog tired' ... but in helicopter flying this comes from a combination of the flying duty period length, the noise and vibration and constant 'hands-on flying' in an aircraft that has no autopilot, FMS, integrated navigation system, etc, etc.
Up to 17	Report LHR 05:30; bus to LGW; operate flight to TAB [Tobago] then onward to GND [Grenada] = 15hr duty. I was relieved that nothing had happened during the flight to test my capabilities and that the weather was benign enough to allow a straightforward approach and landing.
Up to 17	Exhausted and relieved.
Up to 17	Unable to think clearly, only able to focus on small micro-tasks.
Up to 17	Absolutely exhausted. I struggled to complete the flight paperwork and by the time I got to my car I felt unable to drive. Ended up taking a cab home.
Up to 17	Irritable, restless, little concentration.
Up to 17	Relieved that there was no paperwork to complete the first time, and the second time I was frustrated at the amount of facts, figures and paperwork that was needed to explain why we went into discretion.
Up to 17	Extremely tired, distracted, almost irritable. I actually took a rest in the crew room before travelling home by car in order to feel better.

Up to 17	Relieved, relaxed, shattered.
18 - 22	Dazed, numb.
18 - 22	Like a Zombie. Only worse. And probably looked like one, too!
18 - 22	Tired but alert.
18 - 22	Very tired.
18 - 22	I can't describe what I had no conscious awareness of.
18 - 22	Extremely tired. In a daze and 'drunk-tired'.
18 - 22	Unfit to operate. Slow, hazy thinking and reactions. Difficulty with situational awareness and unlikely to be able to deal well with a severe problem (e.g. engine failure on final approach). Quite simply, I was extremely worried.
18 - 22	At shutdown, quite alert. However, approximately 1 hour before landing and 1 hour after shutdown I felt tired, with 'itchy leg' feelings.
18 - 22	Not fit to drive a car home.
18 - 22	Tired, lack of concentration, a feeling of reduced mental capacity and situational awareness.
18 - 22	Too tired to drive home!
18 - 22	Relieved, shattered: I felt that this shouldn't be allowed to happen: I felt that FTLs should be more restrictive on safety grounds.
18 - 22	Very difficult to remember what I'd done the previous hour. Poor ability to collect my thoughts and get organized as I left the flight deck after securing it and shutting it down.
18 - 22	Numb. Thankfully, as I commute from the north of England I have a crash-pad. I wouldn't have wanted to drive home.
18 - 22	This has happened a few times – the

	common symptoms would be: Overall sense of disinterest in things outside my immediate surroundings. 'Scratchy' feeling in eyes. What feels like the onset of a headache. A wish to be somewhere else.
18 - 22	Tired, but still able to function. However I was aware of reduce effectiveness and of making small mistakes.
18 - 22	Shattered. Simple tasks, like remembering where I had parked the car, were difficult. Driving home dangerous.
18 - 22	Relief that we were safe.
18 - 22	Appalling! I should have binned it at a few times during the flight. We pushed back, had a massive delay due to weather at night, and we considered turning back, but as we were underway, this was very difficult. Commercial pressure.
18 - 22	Tired, not able to sleep.
18 - 22	Relief, but up to that point a feeling of being detached from the operation.
18 - 22	Relieved. Punch drunk. Ready for my bed, not a 25-mile drive down the motorway.
18 - 22	Thinking is very hard and slow. Anything unexpected would have taken a long time to recognise and react to.
18 - 22	Exhausted. It was difficult to sleep upon returning home. It took about 4 days to recover.
18 - 22	Almost dizzy. My thoughts were 'clouded'.
18 - 22	Spaced-out and relieved (answered regarding airline job, 28+ with military flying).
18 - 22	Light headed ... unable to concentrate ... trying to work out duty and rest periods basically impossible ... kept coming up with

	different answers. I felt almost drunk.
18 - 22	Terrible!!!!!!
18 - 22	Very glad! Just wanted to go to bed.
18 - 22	Relieved that nothing had happened on the final sector ...
18 - 22	Tired, although difficult to judge as the adrenalin from the approach/landing will affect you.
18 - 22	Relieved to a point where I didn't really care what happened next, I just needed some sleep.
18 - 22	Like I was going to collapse. In hindsight we should not have flown the last sector.
18 - 22	I could not calculate the flight time. All pilots on the crew actually joined a queue for Customs. After a short while we realised we were in a queue for a flight to Acapulco.
18 - 22	Very relieved as on that occasion the weather turned out to be a big factor during the final stages of the flight. Feeling knackered is one thing when all is going well, but as soon as other issues crop up, wx/tech [weather, technical faults] etc., it becomes more critical.
18 - 22	Physically ill.
18 - 22	Exhausted.
18 - 22	The final sector was positioning so no brakes on. CAP371 allows for endless positioning after operating and airlines use this caveat to avoid hotel bills.
18 - 22	Exhausted – ‘the thousand yard stare’.
18 - 22	Mentally exhausted.
18 - 22	Extremely tired, frustrated, irritated and resentful that it is legally possible to get into such a state.
18 - 22	Brakes on was a relief – knowing that it

	would be a couple of days before you could claim to be fully recovered.
18 - 22	Totally exhausted.
18 - 22	The worst I have felt is physically sick, but mostly a little punch-drunk.
18 - 22	STILL FUNCTIONING
18 - 22	Unable to think quickly or very clearly – mentally and physically drained.
18 - 22	I was incapable of driving home, and had to sleep in the Crew Report Centre for 3 hrs in order to catch up on sleep. If there had been an emergency during the disembarkation of the aircraft, I would have suffered from impaired judgement due to fatigue.
18 - 22	That was when I was at easyJet, before BA. It was commonplace for you to do very long days with big delays, going in to discretion. The worst I did was out of CDG [Paris] (I was based at LGW) – three consecutive days into discretion, one with reduced rest.
18 - 22	Relieved that it was all over and conscious of my ability to drive home safely.
18 - 22	Extremely tired.
18 - 22	So tired I felt like falling sleeping in the car in the car park rather than driving home.
18 - 22	Exhausted.
18 - 22	Terrible. Unable to think clearly.
18 - 22	Relieved that the day was finally over, but dreading the drive home in rush hour.
18 - 22	Very tired. Ready for bed.
18 - 22	Incapable of rational thought! Punch-drunk.
18 - 22	Relieved and punch-drunk.
18 - 22	Disorientated.
18 - 22	Relief at having got to the end of the day, overwhelming tiredness as the adrenalin rush from landing subsides.

18 - 22	Not too bad (ironically) as the duty, assigned off standby, started late, involved a long turnaround in Madrid, and although we finished at 4am having been up since 8am the previous day, it was manageable AS A ONE-OFF.
18 - 22	Extremely mentally weary, especially on multi-sector days when lots of things had gone wrong throughout the day causing the extension to the flight duty period in the first place.
18 - 22	Spaced out. Almost mildly intoxicated with alcohol with real difficulty concentrating on the essential parts of the operation.
18 - 22	I would have thought that was pretty obvious ...
18 - 22	Weary!
18 - 22	Tired, not looking forward to driving home.
18 - 22	Mentally drained.
18 - 22	Extremely tired and prone to making small mistakes.
18 - 22	Relieved.
18 - 22	Totally drained and unable to concentrate.
18 - 22	Relieved and looking forward to getting to bed!
18 - 22	Relieved. Drained.
18 - 22	Very relieved, but nearly fell asleep on the drive home as it took 1.5 hours to disembark due to a lack of buses to the remote stand (LGW).
18 - 22	Exhausted. Just about had the strength to drive home and then listen to the rest of the world get up!
18 - 22	Tired.
18 - 22	Extremely tired. I was only kept awake by the stress of a diversion and unfamiliar

	airport. Having difficulty with simple mental arithmetic.
18 - 22	Relieved that it was all over and that nothing had gone wrong that could have challenged my physical state.
18 - 22	The level of concentration required to maintain a safe operation was itself a fatiguing factor. On completion I felt light-headed and without direction. Initially I was unable to sleep.
18 - 22	Shattered.
18 - 22	Tired and ready for bed. Loss of concentration possible.
18 - 22	Tired.
18 - 22	Relieved it all went OK.
18 - 22	Tired, hungry, dehydrated, sometimes with a headache, cold, sleepy.
18 - 22	At brakes-on I usually still have adrenalin flowing. Effects of extreme tiredness are felt later (say an hour later).
18 - 22	Completely drained. Just thought of going to bed. Very difficult to concentrate and unable to do Technical Log hours (basic mathematics).
18 - 22	Relief, and the thought: 'Why did I let myself get into that situation?'
18 - 22	Unsafe.
18 - 22	My recall and cognitive function was significantly impaired. Real effort needed to maintain a sufficient level of alertness.
18 - 22	Relieved and very tired. Also unable to relax or go to sleep subsequently because of the strain of concentrating to stay awake and alert.
18 - 22	Dead tired; dizzy; losing my balance.
18 - 22	Dead.

18 - 22	As if having drunk 3 to 4 pints at the pub.
18 - 22	Stressed. Airlines do not allocate Crew Meal Breaks and you are expected to eat while you are working ... assuming you get food at all. If you are behind schedule then you may not get any mental relaxation for 13 hours. Usually means you end up eating junk.
18 - 22	Fuzzy; lightheaded; physically tired and mentally drained.
18 - 22	Relieved.
18 - 22	After setting the brakes I felt relief. The fatigue really bites before then. The hopelessness sat in the cruise wishing you were home, and then that awful feeling on the ILS when you can't keep your eyes open.
18 - 22	Relieved; physically sick; dreading what the company had in store for me the next day.
18 - 22	Relief to finally be home after a long, tiring day. Also, apprehensive thinking about my 2hr drive home!
18 - 22	Quite irritable and mentally drained – usually as a result of delays and technical challenges, and sometimes CRM issues. Occasionally light-headed.
18 - 22	Tired but relieved to have completed the duty without incident.
18 - 22	Total relief.
18 - 22	Dead and messed up in my head. Not able to think, or do!
18 - 22	Extremely tired; difficulty concentrating on tasks outside the immediate objective; slurred speech; yawning; watering eyes; slightly manic.
18 - 22	Totally spaced-out. Body on autopilot.
18 - 22	Tired to the point of feeling sick. A heavy head with dizzy spells. Coffee did nothing to

	ease the feeling. This whole time the company was still barking orders down the phone.
18 - 22	Tired, but fully alert. Glad to finally get off. Very tired on drive home, to the extent that I had to stop for a nap.
18 - 22	Awful and relieved.
18 - 22	Tired. I struggled to calculate duty hours for the crew.
18 - 22	I could not even string a sentence together. I could not do basic maths. I could not make any decisions. But I have done many long periods at work. Sometimes back-on-back with minimum rest.
18 - 22	Knackered. I was focused exclusively on going back home, missing some actions while securing the aircraft.
18 - 22	Very, very tired and not having normal response capabilities.
18 - 22	Totally shattered. Sick.
18 - 22	Tired, slightly sick.
18 - 22	I felt I was glad we had not had any emergencies to deal with for fear of making fatigue-induced errors!
18 - 22	Exhausted!
18 - 22	I could barely focus.
18 - 22	In short, like death! Relieved that nothing more than the standard sector had happened. I had made a number of small mistakes but luckily they were picked up by the other guy. I almost couldn't face walking through the terminal, my body was so out of energy.
18 - 22	It felt as if it wasn't me flying the aeroplane but there was someone else controlling my limbs. I also didn't really care about what was going on.

18 - 22	Like an absolute zombie. Angry, agitated, fed up. I just wanted to go home and not do another thing.
18 - 22	Completely drained. However, despite this it is then very difficult to go home or go to a hotel and go straight to sleep. A 'wind-down' period is necessary after any period of increased mental activity, regardless of how you feel during/immediately after.
18 - 22	Light-headed.
18 - 22	Very, very tired.
18 - 22	Weak; difficulty in thinking; emotionally low.
18 - 22	Exhausted.
18 - 22	Itchy eyes; problems concentrating; and easily angry. Also angry at the company for not having better resources to aid us. All the time it is left up to the pilots to sort the mess out. Issues like getting on stand and there being nobody there to meet us with stairs.
18 - 22	Physically sick and beyond the point of caring what happened to me.
18 - 22	Tired, stressed and forgetful.
18 - 22	Shattered.
18 - 22	Like I was floating.
18 - 22	Exhausted, slightly stressed but relieved to be back home.
18 - 22	Relieved to be alive, and with licence intact. That sounds dramatic, but it's true.
18 - 22	Physically: numb. Mentally: drained. And of course, relieved nothing serious had happened.
18 - 22	Physically and mentally drained.
18 - 22	Relief that all I now had to do was drive 50 miles home.
18 - 22	If I do not have sufficient sleep before a

	particularly long flight-duty, I notice that I am unable to think as quickly as normal, for example doing mental arithmetic. If I am really suffering I notice my eyes are very sore.
18 - 22	As a foreign national working in the UK, my mother tongue is not English. Although I consider my English to be very good, when I get tired this tends to be the first trigger. Reduced communication skills normally go hand in hand with a general feeling of tiredness.
18 - 22	Relieved that it was over. Sense of disbelief that I could operate such a long day. Hoping that I had some days off to recover.
18 - 22	Physically sick, nauseous, dizzy and very, very tired.
18 - 22	Very tired, particularly brain-tired.
18 - 22	Wrung-out, guilty and apathetic.
18 - 22	Relieved, in a word. Fatigue can be manageable until an emergency occurs. What reserves can you call on when you have been on duty for so long?
18 - 22	I don't think my brain was thinking anything at that point – I know I didn't want to make any decisions. I was past caring.
23 - 27	Completely exhausted, and 'punch-drunk'.
23 - 27	Relieved.
23 - 27	Like a robot on automatic; no emotion; indifferent to anything.
23 - 27	Detached, irritable, uncomfortable, but relieved.
23 - 27	Very fatigued and struggling to stay awake. Almost in a dreamlike state.
23 - 27	Disorientated. Like feeling slightly intoxicated.

23 - 27	Drunk – without having consumed a drop of alcohol in the last 72 hours.
23 - 27	Very tired!
23 - 27	Very tired. Degraded mental capacity. A body having 'wanted a bed' for a few hours.
23 - 27	Relieved, but not too exhausted as it was now during my 'awake' time. The bad bits were earlier in the flight (two-pilot, with no real chance of controlled rest). Mostly a function of flight timings/time zones/sleep patterns.
23 - 27	Exhausted.
23 - 27	It's normally about half an hour after setting the parking brake when the fatigue sensation hits. Just about the time you get in the car to drive home! Fortunately, I sit in the back of another aeroplane and have a rest before getting into my car.
23 - 27	Physically and mentally shattered. The interesting thing is that I didn't actually realise how bad I was until after the flight (which concluded with a bad approach and a bad go-around).
23 - 27	Mental ability impaired: similar to alcohol consumption, or codeine-based painkillers.
23 - 27	Relieved. I have done this when starting duty near my normal rest time, having failed to get any sleep beforehand, usually not because of lack of trying, but simply an inability to go to sleep.
23 - 27	Mentally drained and feeling physically sick. Thankful that we had no significant problems, but I suppose I hoped that my adrenaline would kick in.
23 - 27	Incredible relief that nothing too hard to deal with had occurred on approach.

23 - 27	Drained.
23 - 27	Adrenaline keeps you awake. However, there is a great relief after the parking brake is set. I find it amazing how you can maintain alertness until the end of the sector but then tiredness is very evident, the drive home being very challenging indeed.
23 - 27	Exhausted.
23 - 27	Physically unwell. Short-term tasks keep you awake, but one is unable to meaningfully assess one's own performance.
23 - 27	Exhausted. Unsure whether I was in a fit state to drive home – only half an hour's drive.
23 - 27	Drained.
23 - 27	Relieved.
23 - 27	Relieved.
23 - 27	Lousy, spaced out. We'd had a simple failure (a stuck microphone) on the approach, but neither of us were coherent enough to think of the fairly obvious steps to remedy the problem.
23 - 27	Very tired and glad to have finished duty for that day. Relieved that it was over.
23 - 27	Bloody awful ... and I still have to drive.
23 - 27	Detached. I was probably functioning at 60% of normal capacity.
23 - 27	Tired, both physically and mentally.
23 - 27	Fine. The drive home was the worst part!
23 - 27	I was missing radio frequencies.
23 - 27	Drained.
23 - 27	On an India three-day trip, arriving in India early morning and departing 24-hours later. Horrible sleep patterns. No sleep before pick up. No sleep on the way home as first rest. I was a 'dead man walking' off the aircraft.

23 - 27	I felt OK to operate ... but as soon as the brakes were set I very quickly felt exhausted, and apprehensive not only for my journey home, but how I had not recognised the signs of clearly becoming fatigued during the flight.
23 - 27	I made the maximum effort to feel alert, but was worn-out and ready for a sleep. I wondered how well I would perform if a problem cropped up on arrival that required careful thought.
23 - 27	Utterly exhausted and not sure how it was possible to get where you got to, but relieved it is over.
23 - 27	I felt dizzy and physically sick (like I wanted to vomit).
23 - 27	Slightly disorientated.
23 - 27	I only remember wanting my bed but dreading the drive home, too tired to feel anything else.
23 - 27	Absolutely shattered! In a kind of trance-like state, barely capable of normal conversation!
23 - 27	Like I wanted to curl up and die. The body just wants to shut down.
23 - 27	Incapable of driving home.
23 - 27	Extremely tired.
23 - 27	Not too bad, because the adrenalin released on the approach and landing carries you through. However, after about 30 minutes I felt very tired.
23 - 27	I felt relieved, shortly followed by exhausted.
23 - 27	I was scarcely able to drive home.
23 - 27	This is not particularly uncommon depending on whether, or not, I manage

	some rest before pick-up prior to night transatlantic returns to the UK. After 'brakes-on' I start to feel increasingly 'vacant'.
23 - 27	Ill-tempered; difficulty with decision-making and applying required diligence to operation; absent-minded; difficulty solving simple problems.
23 - 27	Feeling very similar to having had a few alcoholic drinks.
23 - 27	No feelings. Still concentrating on the basic functions of survival. At this point I have to appear <i>compos-mentis</i> to my passengers and crew, then wait an eternity for a company bus before I can finally attempt to drive home.
23 - 27	Tightness in the chest (all ECGs normal!!!); Slurring of words; Dizzy and lethargic.
23 - 27	Mentally disorientated and physically nauseous.
23 - 27	Absolutely drained. Relieved to be off the aircraft, as I was aware that energy and alert levels had fallen to potentially unsafe levels.
23 - 27	I had difficulty in forming decisions.
23 - 27	Relief ... By flying in such a fatigued state we 'roll the dice': We take our training and systems and to a real extent trust them to luck – that nothing serious or 'out of the ordinary' is going to happen – and that if it does we, as a crew, can 'make it work'.
23 - 27	Exhausted!
23 - 27	Extremely tired and finding concentration difficult.
23 - 27	Exhausted.
23 - 27	Atrocious.
23 - 27	At that stage, relief is setting in. It's the last

	hour or so of the flight where it can be extremely difficult to 'hold onto it', and the attention goes, and the head starts falling.
23 - 27	Mentally incapable of doing anything else. A strange, almost out-of-body experience.
23 - 27	Extremely tired, after the effects of adrenaline and caffeine rapidly wear off. Occasionally I feel light-headed (a spinning sensation) and nauseous.
23 - 27	Understandably exhausted.
23 - 27	Tired, but you only realise how tired you REALLY are once you're off the aircraft.
23 - 27	Relieved. Extremely tired. Struggling to keep eyes open on final sector during periods of low workload. OK during approach, landing and taxi-in. Slight worry about driving home due to fatigue.
23 - 27	I would actually have liked the Hotel to be right at the Airport even though we were in Mombasa!!
23 - 27	Punch-drunk. Unable to maintain concentration.
23 - 27	I felt physically and mentally drained and couldn't wait to go to bed. I also felt lucky that nothing had happened on that flight, i.e. A go-around or technical problem, as I'm not sure how well I would have coped with such an issue.
23 - 27	Very relieved that we had completed the flight with no problems as both of our states of alertness were at a very low level.
23 - 27	Physically weak; felt sick; bad tummy; too tired to drive home; had to get someone to pick me up.
23 - 27	Very groggy.
23 - 27	I felt drained and devoid of emotion or

	ability to 'feel' anything. I had an overriding sense of relief that the ordeal was (safely) over.
23 - 27	I was unable to concentrate. I was jittery/shaky. The inability to focus is similar to what you might experience after having two or three glasses of wine.
23 - 27	Relieved.
23 - 27	Relieved.
23 - 27	So exhausted that I couldn't actually get to sleep when I went to bed.
23 - 27	Awful.
23 - 27	I felt like dying.
23 - 27	You're 'frazzled' ... a nerve-endings tingling sensation. And dopey. I once made the mistake of going to Tesco's on the way home. I scraped the car against the trolley park as I reversed out of a spot. That just isn't me. I'm sharp. I'm a good driver.
23 - 27	Concerned for the journey home. Difficult to concentrate. Desperate for sleep.
23 - 27	Utterly exhausted – not sure if I was even able to drive home.
23 - 27	I felt like the waking dead ... feeling weak and with aching legs that twitched.
23 - 27	Loss of concentration; forgetfulness; short temper.
23 - 27	I felt very relieved. But the worst period is not always at the end of the flight. There are times of tiredness earlier in a long, tiring flight where you feel like it is not worth bothering.
23 - 27	Completely exhausted. This was after a night-flight to DME [Moscow] and I was unable to get any rest prior to the flight.
23 - 27	Just about managed to operate. Had to work

	very slowly and methodically. Thank goodness nothing went wrong.
23 - 27	Completely shattered.
23 - 27	Mentally exhausted. One thing on my mind ... go to sleep. No further capacity to deal with anything beyond the ordinary. Aware I was making careless, simple mistakes with the ordinary.
23 - 27	Tired but awake. Strongest feeling is before start of approach. During approach adrenaline usually kicks in.
23 - 27	Knackered.
23 - 27	Like I was drunk.
23 - 27	Tired! In my experience, the day following a longhaul trip can be a bit of a waste of time. You are not particularly aware that you are tired, but get to the end of a day off realising you have accomplished little, unable to settle to one task.
23 - 27	Surprisingly O.K., but basically numb. As the adrenaline subsides, my biggest problem is staying awake on the drive home.
23 - 27	Robotic.
23 - 27	A sense of detachment from reality.
23 - 27	Dead on my feet and unable to develop any cognitive thought processes.
23 - 27	A bit like I was slightly drunk.
23 - 27	Glad that it was over and that it was a normal sector with no technical issues.
23 - 27	Relief.
23 - 27	Light-headed and exhausted.
23 - 27	I normally feel fine, then it hits me on the drive home about an hour later.
23 - 27	Like an automaton; difficulty concentrating on small tasks, like working out duty length, and a feeling of sickness. Also a bit

	unsteady on my feet, and a racing heart.
23 - 27	Nauseous and light-headed.
23 - 27	Utterly drained.
23 - 27	Shattered. I slept in my car before driving home.
23 - 27	Ready to collapse – as if somebody had kept you awake by prodding you continuously for 20 hours.
23 - 27	Can't remember really ... I felt mentally numb.
23 - 27	Generally after a flight this long fatigue comes and goes, so at some points one feels fine and at others so tired that it is impossible to remain awake. After long flights initially one often feels quite lively having just focussed on arrival, approach.
23 - 27	I felt dizzy and fuzzy-headed. I was ambivalent to my surroundings.
23 - 27	Very tired.
23 - 27	Relieved.
23 - 27	It's akin to being drunk.
23 - 27	Completely lethargic. My brain felt like there was a blanket wrapped around it. My thought-processes were very slow compared to normal. My main concern was whether I could remain awake for the whole drive home, and not succumb to micro-sleep.
23 - 27	The feeling is like a dulling of the senses. When I am this tired I feel one step removed from my environment, as if what I am hearing is in the room next door, and I am seeing the world through a viewfinder. My mental process is somewhat slowed.
23 - 27	Fatigued and unable to process information clearly and logically.
23 - 27	Tired.

23 - 27	Shattered.
23 - 27	Tired?
23 - 27	Completely drained. Mentally and physically impaired. Like a fog had descended on my brain and I was mentally retarded. Difficulty speaking and doing. Difficulty concentrating on basic functions. Losing the will to care.
23 - 27	Extremely tired; nauseous; inability to concentrate; inability to make decisions.
23 - 27	Exhausted, drained and unable to do even simple tasks.
23 - 27	Like death! I was aware that, whilst perfectly legal, what I had done was unsafe and I resolved never to be coaxed into doing it again.
23 - 27	I felt numb and detached from reality. It was almost as if I was dreaming the flight, or 'looking in' at myself.
23 - 27	A feeling similar to a hangover; sick; uncoordinated and fuzzy headache.
23 - 27	Eyes burning. Felt sick. Headache. Too tired to risk driving!!!!!!!!!!
23 - 27	Very tired until the adrenalin of the approach. Once the brakes were applied, complete fatigue. Booked myself into a hotel room. Refused to operate the following scheduled duty. Operated a delayed flight.
23 - 27	On one occasion I was dropping on finals.
23 - 27	I decided not to drive home as I had used all my strength to stay awake and on top of the operation. It was a combination of working hard and insomnia.
23 - 27	Wary of whether or not I was fit to drive home (56 miles).

23 - 27	Like I could sleep on the roller-deck! Completely exhausted, mentally and physically.
23 - 27	Drunk.
23 - 27	Relieved to have landed. I was PNF [pilot monitoring] inbound to LHR, and I was missing calls and feeling drowsy throughout the approach.
23 - 27	Very tired, but having slept well previously, not fatigued.
23 - 27	Totally vacant and not in touch with actual events.
23 - 27	I don't remember an awful lot about it – except that we still had to position home from Belfast. We all fell asleep on the flight home. Thankfully, I only lived 10 minutes from the airport at that time, so somehow managed to drive home.
23 - 27	Uncharacteristically emotional. Relief in the knowledge that the duty had ended without further event – as a crew, we would have been relying purely on adrenaline to resolve any additional complications.
23 - 27	Exhausted mentally, relieved that nothing had gone wrong. Feel ill.
23 - 27	Awful.
23 - 27	Giddy, numb and kind of drunk!
23 - 27	Spaced-out. So tired it was almost painful to be awake. Mistakes being made ... just glad we had made it back with nothing going wrong ... but not entirely sure we knew how we'd made it back. Just relieved.
23 - 27	With current North Atlantic two-crew rotations and three crew Far East (particularly NRT [Tokyo] and PVG [Shanghai]) sectors it's routine to be

	fatigued prior to report: At the end of the sector(s) 'something' seems to 'kick-in' (caffeine?) to raise alertness.
23 - 27	Weary! I wouldn't have wanted to do any more flying.
28 or more	Punch-drunk. Utterly exhausted. Incapacitated. I checked straight into a hotel and didn't even drive home. The trouble with long-haul flying is you simply cannot predict how tired you will be at the end of a flight.
28 or more	Mildly euphoric!
28 or more	I suffered from fatigue which persisted for some time and required medical advice.
28 or more	Tired.
28 or more	Wiped-out.
28 or more	Extremely tired.
28 or more	Punch-drunk.
28 or more	KNACKERED!
28 or more	Totally drained and grateful for an extremely good co-pilot!
28 or more	A dead man walking. Of little use in an emergency or high-workload situation. It seems to be just accepted that's how ineffective and fatigued we are, and no-one cares about the safety risk attached to it.
28 or more	Once the adrenaline that carried me through the approach and landing phase had passed through my system, I felt physically sick and so tired that I found (and often do find) it impossible to sleep properly for any meaningful amount of time for the next 24+ hours.
28 or more	Exhausted.
28 or more	I felt detached from the operation.
28 or more	Relief to have completed the sector without

	incident.
28 or more	As soon as the brakes are set the body and mind shuts down. If asked to begin another duty, it would be impossible. You don't realise how shattered you are until you're out of the flight deck. Then it hits you – you don't have the energy to mentally compute anything.
28 or more	Tired on the aircraft, but it hits you afterwards. Your head feels fuzzy. It's almost like an out-of-body experience.
28 or more	Very relieved and glad that we had not had an incident, i.e. the flight was uneventful.
28 or more	Knackered!!!!
28 or more	Detached.
28 or more	I felt useless and dangerously tired.
28 or more	Utter exhaustion; physically drained; unable to think straight.
28 or more	A sensation akin to drunkenness.
28 or more	Fatigued!!
28 or more	Relieved that there had not been an incident. Felt too tired to even drive home safely.
28 or more	Tired and tetchy.
28 or more	Shattered – slept in the car before driving 20 mins to get home.
28 or more	Numb and had difficulty sequencing normally routine tasks.
28 or more	Knackered!!!!!!!!!!!!
28 or more	Shattered.
28 or more	I did not feel unduly fatigued at this stage, due to the 'excitement' and adrenalin effect of approach and landing, but soon after I felt extremely fatigued. Driving home, I had a 'micro-sleep' and crashed my car into a kerb after pulling across a main road.
28 or more	I felt detached from reality.

28 or more	Relieved; nauseous; aching. Extremely tired.
28 or more	Very tired and nauseous.
28 or more	I felt drunk, fidgety, very short-tempered, euphoric. This followed a 3 day ad-hoc charter in a previous (charter) company. Total time awake was something like 48 hours as sleeping arrangements down-route were grossly sub-par.
28 or more	I felt very 'woolly-headed'. Dreading the drive home, and difficult to focus.
28 or more	I felt shattered to the extent I wasn't sure I should be driving home (it's only 25 miles to my home).
28 or more	Very Tired. My eyes we're itching and I had a slight headache.
28 or more	I felt very very tired and a bit vague ... and then you have to drive home!
28 or more	I felt exhausted ... but so tired it was hard to sleep when I finally got to bed: this has happened to me many times. I have been to the BA doctor as well as my GP. I have also discussed this issue with my AME.
28 or more	Extremely tired; relieved; delirious; fatigued!
28 or more	Relieved and looking forward to a rest.
28 or more	In a trance-like state.
28 or more	I felt psychologically and emotionally irritable. I was unable to complete routine post-flight procedure without error or omission. I felt that I was prone to cognitive and tactical error during the flight.
28 or more	Very tired, light headed and grumpy.
28 or more	My last trip. If I wake up with the children going to school at 07:30, and don't land in the far east until late morning the following

	day, I am often awake for this length of time. Generally I hope to sleep for 2 or 3 hours in the bunk.
28 or more	I felt awful. Initially a sense of overcoming all obstacles to 'get the job done', followed by the miserable thought of a two-hour drive home in bad weather at night, with more to come the day after!!
28 or more	Vague; unconnected; light-headed; weak; distracted; incapable of mental focus.
28 or more	Pretty tired, but not falling asleep; the adrenalin of the approach and landing wakes you up.
28 or more	Much more than 28hrs when I had small children. I felt physically nauseous, disorientated, extremely short-tempered (when I am not naturally so) and 'fuzzy'.
28 or more	Very tired and obviously not at 100% efficiency!
28 or more	I felt light-headed. Extreme tiredness and inability to think straight. A feeling of 'can't be bothered, just want to sleep'.
28 or more	Like a zombie.
28 or more	Physically sick; noticeably less able to prioritise/organise; lethargic; short-tempered.
28 or more	Adrenaline tends to get you through until then, but about half an hour or so after setting the brakes the fatigue really sets in. I have had to sleep in my car before driving home. I am probably not alone in having fallen asleep at the wheel whilst driving.
28 or more	Exhausted and relieved.
28 or more	Total loss of realism.
28 or more	Mentally and Physically exhausted.
28 or more	Confused.

28 or more	Punch-drunk.
28 or more	I felt like I had been lucky to 'get away with it'. I felt extremely lucky that nothing had gone wrong as I would not have been able to deal with even the most basic of adverse conditions or emergency.
28 or more	Extremely tired; mindful of poor performance and aware of many mistakes made.
28 or more	Sick.
28 or more	Mentally and physically exhausted. Quite tearful.
28 or more	Unable and unwilling to deal with simple problems; headache; facial twitch.
28 or more	Sick, nauseous, elevated heart rate and occasional palpitations.
28 or more	Shattered. I revert to a kind of 'safe mode' and make sure that I'm operating knowing my limitations.
28 or more	Shattered.
28 or more	Weak and faint/dizzy.
28 or more	I felt utterly shattered. It was pure adrenaline that was preventing me from falling asleep. I had a long day at home and was unable to sleep prior to my duty. I flew a long-haul, three-crew flight to the Far East.
28 or more	Nauseous; dull; detached; as though I do not inhabit my own skin.
28 or more	I felt 'drunk' with tiredness. I was unable to carrying out any task that required any form of mental agility.
28 or more	I felt physically sick and felt in danger driving home.
28 or more	I felt relieved the day was done. It was a constant battle against complacency. This

	occurrence was due to a sleepless night spent in a noisy (60dB on average with 73dB peaks) hotel room. After that day, I considered really seriously writing an ASR.
28 or more	Relief that the working day was over without SERIOUS incident. Wishing I did not have to drive home ... and that someone could just pick me up from work.
28 or more	Intoxicated would be the best description.
28 or more	The circumstances were entirely company-induced. I felt overwhelmingly tired, and angry with myself, but most of all I felt like an irresponsible fool/criminal for not having the balls to say 'I was too fatigued to do the duty'. I should have done that.
28 or more	When on long-haul ... returning from Far East, I was regularly awake for more than 24 hours. The last few hours were torture with a desperation to get home and in my car.
28 or more	Mildly intoxicated and dreading the 12-mile car journey home.
28 or more	Dizzy, disembodied, unaware of my surroundings. On the drive home I frequently drove past traffic cameras I knew were there, but in my tired state they failed to register.
28 or more	I felt completely drained of energy but found sleep difficult to achieve even though I was extremely tired.
28 or more	Nauseous. It felt like I was drunk.
28 or more	Shattered.
28 or more	Completely drained; Muscles aching; Loss of appetite; Sick!
28 or more	I could hardly stand, let alone think clearly! Not a very nice feeling!

28 or more	Shattered.
28 or more	A gibbering idiot.
28 or more	Exhausted.
28 or more	Relieved that I'd got through the sector without an incident. For all the modern safety hardware airlines seem keen to invest in (EGPWS, TCAS, Runway Incursion Monitors), I am absolutely certain that the fatigue level of myself and my colleagues on the flight is the most important influence on the safety of the flight.