1 The problem of fatigue

Background

Fatigue is a pervasive influence on human life, experienced by everyone on a regular basis. It may be felt as a low mood (tiredness, weariness, lethargy) or unfocused mental state (distraction, frustration, discomfort), or as an unpleasant bodily state, including headaches, tension, and vague pains in muscles and joints. It is also implicated in everyday disturbances of mood and quality of life, and, in more intense cases, can be felt as physical exhaustion, a total incapacity for any exertion, a profound lack of motivation, or depression. In terms of cognitive activities, fatigue is associated with problems of completing – or even starting – tasks, particularly where there is a requirement to sustain high levels of effort over long periods. In addition, fatigue (along with headache and colds) is among the most frequently reported health complaints in primary care clinics in Western countries, a feature of almost all illnesses, and a common after-effect of surgical intervention. Yet, fatigue remains a puzzle. How is it that we can feel tired when we do not appear to have done very much? How is it that we appear to be able to recover so quickly under some conditions, but not others? What is going on when weariness following a hard day at work can be banished by going for a run or a session at the gym? Why do some kinds of activity make us feel tired, while others, equally or even more demanding, do not? Just what is fatigue about, and how does it come to play such a significant part in mental life? Does it have an adaptive function, or is it simply an end state of the failure of the normal process of energy management? Or is it something else altogether?

Fatigue in the modern world is widely regarded as a major problem for health and wellbeing. Endemic tiredness is recognized not only in practical areas of life such as work and driving, but also in everyday experience. General practices are beset with patients reporting being 'tired all the time', and there is increasing clinical recognition of the related condition of chronic fatigue. Yet, despite the widespread general

interest in fatigue, and the plethora of popular books on the subject – an Amazon search on mental energy and fatigue conducted in early 2009 generated over 500 such books – the topic is poorly understood. This is true even within the scientific community, where it has been surprisingly neglected in terms of systematic scientific investigation. Following the stimulation of interest in human work and fatigue during the late nineteenth century, there was a proliferation of research on the topic, reaching its peak during the 1930s. The period between 1900 and 1940 was characterized by a wealth of detailed empirical studies, widespread theoretical interest, and a concern with application of knowledge to both educational and industrial practice. Since that time, fatigue has gradually receded from the scientific landscape, so much so that it now rarely appears even in the index of modern textbooks of cognitive psychology or even work psychology, and not at all in recent monographs and major reviews on attention and performance (Logan, 2004; Pashler, 1997; Pashler, Johnson & Ruthruff, 2001; Styles, 2006).

This trend is illustrated in Figure 1.1, which summarizes the results of a search on PsycARTICLES for journal articles that included the word 'fatigue' in the title, published during successive ten-year periods. The pattern is somewhat obscured by the fact that the number of academic periodicals (in all fields) has increased by a factor of several hundred during this period, from around 100 at the beginning of the twentieth century to a current total of somewhere between 20,000 and 50,000, depending on definitional criteria.[1] I could not find the relevant data for psychology and mental health, but have assumed that the growth rates are similar to those in other disciplines, as estimated by Mabe and Amin (2001), and shown here on a logarithmic scale. Figure 1.1 also indicates the very high values for fatigue publications over the two most recent decades. In fact, little of this dramatic upturn refers to the traditional laboratory research on work and fatigue that is the core of this monograph. Instead, it reflects the renewed interest over the past 20 years or so in research in two areas of practical significance. One is a concern for the effects of fatigue in the form of sleep deprivation, especially in military and transport applications. The other, a much stronger influence, is the proliferation of research on fatigue as a clinical problem within medical and neurological contexts. Such a resurgence of interest is welcome, and is likely to provide a valuable focus for fatigue research from many different directions: not only clinical, but

[1] These numbers are estimated from various sources, all based on Ulrich's *Periodicals Directory*.

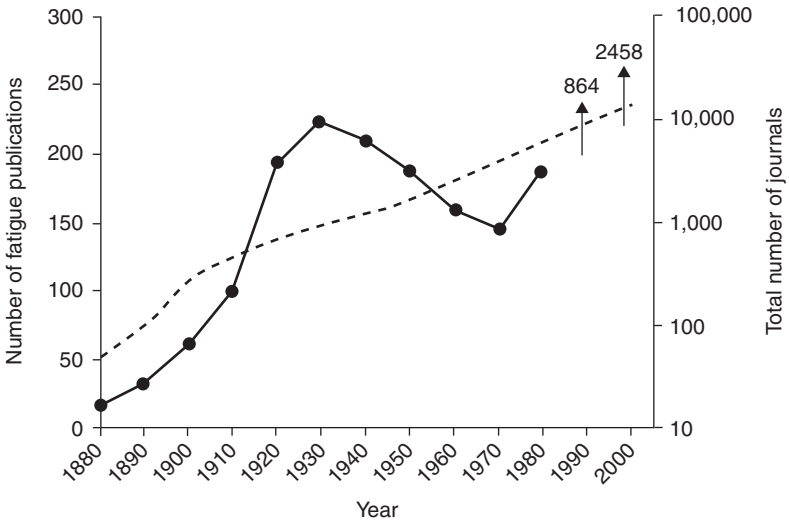

Figure 1.1 Changes in frequency of fatigue publications 1890–2000

cognitive, physical, sleep, stress and neuroscience. Even so, if an adjustment is made for publication opportunities, current publication rates of articles on fatigue are no more than around a tenth of the peak levels achieved during the 1930s and 1940s.

Of course, the tailing-off of interest in fatigue is not, in itself, noteworthy. Science is as much prone to fashion as any other aspect of human experience, and other topics take their turn in the limelight. Research on vigilance and monitoring, another topic within the attention and performance genre, emerged during the 1950s, and flourished during the second half of the twentieth century. The parent discipline of attention had an early peak, along with fatigue, in the 1920s and 1930s, before fading from view until its revival during the 1960s at the heart of the new cognitive psychology. What is strange in the case of fatigue is not that it has declined in intensity but that the problem appears to have been more or less abandoned (at least by experimental psychologists), and before it had been even partially solved. Instead, fatigue is now predominantly a topic for medical research, with a focus on its role not only in chronic fatigue but also in a wide range of other chronic illnesses. Even today, there is no widely accepted view of what fatigue is, no mature theory of its origins and function, and little understanding of the relationship between the several different types of fatigue (mental, physical, sleepiness) that are routinely confused in the scientific literature.

Rationale and focus of the book: the adaptive role of fatigue

The present monograph is the first dedicated to the scientific treatment of the topic of fatigue for more than 60 years, since Bartley and Chute's (1947) comprehensive review. Since then, publications on fatigue have been confined to edited symposia (Ackerman, 2011; Floyd & Welford, 1953), collections of chapters (DeLuca, 2005; Hancock & Desmond, 2001; Hockey, 1983; Matthews, Desmond, Hancock & Neubauer, 2012; Simonson, 1971; Simonson & Weiser, 1976), and individual chapters in textbooks or more general collections (Craig & Cooper, 1992; Hockey, 1986, 2011; Holding, 1983; Matthews, Davies, Westerman & Stammers, 2000). While many of these have usefully updated the literature and provided new ideas and insights, they have been necessarily eclectic, and have generally had little lasting impact on our understanding of what fatigue is: what causes it; what its function is (if any); what brain processes are implicated; and so on. Some of these sources also deal with the relationship between fatigue and stress, as a package of closely related issues, and it will be clear that the present book also makes no sharp distinctions between the two. Rather, they are considered to be different facets of the same adaptive process, in which the process and feeling of fatigue refer to the complex pattern of changes that follow a sustained attempt to maintain task goals under threat from environmental or task stressors. The book offers a reinterpretation of the nature of the experience of fatigue, starting with an analysis of its historical and social context. It proposes a new theory, based on the idea that such experience is a natural, adaptive feature of mental life. While fatigue is regarded as a major problem for present-day society, this was not always the case. So how did it get to be this way? And what can we do to help reduce its impact on everyday wellbeing and chronic ill-health?

The motivation for this monograph was to provide a new perspective on the nature of fatigue. At its core is the hypothesis that the experience of fatigue serves an adaptive signal function for the effective control of actions and human motivation. I argue that, rather than interfering with our ability to carry out tasks by wearing down our energy or resources, fatigue makes us aware of the opportunity costs of current activities, and of the attraction of neglected needs and alternative goals. This is a long-held perspective that has become lost from scientific view. For example, the influential Italian physiologist Angelo Mosso said of fatigue, that:

what at first sight might appear an imperfection of our body, is on the contrary one of its most marvellous perfections. The fatigue increasing more rapidly than the amount of work done saves us from the injury which lesser sensibility would involve for the organism. (Mosso, 1906, p. 156)

Such insights are also evident in the writings of Edward Thorndike, one of the most significant experimental psychologists of the early twentieth century. Thorndike (1900) rejected the idea of fatigue as a state of reduced effectiveness, likening it more to a state of mental discomfort or aversion to mental activity. He argued that:

feelings of fatigue, such as they were, were not measures of mental inability … we can feel mentally fatigued without being so, that the feelings described above serve as a sign to us to stop working long before our actual ability to work has suffered any important decrease which an experimenting psychologist could measure and use as a warning to us. (p. 481)

A similar perspective was offered by Bartley and Chute (1947) in their comprehensive review of the problem. They interpreted the emergence of a feeling of fatigue within an individual as part of the transaction between the performer and the environment, representing a change of orientation from acceptance and engagement to one of discomfort, resistance and aversion to continuing with the present activity. The conflict between present and desired goals demands (or at least invites) a reappraisal of priorities.

While the approach and content of the present book are inevitably led by my personal research interests over the past 25 years or so, they are informed by an extensive literature. My goal in writing this book is to provide a broad context for understanding the meaning and function of fatigue, through the use of a wide range of sources: empirical and theoretical; experimental and clinical; modern and historical. I believe that a better understanding of the problem of fatigue will have benefits not only for psychological theory, but also for managing fatigue on a practical level: within work design, everyday wellbeing and mental health.

It will be clear from a quick leaf through the pages of this book that its primary focus is on the experimental psychology of *mental* or *cognitive* fatigue. Yet, the title suggests a concern with the unqualified topic of fatigue in general. This more inclusive term was chosen deliberately to reflect a desire to reconnect the various facets of the problem that have become dissociated over the past 100 years or so. These include not only fatigue from mental activity, but also issues related to sleep disturbances and physical work. My strategy, in basing the book on mental fatigue, is to emphasize the centrality of the cognitive and subjective experience of fatigue, in understanding not only mental fatigue itself

but also the impact of sleep deprivation and physical work on mental processes. This is not to say that all fatigue is mental fatigue: that there is no need to look beyond a general explanation; on the contrary, it is clear that fatigue from sleep disturbances is associated with specific needs and brain mechanisms, while physical fatigue involves muscular and metabolic demands far in excess of those met in cognitive tasks. However, I argue that, while the various forms of fatigue appear to have distinctive aetiologies, contexts and forms of expression, the development and management of mental fatigue underlies or plays a major part in all of them. A comprehensive review of the literature in these different specialist areas is not a practical goal for a monograph of this kind. Instead, I make reference to physical fatigue and sleepiness whenever it is appropriate to do so throughout, and attempt in Chapter 7 to summarize the major issues relating to these alternative manifestations of the fatigue problem, and to consider how they may be integrated into a general framework.

Another deliberate focus of the book is on short-term (transient) effects of fatigue – the state experienced under conditions of acute task demands or stress, but that normally recedes when more favourable conditions prevail – rather than on enduring problems of health and wellbeing such as chronic fatigue. Inevitably, a systematic treatment of chronic fatigue is beyond the scope of this book. However, I again try to address relevant issues throughout, and, in Chapter 8, review the core issues on persistent fatigue of different origins, including work and problems of chronic ill-health. I also put forward a tentative dynamic model to show how pathologies of fatigue may occur through a failure to manage the response to stress and short-term motivational conflicts.

The failure of classical fatigue theory

Despite over 100 years of research and scientific thinking about fatigue, we still have no well-developed theory of how the process works or what its function might be. A recurring theme throughout the book is that there have been two major obstacles to our understanding. The first is the irresistible tendency to think of fatigue in terms of the exhaustion of energy (feeling spent, worn out, exhausted, batteries running down). A second problem has been the near-universal tendency to consider fatigue as a negative state, and as an inevitable consequence of work. Both of these assumptions are considered in this section and found to be flawed. The alternative view, proposed in this book, argues that fatigue has an adaptive function, serving the management of motivation.

Limitations of the energy account of fatigue

The most serious failure of traditional fatigue theory has been its assumption that it is caused by a loss of energy, caused by the activity of carrying out (too much) work. This is not surprising, given the widespread influence of ideas on energy conservation and transformation on nineteenth-century thought (Rabinbach, 1990). The tendency to think about fatigue in terms of energy failure can be seen to have its origins during the Industrial Revolution, in the growing awareness of the role of energy in the work of machines, and as the limiting factor in production. Within a short time, as Anson Rabinbach (1990) shows in his analysis of the social history of fatigue, the *work→energy depletion* framework was being applied not only to the work of machines, but also to that of humans, and further extended to include mental activity as well as the more directly comparable physical work. The idea had an immediate and major impact on both the scientific literature and everyday language, which began to use the terms *fatigue* and *energy* together in relation to human activity from around 1870. It was a short step from this to 'explain' the problem of fatigue – the failure to continue to produce output – as the result of a loss of energy. The feelings of weariness during and after periods of demanding work appeared to make sense within this new way of thinking about the body. I shall discuss the derivation of these ideas in Chapter 2, and argue that the roots of the link between work, energy and fatigue are to be found in the dramatic changes in working life during the second half of the nineteenth century.

Energy-based explanations are ubiquitous within psychological theorizing on motivation, personality and cognitive psychology, often taking the form of drives or resources, though they probably had their greatest impact through Freud's psychodynamic model, which posited 'psychic energy' as the basic driving force of mental life (Strachey, 1953). Reinforced by followers such as Jung, Adler and Klein, such views had a major influence on cultural thought during the first half of the twentieth century, and led to the widespread acceptance of mental energy as the prime mover of motivation and action, and lack of energy as the reason why things were not (or could not be) done. The late nineteenth-century energy view of fatigue has been highly resistant to change, even in the face of the growth of psychology as a science and the emergence of new understanding of brain and body mechanisms. While (up to a point) an energy explanation can be made to work for physical exercise, it has not stood the test of time as a way of

understanding patterns of decrement in mental work. Of course, at the most basic level, energy transformations are the basis of all neural events and all behaviour. But this does not mean that it is necessarily appropriate for high level explanations of behavioural change. It is possible (though still not confirmed) that the brain uses up more glucose and oxygen to carry out more demanding tasks than simpler ones, but the difference appears to be very small, and there are never signs of anything approaching a state of a *depletion* of energy reserves (Gibson, 2007; Raichle & Mintun, 2006).

Despite the lack of any convincing role for energy variations in behaviour, we talk freely about psychological energy (or vigour, or vitality) as a primary agent of action in many areas of mental life: for example, motivation (Ryan & Deci, 2008), work engagement (Shirom, 2003), self-control (Baumeister, Vohs & Tice, 2007), or mood (Matthews, 2011; Thayer, 1989). What we refer to as 'mental energy' seems to be a convincing characteristic of people, readily understood as a feeling of liveliness and active enthusiasm for the pursuit of goals. Yet, there is no evidence that healthy, highly energetic individuals differ from others in terms of actual brain energy (Lieberman, 2006). If mental energy is not a function of differences in physical energy, what is it? The continued use of the energy metaphor makes it difficult to consider other explanations for what lies behind such a state.

Fatigue is not (just) a negative state

A second, related, reason for the failure of the fatigue construct to attain scientific maturity is its narrow interpretation as an *unwanted* by-product of (physical and mental) work. This is a natural consequence of identifying human transactions with the environment with the work done by industrial machines, and the exhaustion of energy in the execution of that work. However, the ensuing emphasis on fatigue as a negative state associated with the depletion of energy has not been as useful an idea as was initially assumed. I would go further and argue that such views have impeded progress towards a genuine theory of fatigue. Examination of archival material in Chapter 2 suggests that fatigue may have been experienced quite differently in the pre-modern era (before the full impact of industrialization). I shall argue that the widespread use of energy and fatigue terms in everyday language dates from the increasing shift to factory-based work over the second half of the nineteenth century; before that time, as Rabinbach (1990) argues, there is little to indicate that fatigue was experienced as a generally negative state. I will argue that the same principle applies today, even

though the environmental and cultural context of working life has changed considerably; work is not always experienced as tiring.

As others have commented (notably, Bartley & Chute, 1947), the energy depletion perspective has almost certainly been a source of distraction in the search for an understanding of fatigue. Fatigue has always been associated with work, specifically with the depletion of energy through excessive work (what I refer to as the work–fatigue hypothesis). Such a view has long been considered an inadequate account of the varied phenomena of fatigue. Bartley and Chute (1947) concluded categorically that, even for physical work, unless extreme, fatigue represented not an inability to do work, but rather a *lack of desire*: an 'attempt to retreat or escape from a situation' (p. 53). I examine the relationship between work and fatigue in Chapters 3, 4 and 5, in relation to stress and coping strategies, and try to determine the boundary conditions for the assumed causal nature of the work–fatigue relationship. At one level, work may represent simply the physical and mental load on the body and brain defined by the energy requirement of the activities carried out. It becomes clear that this is not a good predictor of fatigue and its consequences, except in the case of extreme physical work. Instead, the evidence shows that it matters how activities are understood by the performer: whether they are externally driven (tasks) or self-selected (leisure); or, if they are tasks, whether they allow a high level of control (discretion in how and when they are carried out). As has long been known (Thorndike, 1900), when activities are self-initiated (and sustained by personal goals) mental work is not generally perceived as tiring, and may even have the opposite effect: that of energizing the performer, as in the experience of 'flow' described by Czikszentmihalyi (1977, 1990; Demerouti, 2006).

Holding (1983) identified the core effect of being fatigued as an aversion to further activities that demanded high levels of effort. It is important to acknowledge at the outset the explicit link between fatigue and effort. Effort is assumed to act as a precursor to fatigue, which then triggers control activity that serves to reduce effort. In many contexts, where the time course of feelings is not well defined, the two may be almost interchangeable; phenomenologically, needing to make more and more effort is functionally equivalent to becoming more and more tired. Bartley and Chute (1947) argued that fatigue (or effort?) may be considered both a warning of the need to escape and a marker of the distress felt when this action is not carried out. They emphasized the importance of the 'stance' or 'attitude' an individual takes to the task: whether it is desired by the performer, or not; whether it leads to

engagement or resistance. This reinterpretation of the nature of the experience of fatigue has been largely forgotten, or at least overlooked in modern treatments of the problem, though it is rekindled by recent work that shows the value of considering effort in terms of its cost for behavioural direction and decision-making (Boksem & Tops, 2008; Kool, McGuire, Rosen & Botvinick, 2010; Kurzban, Duckworth, Kable & Myers, in press).

A motivational perspective

In contrast to the prevailing view of fatigue as a failure of energy, the approach taken in this volume is to regard fatigue as primarily affecting the selection and control of goals. As with all organisms, humans are in a state of constant dilemma between the choice of maintaining current goals and behavioural directions and switching to new ones whenever they offer greater potential benefits. A more general motivational context is the conflict between the need to exploit established sources of reward and explore the environment for new opportunities. This is a well-established principle in evolutionary biology (e.g., Tooby & Cosmides, 2005), where, for example, foraging behaviour is shown to accurately reflect changing utilities of available food sources; animals decide almost optimally whether to stay or to shift. In human behaviour such ideas are less well developed, though they are implicitly understood in theories of motivation and cognitive control (Dreisbach, 2006). In Chapter 4, I outline the case for considering fatigue as an emotion, with the adaptive function of maintaining this motivational balance. Interruptions of current behaviour allow alternative options for the control of behaviour to be entertained. By interrupting ongoing activity, fatigue provokes a reappraisal of the benefits and costs of current goals, and allows alternatives to compete for access to motivational control. As I shall discuss in Chapter 5, goals need to be protected from such intrusion only when they rely heavily on top-down executive control. Specifically in the context of work and fatigue, the act of carrying out work is assumed to be fatiguing only when it takes the form of a *task*, a goal that is driven by external or internal targets, whether for someone else or for oneself. Fatigue develops if the performer is motivated to maintain the task goal in the face of a desire to stop or change to something else, and needs to employ a high level of effort to do so.

Over a century ago Thorndike (1900) interpreted the development of fatigue as the problem of doing the right thing, rather than doing too much. The same point was being made by Cattell (1941), who argued for a strong guiding role of purpose (or goal) in preventing fatigue-related